



# DOCTORAL THESIS

## ESSAYS ON SUSTAINABLE FINANCE, CLIMATE RISKS, AND INVESTOR BEHAVIOR

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# Chapter I

## General Introduction

This doctoral thesis, consisting of six papers, explores a range of empirical research questions in the field of sustainable finance, which can be broadly defined as the integration of environmental, social, and governance (ESG) considerations into financial decision-making (Starks, 2023). The growing relevance of climate change in this field, in particular the role of climate risks as drivers of financial risks, is also reflected in this thesis, with several papers focusing on climate-related financial considerations. Another recurring theme throughout this thesis is, furthermore, the discussion of the motivations, preferences and behaviors of different types of investors in relation to these issues.<sup>1</sup>

The first chapter examines “sustainability-linked loans” (SLLs), a new type of financial instrument introduced by credit institutions to incentivize borrowers’ sustainability efforts by tying loan margin adjustments to the achievement of pre-defined ESG targets. This study, conducted with Christina E. Bannier and Fabio Martin, focuses on SLL transactions involving firms based in the United States (US) and the European Union (EU). In recent years, a growing number of firms, including financial institutions, have committed to expanding their sustainable finance portfolios as part of broader corporate strategies, contributing to the increasing issuance of SLLs. From a risk management perspective, SLLs also offer the potential to mitigate sustainability risks within loan portfolios by systematically embedding and monitoring sustainability aspects. In this

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<sup>1</sup>Each of the following chapters corresponds to a specific paper. The chapters may differ slightly from the published versions due to formatting adjustments, with no alterations to the main content.

context, our study focuses on a key element of SLLs: their key performance indicators (KPIs). Such KPIs play a crucial role in measuring progress towards pre-defined ESG targets and in determining the financial reward (or penalty) borrowers may receive from the loan margin adjustments. After shedding light on the design of these KPIs across several dimensions (e.g., strategic relevance and materiality), our study depicts a mixed picture of SLLs, both in terms of their intended incentivization and signaling effects. Notably, we find no significant improvement in borrowers' sustainability performance in the years following SLL issuance. Furthermore, we find that US firms experience a significant negative market reaction around SLL issuance, especially when their loans include environmental KPIs. In many ways, the results of this study, as well as the evolution of the SLL market, are quite telling of some broader trends in the sustainable finance space. For example, between 2017 and 2022, the SLL market witnessed rapid growth. However, concerns over greenwashing and reputational risks have since dampened investor enthusiasm. While investors and stakeholders demand that firms incorporate and report an ever-increasing set of ESG metrics, as noted by Edmans (2023a), our study underscores the need for robust and credible mechanisms to ensure that sustainability-linked financing delivers on its objectives.

The second chapter examines retail investors in Germany and their behavior towards sustainable investments. In an experimental setting, Christina E. Bannier, Florian Gärtner and I investigate whether a particular form of literacy, defined by Filippini et al. (2024b) as “sustainable finance literacy”, influences the sustainable investment choices of retail investors. To study sustainable investments, our study focuses on ESG-related mutual funds and ESG-related exchange-traded funds (ETFs), which by definition take into account specific sustainability characteristics of assets in their investment strategies. Such products have experienced rapid growth in the last decade (Giglio et al., 2025). However, despite an increased supply from the institutional side, demand from the retail investor side has been more hesitant, with sustainable finance products currently representing only a small fraction of retail investor portfolios (DIA, 2020). In surveys, retail investors often cite insufficient knowledge and lack of transparency as barriers to choosing such products (DIA, 2020; Dumas and Louche, 2015;

Gutsche and Zwergel, 2020; Filippini et al., 2024a). We posit that investors with clear preferences for sustainability also need specific knowledge to properly identify and evaluate ESG-related funds. In our experiment, we provide our treatment group with an information brochure designed to increase sustainable finance literacy. We find that the brochure increases the probability of investing sustainably, and we show that this effect is moderated by sustainability preferences. Interestingly, we also find some evidence that increased sustainable finance literacy decreases investments in ESG funds among participants with very low sustainability preferences. These findings highlight the need to complement preference-based regulatory frameworks, such as MiFID II, with efforts to enhance sustainable finance literacy.

The third chapter examines shareholder engagement on ESG issues at US annual general meetings (AGMs). Shareholders are known to use a range of engagement strategies, including the submission of proposals and private negotiations, to draw attention to issues they consider critical to shareholder value and, thus, to influence corporate behavior in line with their interests (see e.g., Gillan and Starks, 1998; Denes et al., 2015; McCahery et al., 2016; Blau et al., 2015; Dzielinski et al., 2022). In recent years, a growing body of research has underscored a trend of shareholder activism focused on sustainability-related matters (see e.g., Flammer et al., 2021; Hoepner et al., 2023). Although they provide a unique public setting in which both institutional and non-institutional shareholders may engage directly with management, AGMs have received little scholarly attention in this context. Focusing on “soft” engagement in the form of questions and comments directed at company management, the study, conducted by Christina E. Bannier, Fabio Martin and I, contributes to the literature by using textual analysis of AGM transcripts and analyzing the sustainability issues verbally raised by shareholders. We find that institutional shareholders — such as large asset managers, public-sector investors and faith-based investors — are particularly vocal on ESG issues compared to non-institutional shareholders. This finding aligns with the insights from the second chapter of this doctoral thesis, which highlights that retail investors face knowledge barriers and exhibit a more cautious behavior in the context of sustainable finance. While personal experience with environmental or social issues

can enhance individual awareness for such topics (see, e.g., Akerlof et al. 2013; Choi et al. 2020), institutional investors tend to possess more advanced ESG expertise and have formalized internal sustainability policies. These factors are likely to contribute to a more proactive engagement on ESG matters. Moreover, we identify a negative relationship between firms' ESG performance and the frequency of ESG-related language in shareholder comments at AGMs. We also find that a higher ESG performance is associated with a less negative tone of shareholders. Such negative tone is, furthermore, associated with lower approval rates for management-sponsored proposals. Overall, our study shows that shareholder soft engagement at AGMs serves as an important barometer of broader sentiment toward firms' ESG commitments. The findings also suggest that AGMs are strategic opportunities for the board to demonstrate accountability and progress in sustainability efforts.

The fourth chapter examines the extent to which investors consider greenhouse gas (GHG) emissions in their investment decisions by analyzing the relationship between such emissions and equity risks across a sample of European firms. In recent years, climate change has become a pressing issue for a wide range of stakeholders, including civil society and institutional investors (see e.g., Krueger et al., 2020; Ilhan et al., 2023; Hoepner et al., 2023). Furthermore, there is a growing scientific consensus that high concentrations of GHG emissions are the primary driver of climate change (EPA, 2021), with human activities in key economic sectors such as energy, agriculture, industry, buildings, and transportation being major contributors to this global challenge (IPCC, 2014). To measure GHG emissions, the widely recognized GHG Protocol categorizes them into three scopes: scope 1 (direct emissions), scope 2 (indirect emissions from energy consumption), and scope 3 (indirect emissions across the value chain) (World Business Council for Sustainable Development and World Resources Institute, 2004). In this study, Christina E. Bannier, Yannik Bofinger, Björn Rock and I show that scope 1 and scope 2 GHG emissions are positively associated with firm equity risks, whereas scope 3 emissions do not show a significant relationship. Furthermore, we find that mandatory regulatory frameworks for GHG disclosure have a risk-mitigating effect, and overall, that firms that disclose GHG emissions are associated with lower equity risks



compared to those that do not disclose such information. As new regulatory initiatives, such as the EU’s Corporate Sustainability Reporting Directive (CSRD) and the US Securities and Exchange Commission’s (SEC) Climate Disclosure Rule, contribute to a shift towards mandatory GHG reporting, such data is likely to become an increasingly essential component of investor risk assessments in the coming years.

The fifth chapter examines an international sample of credit institutions that are members of the Task Force on Climate-Related Financial Disclosures (TCFD) and their disclosures practices between 2010 and 2021. The TCFD is one of many voluntary sustainability reporting frameworks that have emerged in the past decade to encourage firms, including financial institutions, to disclose risks that are not typically captured in more traditional financial reporting. Firms that become members are expected to provide detailed disclosures on their governance, strategy, risk management, and metrics & targets related to climate risks. This work, conducted in collaboration with Christoph Funk, David Lenz and Elena Tönjes, applies natural language processing (NLP) and a zero-shot text classification method to analyze large amounts of textual data extracted from the credit institutions’ reporting. Given the voluntary nature of the TCFD framework, a key question is whether credit institutions selectively disclose information on specific areas and topics (Bingler et al., 2022). Our findings suggest that climate-related disclosures increase following credit institutions’ adoption of the TCFD guidelines, yet reporting remains uneven across disclosure categories. The most notable improvements are seen in the areas of strategy, and metrics & targets. However, we highlight important gaps in other areas, including in the risk management dimension. Specifically, we find that banks are less likely to report on critical topics such as the management of physical climate risks and the use of climate-related scenario analysis. That said, it remains unclear whether this reflects intentional omissions by credit institutions or whether they have yet to fully implement the TCFD’s recommendations. Our findings also highlight a broader limitation of voluntary reporting frameworks such as the TCFD. In particular, we show that the guidelines are relatively broad (see e.g., the requirement to describe the *resilience* of a firm’s strategy, TCFD, 2017b), which results in highly descriptive textual disclosures that are difficult to systematically compare

across firms. This may partly explain why EU regulators have prioritized the development of very detailed and prescriptive sustainability reporting standards in recent years.

The sixth and final chapter focuses on large credit institutions in the EU and their integration of climate-related risks into risk management and capital adequacy frameworks. As outlined in the fifth chapter of this doctoral thesis, institutions display varying levels of progress in addressing these risks. To support their integration, the European Central Bank (ECB) published a guide in 2020 outlining key supervisory expectations for climate risk management and disclosure (ECB, 2020b). In addition, since 2022, large EU credit institutions under the scope of the Capital Requirements Regulation (CRR) have been required to provide both qualitative and quantitative disclosures on climate risks in their Pillar 3 reports, representing a major step compared to voluntary frameworks such as the TCFD. Drawing on semi-structured interviews with risk experts and an analysis of Pillar 3 reports, Christina E. Bannier and I explore the approaches and practical challenges institutions face in this context. Key findings show that substantial progress has been made in crucial areas — such as the inclusion of climate-related considerations into the internal capital adequacy assessment process (ICAAP) or the development of methodologies for both top-down and bottom-up climate scenario analyses. Nevertheless, important barriers remain, including in terms of data limitations and model integration. Overall, this chapter indicates that credit institutions are still in a learning phase, while also underlining the essential role of supervisors and regulators in shaping risk management practices.

# Chapter II

## Are sustainability-linked loans designed to effectively incentivize corporate sustainability? A framework for review

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# Are sustainability-linked loans designed to effectively incentivize corporate sustainability? A framework for review

## Abstract

This paper analyzes sustainability-linked loans (SLLs), a new category of debt instrument that incorporates ESG considerations. Using a large sample of loans issued between 2017 and 2022, we assess the design of SLLs by evaluating their key performance indicators (KPIs) using a comprehensive quality score. Our findings suggest that SLLs only partially rely on KPIs that generate credible sustainability incentives. We document that SLL borrowers do not significantly improve their ESG performance post issuance and show that stock markets are rather indifferent to the issuance of SLLs by EU borrowers, while SLL issuance announcements by US borrowers are met with significantly negative abnormal returns by investors. These findings call into question the beneficial sustainability and signaling effects that borrowers may hope to achieve by issuing ESG-linked debt.

**JEL Classification:** G21, G32, M14

**Keywords:** Sustainability-linked loans, sustainability KPIs, ESG-linked loans

## II.1 Introduction

A recent development in the realm of corporate finance is the emergence of debt instruments that incorporate environmental, social, and governance (ESG) considerations. These instruments serve two primary purposes: procuring capital and fostering corporate sustainability practices. One category of such instruments, sustainability-linked loans (SLLs),<sup>1</sup> is particularly distinct from other emerging instruments such as green bonds, social bonds, and green loans. Unlike these instruments, whose proceeds have to be allocated towards environmentally or socially responsible projects, SLLs are general corporate purpose loans. The issuance of SLLs is therefore not characterized by their use of proceeds, but by the borrower’s performance against pre-defined ESG targets.

Achievement of these targets is measured by key performance indicators (KPIs), which typically impact loan pricing in the form of an interest rate discount or premium. The Loan Market Association (LMA), which published the Sustainability-Linked Loan Principles (SLLP) as a set of voluntary guidelines for market practitioners, defines SLLs as “any types of loan instruments and/or contingent facilities for which the economic characteristics can vary depending on whether the borrower achieves ambitious, material and quantifiable pre-determined sustainability performance objectives” (Loan Market Association, 2023b, p.2). The primary objective of SLLs is therefore to support the borrower’s efforts to improve its sustainability profile over the life of the loan (Loan Market Association, 2023b).

While SLLs have gained increasing popularity, accounting for approximately 10% of the global corporate syndicated loan market in 2021 (Kim et al., 2023), there is still limited understanding of the specific characteristics of the sustainability KPIs that are included in these contracts. This aspect is particularly relevant when considering that SLLs can be tied to multiple KPIs covering a wide range of ESG issues. At a time when there is growing concern about greenwashing practices (Carrizosa and Ghosh, 2022; Kim et al., 2023), it is critical to gain more clarity on whether - and if so, which - KPIs are credible and meaningful for achieving sustainability goals.

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<sup>1</sup>SLLs are also sometimes called “ESG-linked loans”. We use the terms interchangeably throughout this paper.

This is where our paper seeks to contribute. By providing a detailed analysis of KPI characteristics, we aim to further the discussion on the effectiveness of SLLs in promoting ESG activities beyond “business as usual” (Loan Market Association (2023a), p.3). Specifically, we evaluate the design of KPIs in ESG-linked loan contracts along six key dimensions derived from the SLLP. We then use this evaluation as a basis for investigating whether the issuance of SLLs positively incentivizes borrowers to improve their sustainability performance ex-post. In addition, we examine whether SLLs are perceived by the stock market as credible signals of corporate commitment to ESG considerations.

Our study is based on a sample of SLLs extracted from the Refinitiv DealScan database. We focus on borrowers headquartered in the European Union (EU) and the United States (US) for both historical and regulatory reasons. From a historical perspective, the emergence of SLLs, which were virtually non-existent prior to 2017, saw a rapid increase in total issuance volume, rising from over \$2 billion in 2017 to more than \$310 billion by the end of 2021.<sup>2</sup> This growth trend was particularly pronounced in Western Europe in the early years and later spread to other regions of the world, most notably the United States (Kim et al., 2023). While current regulations do not specifically require companies to report comprehensive information about their credit agreements, the existing regulatory frameworks in both the EU and the US still create important incentives for disclosure. In the EU, for example, large companies are required to disclose environmental and social policies in their non-financial statements. Large US corporations proceed similarly. Such disclosures allow us to obtain detailed information about the issuance of SLLs and the KPIs set forth in those contracts.

In the first part of this paper, we examine whether the design of KPIs creates credible incentives for companies to improve their sustainability practices. We address this question by developing a qualitative scoring methodology along six key dimensions: (1) strategic relevance, (2) materiality, (3) measurability, (4) benchmarking, (5) pricing mechanism, and (6) external review. These dimensions serve as a framework that

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<sup>2</sup>Kim et al. (2023) capture a similar trend by documenting a rapid increase in ESG lending activity from 2017 to 2021, with most of the SLL borrowers concentrated in the US and Western European countries.

outlines distinct criteria that, according to the LMA, SLLs should meet in order to be considered credible (Loan Market Association, 2023b). Our analysis delivers a multi-dimensional KPI score per loan that can be used to assess and compare the quality of the incentives defined in the SLLs. As each dimension captures unique information that contributes to a comprehensive understanding of the KPIs' credibility, our approach is consistent with the recommendations of Edmans (2023b), who calls for granular assessments in ESG-related studies.

The results of our KPI analysis suggest that SLLs only partially rely on KPIs that create credible sustainability incentives. In particular, our results show significant variation across the dimensions assessed in our framework. On the positive side, we find that most SLLs include KPIs that are strategically relevant and part of the borrowers' existing sustainability strategies: Only 22% of SLLs feature KPIs that do not match the borrowers' stated sustainability objectives or priorities. This suggests that firms employ SLLs as a holistic approach to further integrate existing ESG considerations into corporate operations. In addition, we observe that the vast majority of SLLs are tied to measurable and objectively quantifiable KPIs that allow lenders to easily track performance against the selected KPIs.

However, on the negative side, our materiality assessment against the SASB standards shows that 42% of the SLLs in our sample are linked to KPIs that are not financially material. This indicates a misalignment between the sustainability goals that the SLLs seek to achieve and the sustainability considerations that are most likely to impact the company's financial performance. In addition, only 15% of the SLLs in our sample are clearly benchmarked, suggesting a lack of reference points for setting the KPIs. As a result, key stakeholders, including investors, may not be able to objectively assess and compare the level of ambition of the KPIs. Our analysis furthermore reveals mixed results with respect to the pricing mechanism and external review of the KPIs. While 40% of the SLLs in our sample explicitly include a malus system that requires borrowers to pay higher interest rates if they fail to meet their sustainability targets, we find that 17% include only a bonus and no financial penalty. In addition, only half of the SLLs in our sample are linked to KPIs that are subject to external and independent

verification at least annually.

Overall, the SLLs in our sample achieve an average KPI score of 3.47 on a scale of 0 to 6, suggesting that these debt instruments are only partially designed to incentivize sustainability efforts by their borrowers. Surprisingly, we observe that the number of KPIs that are included in a loan is negatively associated with this score. While companies may fear that focusing on only a small number of ESG objectives could signal a weaker commitment to sustainability, increasing the number of KPIs actually seems to make such instruments less effective in improving sustainability incentives.

In the second part of our paper, we empirically test whether the issuance of SLLs is associated with a positive ex-post change in borrowers' ESG performance. To do so, we employ a difference-in-differences design based on a matched sample. To identify the relationship between SLL issuance and ex-post ESG performance, we use a two-way fixed effects (TWFE) estimator that compares SLL issuers to a control group of conventional borrowers before and after the treated firms issued their first SLL. Our analysis relies on several ESG performance metrics obtained from MSCI, including the overall industry-adjusted total ESG scores and environmental, social, and climate change pillar scores. We primarily examine these performance metrics to account for the fact that most KPIs in ESG-linked loan contracts relate to environmental and social issues (58% and 25% of all KPIs in our sample, respectively), while governance-related KPIs make up only 1.35% of our sample. In addition, about 17% of the KPIs in our sample are linked to ESG ratings or similar certifications.

Our results show that the issuance of SLLs is not associated with a significant change in the ex-post ESG performance of the borrowers. In other words, we observe neither an improvement nor a deterioration in ESG performance. This holds also when looking at the overall ESG score and the scores of each pillar separately. We repeat our analysis by measuring the weighted group time average treatment effect on the treated (ATT), as proposed by Callaway and Sant'Anna (2021). This procedure allows us to address concerns about the reliability of the TWFE estimator in ordinary least squares (OLS) (de Chaisemartin and D'Haultfœuille, 2020; Baker et al., 2022). Once again, the ATT coefficients are statistically insignificant, confirming our earlier findings and suggesting



that SLLs are not associated with a subsequent change in ESG performance. Overall, these results indicate that the issuance of SLLs primarily maintains the current level of ESG performance rather than leading to significant improvements in subsequent years.

In the final part of our paper, we conduct an event study to determine whether equity investors perceive SLLs as credible signals of corporate commitment to sustainability and, therefore, whether the issuance of such loans is associated with positive stock market reactions. Previous research shows that investors react particularly strongly to the release of environmental and community news (Krüger, 2015). In addition, (Flammer, 2021) finds that stock market investors respond positively to the issuance of green bonds when such instruments are subject to third-party verification and when the use of proceeds is financially material to the company's operations. Thus, we use variation in KPI quality, as measured by our KPI score, to examine stock market reactions to SLL issuance announcements in relation to specific KPI characteristics, such as materiality and external verification. This approach allows us to gain further insights into the perceived credibility of SLLs.

We find that stock markets are rather indifferent to the issuance of SLLs by EU borrowers. In contrast, investors react cautiously to SLL issuance announcements by US borrowers, especially when such loans include environmental KPIs. More precisely, we document a significant negative market reaction with an average cumulative abnormal return of -0.49% in the event window symmetrically surrounding the announcement date of issuance. In a further analysis, we also find a negative association between a higher number of KPIs and the market response to loan issuance announcement. There are several possible interpretations for these results. For example, the results may reflect growing skepticism, particularly in the US, about the value of integrating ESG factors into investment decisions (see e.g., Edmans, 2023b). In addition, as the selected KPIs in SLLs often fail to address financially material issues, assessing the potential financial benefits of SLLs may be challenging. Finally, investors may also be wary of possible greenwashing practices, which have become increasingly common in recent years (Kim et al., 2023).

Our study builds on and complements the work of other scholars, including Kim

et al. (2023), Carrizosa and Ghosh (2022), Du et al. (2023), Caskey (2022), Loumiototi and Serafeim (2022), Dursun-de Neef et al. (2023). Collectively, our findings make important contributions to the rapidly growing literature on SLLs. In particular, our paper adds to recent studies that explore the selection and design of sustainability KPIs in ESG-linked loan contracts. Loumiototi and Serafeim (2022) investigate KPI materiality and report that most SLLs fail to focus on material ESG features and do not address borrowers' relevant ESG risks. Carrizosa and Ghosh (2022) examine the presence of an external KPI auditor and find that the likelihood of KPIs being monitored and audited is positively associated with the ESG expertise of the lead arranger and the number of KPIs. Kim et al. (2023) and Du et al. (2023) report that SLL borrowers face limited financial penalties for failing to meet their sustainability targets. Although these prior studies have individually explored different aspects of KPI characteristics, our paper stands out as the first attempt to systematically analyze a set of six dimensions (i.e., strategic relevance, materiality, measurability, benchmarking, pricing mechanism and external review) together in a single framework. This framework is based on the SLLP, a set of recommendations for market practitioners developed by the LMA, outlining fundamental characteristics that SLLs should meet in order to provide credible sustainability performance incentives. We show that the six dimensions deliver complementary information and collectively contribute to a comprehensive understanding of the incentive structures (and their current limitations) built into ESG-linked loan contracts.

Our study also sheds new light on the mixed results observed in the existing literature regarding the ability of SLLs to influence corporate sustainability performance. Dursun-de Neef et al. (2023) find that firms improve their overall ESG performance after issuing SLLs by increasing their environmental and governance scores. Kim et al. (2023) find that borrowers' ESG performance metrics deteriorate after the issuance of low-transparency SLLs. Du et al. (2023) use the ESG scores of different rating agencies (Asset4, RepRisk and S&P) and document that SLL issuance does not result in a significant change in overall ESG performance. We complement this study by providing additional evidence on the lack of a clear relationship between SLL issuance and ex-post

ESG performance based on MSCI ratings. We show that SLL issuance does not lead to a significant change, i.e., neither deterioration nor improvement, in borrowers' ESG profiles, as measured by their industry-adjusted, environmental, social and climate scores from MSCI. In addition, our KPI analysis, which highlights the limitations of current SLLs, extends this literature by providing new rationales for the lack of meaningful sustainability improvements in the years following SLL issuance.

Finally, our findings also contribute to the literature on sustainable finance instruments and their signaling function (Flammer, 2021). Examining SLLs, Kim et al. (2023) find that stock prices react positively to public announcements of high-transparency SLLs, while Carrizosa and Ghosh (2022) report negative and mostly statistically insignificant reactions to loan announcements. Our study adds to this literature by highlighting marked differences between EU and US borrowers, revealing distinct patterns in stock market reactions across regions. Here as well, the results of our KPI analysis, such as the number of KPIs and the lack of financial materiality, provide additional explanations for the negative market reactions in the US or the absence of market response observed in the EU, respectively. Relatedly, our paper contributes to the growing body of research that questions the value implications of green financial instruments (Kölbel and Lambillon, 2022; Aswani and Rajgopal, 2022). Specifically, our results add to the study by Aswani and Rajgopal (2022), who find negative or partially insignificant reactions for issuers of green bonds and sustainability-linked bonds. Similar to our analysis of ex-post ESG performance, their study shows that green bond issuers do not change significantly reduce their greenhouse gas emissions in the years following bond issuance. Overall, our paper provides somewhat sobering evidence on the stock market reactions to the issuance of SLLs and their immediate impact on corporate sustainability.

The remainder of this paper is organized as follows. Section 2 discusses the potential motivations for issuing SLLs. Section 3 describes the data collection procedure and provides descriptive statistics for our sample of SLLs. Section 4 explains our KPI scoring methodology and presents the results of our KPI analysis. Section 5 describes the empirical results. Finally, Section 6 concludes.

## II.2 Background

At first glance, it may seem surprising that companies would choose to issue SLLs over conventional loans. Not only can SLLs result in higher interest rates if certain sustainability targets are not met, but they also come with additional administrative and compliance constraints. By including ESG considerations in their loan agreements, companies explicitly commit to targets for which they can be held accountable and for which they are financially liable (Kim et al., 2023). Nevertheless, SLLs are becoming increasingly popular (Du et al., 2023). So what are the motivations for firms to issue them?

One potential motivation for firms to issue SLLs may be the need to strengthen their sustainability strategy. SLLs allow firms to take a holistic approach to sustainability objectives by embedding existing ESG considerations into an important aspect of their business: their financing. SLLs may serve as an additional mechanism to ensure that strategic sustainability considerations are actually implemented within the company. In doing so, SLLs also enable companies to receive advice and regularly engage with their lenders on sustainability issues. From the lenders' perspective, the issuance of SLLs may also be motivated by the need to mitigate financial and reputational risks associated with any poor sustainability practices by their borrowers Kim et al. (2023). As borrowers are encouraged to seek external, independent advice on the selection of KPIs prior to signing (Loan Market Association (2023b)), the process of issuing an SLL may also reinforce and lend further credibility to the company's overall sustainability strategy.

By requiring lenders to sign off on KPIs, SLLs may demonstrate lenders' confidence in their borrowers' strategic ESG commitments (Kim et al. (2023)). Therefore, another possible motivation for issuing SLLs may be an attempt to signal commitment to sustainability issues to a broader group of stakeholders in response to growing investor demand and public scrutiny (Krueger et al., 2020; Flammer, 2021; Ilhan et al., 2023). Because investors often do not have sufficient information to assess a company's commitment to ESG goals, this information asymmetry creates a need for companies to

differentiate themselves from their peers by signaling their strategy in a credible way (Flammer, 2021). SLLs may therefore serve as signaling tools, for example, by being mentioned in media press releases or by encouraging borrowers to regularly disclose their progress toward specific ESG goals in their annual reports. In this way, SLLs allow to increase the visibility of borrowers' ESG commitments.

In addition, SLLs represent a particularly attractive financing instrument for companies that were previously excluded from sustainable lending due to the nature of their core activities and wish to enter this space (Kim et al., 2023). In particular, the absence of requirements on the use of proceeds ensures that SLLs are not limited to firms with specific environmental and climate-friendly projects. Thus, unlike green loans or green bonds, SLLs can be used in a wider range of industries and for a broad variety of purposes. By design, these loans offer a high degree of flexibility, allowing borrowers and lenders to tailor the KPIs to the specific situation of the company (Dursun-de Neef et al., 2023).

Finally, financial discounts may also motivate the issuance of SLLs. In the case of conventional loans, borrowers typically pay a spread in addition to a benchmark (e.g., Euro Interbank Offered Rate, Euribor) based on various measures of a borrower's credit risk, such as credit rating. In the case of SLLs, this spread is adjusted by a pre-defined amount to reflect a borrower's progress, assessed on an annual basis, against one or more sustainability KPIs (Loumiotis and Serafeim, 2022). For example, a loan may be priced at 175 basis points (bps) over Euribor, with this spread reduced by 5 bps if the borrower meets its sustainability target in a given year. The pricing mechanism of SLLs can include not only financial rewards but also penalties for not meeting the targets. Appendix C includes a detailed example of such pricing mechanism. While Kim et al. (2023) show that the initial spreads at which SLLs are issued are no different from those of conventional loans, borrowers may still have an incentive to issue SLLs because of the financial rewards that can be earned by meeting their sustainability targets over the life of the loan.

Despite these motivations, SLLs also carry risks for both borrowers and lenders. In particular, the emerging literature on SLLs already suggests that such loans can be

misused for greenwashing purposes and frequently serve to showcase an empty emphasis on ESG to stakeholders (Kim et al., 2023). Moreover, despite the appeal of potential margin discounts, initial evidence on the pricing of SLLs indicates that the size of these discounts to borrowers is limited (Du et al., 2023). These observations make an analysis of the sustainability KPIs at the core of SLLs even more crucial.

## II.3 Loan data and sample

### II.3.1 SLL data

We obtain our data from the Refinitiv DealScan database by extracting loans originated between 2017 and 2022 that are labeled as “sustainability-linked loans”. Refinitiv DealScan assigns this specific label based on loan characteristics gathered from loan agreements, corporate press releases, business press articles, and discussions with borrowers and lenders. We also exclude from our database all SLLs that do not have an announcement date and a closing date. The loan announcement date is critical for our analysis of market reactions, and the financial close date ensures that the transaction was successfully completed. In total, we identify 595 ESG-linked loans issued to listed borrowers in the EU and the US over the sample period from 2017 to 2022.

Table II.1 shows the time series of SLL issuance for our sample. SLL issuance totals \$755 billion over the sample period, growing from \$2 billion in 2017 to approximately \$248 billion in 2022. In terms of issuance volume, the US surpasses the EU in 2021 and shows a comparable, slight downward trend in 2022.

Table II.2 shows the country distribution of the SLLs in our sample. The largest issuer of SLLs are the US (25.55%), followed by France (15.29%) and Spain (14.29%), which is similar to what has been documented in previous literature on ESG lending (Kim et al., 2023; Dursun-de Neef et al., 2023).

Table II.3 provides an overview of SLLs by sector, as defined by the Thomson Reuters Business Classification (TRBC). We find that most SLLs were issued by firms operating in the industrials (17.82%) and utilities (15.46%) sectors, while firms in the healthcare (4.03%) and financials (2.69%) sectors issued the lowest number of loans and

Table II.1: Issuance of sustainability-linked loans over time.

| Year  | European Union |                     | United States  |                     | Total          |                     |
|-------|----------------|---------------------|----------------|---------------------|----------------|---------------------|
|       | Number of SLLs | Volume (in Mio. \$) | Number of SLLs | Volume (in Mio. \$) | Number of SLLs | Volume (in Mio. \$) |
| 2017  | 4              | 2,176.24            | 0              | 0                   | 4              | 2,176.24            |
| 2018  | 19             | 23,318.04           | 2              | 3,050.00            | 21             | 26,368.04           |
| 2019  | 60             | 61,249.63           | 4              | 7,025.36            | 64             | 68,274.99           |
| 2020  | 71             | 84,737.86           | 5              | 11,730.80           | 76             | 96,468.66           |
| 2021  | 135            | 141,462.22          | 76             | 172,776.84          | 211            | 314,239.06          |
| 2022  | 154            | 123,862.07          | 65             | 123,765.92          | 219            | 247,627.99          |
| Total | 443            | 436,806.06          | 152            | 318,348.92          | 595            | 755,154.98          |

*Remark:* This table reports the total issuance amount and number of SLLs issued to borrowers headquartered in the European Union and the United States. The sample consists of 595 loans issued between 2017 and 2022.

Table II.2: Sustainability-linked loans by country.

| Country       | Number of SLLs | Percentage of SLLs | SLL Volume (in Mio. \$) |
|---------------|----------------|--------------------|-------------------------|
| United States | 152            | 25.55%             | 318,348.92              |
| France        | 91             | 15.29%             | 137,569.37              |
| Spain         | 85             | 14.29%             | 57,111.15               |
| Italy         | 68             | 11.43%             | 73,281.31               |
| Germany       | 42             | 7.06%              | 66,835.80               |
| Finland       | 40             | 6.72%              | 14,325.55               |
| Netherlands   | 29             | 4.87%              | 22,836.00               |
| Sweden        | 21             | 3.53%              | 18,051.81               |
| Belgium       | 18             | 3.03%              | 7,600.47                |
| Denmark       | 13             | 2.18%              | 14,513.09               |
| Ireland       | 12             | 2.02%              | 11,028.35               |
| Austria       | 6              | 1.01%              | 2,750.90                |
| Greece        | 5              | 0.84%              | 628.19                  |
| Portugal      | 5              | 0.84%              | 4,004.31                |
| Luxembourg    | 4              | 0.67%              | 6,937.70                |
| Poland        | 3              | 0.50%              | 1,189.39                |
| Estonia       | 1              | 0.17%              | 142.66                  |
| Total         | 595            | 100.00%            | 757,154.98              |

*Remark:* This table reports the total issuance amount and number of SLLs categorized by borrowers' country of incorporation. The percentage of SLLs for each country is calculated as the ratio of the number of SLLs per country to the total number of SLLs in our sample. The sample consists of 595 loans issued between 2017 and 2022.

Table II.3: Sustainability-linked loans by sector.

| Sector                 | Number of SLLs | Percentage of SLLs | SLL Volume (in Mio. \$) |
|------------------------|----------------|--------------------|-------------------------|
| Industrials            | 106            | 17.82%             | 124,093.55              |
| Utilities              | 92             | 15.46%             | 127,140.83              |
| Real estate            | 85             | 14.29%             | 103,166.27              |
| Consumer cyclicals     | 84             | 14.12%             | 89,574.33               |
| Basic Materials        | 75             | 12.61%             | 69,331.60               |
| Technology             | 46             | 7.73%              | 94,092.35               |
| Consumer non-cyclicals | 36             | 6.05%              | 35,219.64               |
| Energy                 | 31             | 5.21%              | 45,337.04               |
| Healthcare             | 24             | 4.03%              | 33,065.02               |
| Financials             | 16             | 2.69%              | 29,715.46               |
| Total                  | 595            | 100.00%            | 757,154.98              |

*Remark:* This table reports the number of SLLs and total issuance amount by sector of the borrowers. Sectors are defined using Thomson Reuters Business Classification (TRBC). Percentage of SLLs is the ratio of the number of SLLs in each sector to the total number of SLLs in our sample. The sample consists of 595 loans issued between 2017 and 2022.

the lowest total volume.

Overall, we observe a broad diversification of SLL issuance across sectors. Compared to green loans, SLLs are not concentrated in the energy and utilities sectors (Dursun-de Neef et al., 2023), but are also widespread in the industrials (17.82%), real estate (14.29%), consumer cyclicals (14.12%) and basic materials (12.61%) sectors. In addition, we note regional differences within our sample. For example, the majority (58.82%) of SLLs issued by firms in the real estate sector are loans to US borrowers. US firms also account for a large share of SLLs in the financials (37.50%) and technology (33%) sectors. In contrast, EU borrowers account for the largest share of loans to the utilities (80.43%) and industrials (79.30%) sectors. These regional differences in SLL lending may be due to varying regulatory frameworks and market conditions between the EU and the US.

As shown in Table II.4, approximately 86% of SLLs in our sample are general corporate purpose loans, which is consistent with the notion that these loans can be used for a wide range of corporate purposes, without a pre-specified use of proceeds. Because SLLs can be tailored to different corporate needs and strategies, they represent a flexible and particularly attractive tool for companies looking to enter the sustainable



Table II.4: Sustainability-linked loans by use of proceeds.

| Use of proceeds                  | Number of SLLs | Percentage of SLLs |
|----------------------------------|----------------|--------------------|
| General corporate purpose        | 512            | 86.05%             |
| Refinancing                      | 22             | 3.70%              |
| Working capital                  | 21             | 3.53%              |
| Acquisition finance              | 13             | 2.18%              |
| Capital expenditures             | 13             | 2.18%              |
| Real estate/property acquisition | 5              | 0.84%              |
| Ship financing                   | 5              | 0.84%              |
| Leveraged buyout                 | 1              | 0.17%              |
| Management buyout                | 1              | 0.17%              |
| Project finance                  | 1              | 0.17%              |
| Aircraft financing               | 1              | 0.17%              |
| Total                            | 595            | 100.00%            |

*Remark:* This table reports the breakdown of SLLs by the use of proceeds. The percentage of SLLs for each category is calculated as the ratio of the number of SLLs by use of proceeds to the total number of SLLs in our sample. Use of proceeds are extracted from the Refinitiv database. The sample consists of 595 loans issued between 2017 and 2022.

finance market.

### II.3.2 KPI data

Since Refinitiv DealScan does not include detailed data on KPI characteristics, we manually collect such data from company websites, annual reports, stand-alone ESG reports, integrated reports, general registration documents, company presentations and press releases from both borrowers and lenders. Since there is no standardized reporting system for SLLs, most of this data is selectively disclosed by borrowers and lenders. For US companies, we also look for credit-related information in the 8-K and 10-K filings in the SEC’s Electronic Data Gathering, Analysis, and Retrieval (EDGAR) system. In rarer cases, we obtain data from financial news reports. We then classify each loan in our sample according to the level of information available on its underlying KPIs. Loans with information on their main sustainability objectives and KPIs are classified as “with KPI information”. In total, our sample of SLLs contains 364 loans with KPI information, representing slightly more than 61% of the original SLL sample.

Table II.5 shows that the total number of KPIs per SLL ranges from 1 to 5, although

Table II.5: Number of KPIs per sustainability-linked loan.

| Number of KPIs | Number of SLLs | Percentage of SLLs |
|----------------|----------------|--------------------|
| 1              | 131            | 35.99%             |
| 2              | 121            | 33.24%             |
| 3              | 84             | 23.08%             |
| 4              | 26             | 7.14%              |
| 5              | 2              | 0.55%              |
| $\sum$ 364     |                | $\sum$ 100.00%     |

*Remark:* This table reports the distribution of SLLs by the number of KPIs per loan. The percentage of SLLs is calculated as the ratio of the number of SLLs in each category of KPIs per loan to the total number of SLLs in the sample. The sample consists of 364 SLLs with KPI information issued between 2017 and 2022.

most loans in our sample contain between 1 and 3 KPIs. Specifically, almost 36% of SLLs are tied to only 1 KPI, while around 56% of SLLs in our sample include 2 or 3 KPIs. Only less than 9% of the SLLs in the sample have 4 or more KPIs. From a regional perspective, we identify KPI information for 281 out of 443 SLLs (63.43%) issued to EU borrowers. For the US sample, we are able to collect KPI information for 83 out of 152 SLLs (54.61%). These observations suggest that EU borrowers are more likely to disclose information about the characteristics of their loans than their US counterparts. We also observe sector-specific disclosure characteristics. For example, we find that SLLs issued by firms in the utilities sector account for the largest share (16%) of loans with KPI information, while SLLs issued by firms in the real estate sector represent a large share (18%) of SLLs without KPI information. One possible explanation for this difference is the level of regulatory oversight in the utilities sector, where firms are subject to strict environmental regulation and therefore more likely to disclose sustainability-related information as part of their annual reports and in loan agreements.

Our analysis shows considerable heterogeneity in the thematic focus of the underlying KPIs among the SLLs in our sample, suggesting that borrowers customize and tailor KPIs to meet their specific sustainability objectives. In addition, it is important to note that SLLs may be linked to multiple KPIs, and each KPI may cover different ESG dimensions. To ensure a granular analysis of the KPIs, we have grouped them into

Table II.6: Distribution of KPIs within sustainability pillars.

| Category                                       | Number of KPIs | Percentage of KPIs |
|------------------------------------------------|----------------|--------------------|
| <b>Environmental</b>                           | <b>433</b>     | <b>58.43%</b>      |
| Greenhouse gas emissions                       | 247            | 33.33%             |
| Renewable energy                               | 55             | 7.42%              |
| Energy consumption and efficiency              | 35             | 4.72%              |
| Circular economy                               | 24             | 3.24%              |
| Waste reduction and elimination                | 21             | 2.83%              |
| Water consumption                              | 19             | 2.56%              |
| Use of sustainable resources                   | 18             | 2.43%              |
| Environmentally sustainable investments        | 9              | 1.21%              |
| Biodiversity                                   | 5              | 0.67%              |
| <b>Social</b>                                  | <b>176</b>     | <b>23.75%</b>      |
| Employee diversity and gender equality         | 63             | 8.50%              |
| Employee health and safety                     | 45             | 6.07%              |
| Sustainable products and customer benefits     | 26             | 3.51%              |
| Social responsibility and community engagement | 18             | 2.43%              |
| Diverse and sustainable supply chain           | 13             | 1.75%              |
| Employee training                              | 11             | 1.48%              |
| <b>Governance</b>                              | <b>10</b>      | <b>1.35%</b>       |
| Business ethics                                | 10             | 1.35%              |
| <b>ESG</b>                                     | <b>122</b>     | <b>16.46%</b>      |
| ESG rating                                     | 70             | 9.45%              |
| Other ESG assessment or certification          | 52             | 7.02%              |
|                                                | $\sum 741$     | $\sum 100.00\%$    |

*Remark:* This table shows the distribution of KPIs (in absolute and percentage terms) within the environmental, social, governance pillars. In addition, the table presents the distribution of KPIs linked to ESG ratings or similar certifications. The sample consists of 741 KPIs in 364 SLLs issued between 2017 and 2022.

a total of 18 different categories based on four thematic pillars: environmental, social, governance, and ESG.<sup>3</sup>

Table II.6 provides an overview of the distribution of KPIs within the clusters. With respect to the overarching pillars, we find that more than half of the KPIs in our loan sample (58.43%) belong to the environmental pillar. In contrast, the social pillar accounts for about 24% of all KPIs identified in the SLLs in our sample, and the governance pillar accounts for less than 2% of the KPIs in our sample. Finally, we find that ESG ratings and ESG certifications are also commonly used in SLLs, accounting for

<sup>3</sup>An overview of the pillars, including a summary description of the KPIs included in each category, is provided in Appendix A.

about 17% of the KPIs in our sample. Overall, this distribution of KPIs suggests that borrowers place more emphasis on environmental aspects than on social or governance aspects when determining their KPIs. One possible explanation for this observation could be that investors (including lenders), regulators, and society place a high value on environmental responsibility (see e.g., Ilhan et al., 2023; Krueger et al., 2020). As a result, companies may have stronger external incentives to set environmental KPIs.

Within these pillars, about one-third of all KPIs fall into the category of greenhouse gas emissions, suggesting that a significant proportion of KPIs are aimed at reducing such emissions, which is consistent with the analyses of Carrizosa and Ghosh (2022) and Loumiotis and Serafeim (2022). In addition, a significant proportion of the KPIs fall into the category of ESG ratings. We find that SLLs are linked to up to three ESG ratings from three different rating agencies, although most SLLs have only one ESG rating as a main KPI. However, if we look at the trend in the use of ESG ratings as KPIs, we find a steady decline over the period of our sample. This trend may be due to the lack of transparent methodology underlying ESG ratings (Berg et al., 2022b). In addition, the LMA recommends that borrowers explain why a particular ESG rating best reflects the ESG challenges of their core business when using it as a KPI (Loan Market Association, 2023a). Overall, such developments are likely to encourage the use of individual and company-specific KPIs in the future.

Table II.7 provides an overview of the distribution of KPIs across sectors. The utilities sector has the highest proportion of environmental KPIs (19.17%), followed closely by the industrials and consumer cyclicals sectors, which account for 16.86% and 14.55% of all environmental KPIs, respectively. Overall, the distribution of environmental KPIs suggests that they are widely used across various sectors. Social KPIs are prevalent in SLLs issued to firms in the industrials (21.02%) and technology (17.05%) sectors, while the majority of KPIs covering ratings or similar certifications can be found in the real estate (23.77%) and industrials (18.85%) sectors. In contrast, KPIs covering corporate governance factors are concentrated in only three main sectors, namely financials (40%), utilities (40%) and energy (20%).

Table II.7: Distribution of KPIs within sectors.

| Sector                 | Environment     | Social          | Governance      | ESG             |
|------------------------|-----------------|-----------------|-----------------|-----------------|
| Basic materials        | 12.93%          | 10.23%          | 0.00%           | 16.39%          |
| Consumer cyclicals     | 14.55%          | 15.91%          | 0.00%           | 11.48%          |
| Consumer non-cyclicals | 8.78%           | 6.25%           | 0.00%           | 7.38%           |
| Energy                 | 4.16%           | 3.41%           | 20.00%          | 3.28%           |
| Financials             | 1.39%           | 4.55%           | 40.00%          | 1.64%           |
| Healthcare             | 2.31%           | 6.25%           | 0.00%           | 2.46%           |
| Industrials            | 16.86%          | 21.02%          | 0.00%           | 18.85%          |
| Real Estate            | 10.16%          | 3.41%           | 0.00%           | 23.77%          |
| Technology             | 9.70%           | 17.05%          | 0.00%           | 5.74%           |
| Utilities              | 19.17%          | 11.93%          | 40.00%          | 9.02%           |
|                        | $\sum 100.00\%$ | $\sum 100.00\%$ | $\sum 100.00\%$ | $\sum 100.00\%$ |

*Remark:* This table shows the distribution of environmental, social, governance, and ESG KPIs (absolute and percentage terms) within each sector in our sample. ESG KPIs are tied to ESG ratings or similar certifications. The sample consists of 741 KPIs in 364 SLLs issued between 2017 and 2022.

## II.4 The design of SLLs

### II.4.1 Scoring methodology

In recent years, academics and practitioners have raised concerns about greenwashing practices observed in SLL transactions.<sup>4</sup> Greenwashing is particularly likely when KPIs are not material and central to the borrower’s business activities, when they are not sufficiently ambitious or meaningful, and when the borrower’s performance is inaccurately or inadequately measured, benchmarked, and monitored (Loan Market Association, 2023a). Given their critical role in incentivizing corporate sustainability efforts, we begin our analysis by shedding light on the characteristics and quality of the KPIs in our sample. To this end, we evaluate each SLL individually and measure KPI quality by developing a scoring system based on the SLLP (Loan Market Association, 2023b). The SLLP provide a framework for the key characteristics that SLLs and their associated KPIs should meet in order to credibly and effectively incentivize ESG performance. In line with the SLLP, we develop six scoring dimensions to assess the quality of KPIs. They are summarized in Table II.8.

<sup>4</sup>For example, the oilfield services company Schlumberger signed an SLL in 2021 before it had even established official sustainability KPIs (International Financing Review, 2021).

Table II.8: KPI score dimensions.

| Score dimensions |                     |
|------------------|---------------------|
| 1                | Strategic relevance |
| 2                | Materiality         |
| 3                | Measurability       |
| 4                | Benchmarking        |
| 5                | Pricing mechanism   |
| 6                | External review     |

*Remark:* This table shows the six main dimensions on which our score for measuring the quality of SLL KPIs is based. Strategic relevance refers to the relevance of the KPIs to the borrower’s strategy and sustainability objectives. Materiality assesses whether the KPIs address financially material issues based on the SASB Materiality Map. Measurability assesses whether the KPIs are measurable or quantifiable on a transparent methodological basis. Benchmarking examines whether the KPIs are benchmarked against relevant standards or targets. Pricing mechanism refers to the existence of a bonus and malus system related to interest rate adjustments. External review refers to an external independent verification of performance against the KPIs.

To calculate a score for each SLL based on the dimensions described, each dimension is assigned a value of 0, 0.5, or 1 depending on the degree of fulfillment. Thus, the maximum score per SLL is 6 points if all dimensions score fully. The KPIs are considered at the loan level. An overview of examples of KPIs that have been assigned a value of 1 in a particular dimension can be found in Appendix B.

The first dimension assesses whether the KPIs are relevant to the borrower’s strategy (Loan Market Association, 2023b). To satisfy the first dimension, a KPI must either be an integral part of a clearly defined sustainability strategy, or represent an important sustainability objective set by the company prior to the loan issuance. KPIs are assigned a value of 0 if they are not in line with the borrower’s official sustainability goals. In addition, KPIs are assigned a value of 0 if there is no public information on the borrower’s sustainability goals. Consequently, companies without a sustainability strategy cannot receive a full score in this dimension. This is consistent with the following principle: “A SLL could be made theoretically to any borrower, but will be best suited to those that already have a sustainability strategy in place.” (Loan Market Association (2023a), p.4). However, it is important to note that this does not disadvantage companies with low ESG ratings. These companies may already have a sustainability strategy or be actively developing one to improve their ESG performance. This dimen-

sion therefore assesses the strategic relevance of KPIs included in SLLs, regardless of the company's ESG performance. In contrast, KPIs are assigned a value of 0.5 if they are only partially aligned with the borrower's sustainability strategy. Finally, KPIs are assigned a value of 1 if they are fully aligned with the borrower's publicly disclosed key sustainability objectives.

The second dimension of the score examines whether the KPIs are material and address financially relevant sustainability challenges in the industry in which the company operates. For example, a company may choose to reduce its scope 1 emissions as part of its SLL, even though these emissions are not a material part of its total emissions because it operates in an industry that primarily generates scope 3 emissions. In accordance with the LMA guidance (Loan Market Association, 2023a), we consider whether KPIs cover material issues by applying the materiality standards developed by the Sustainability Accounting Standards Board (SASB). In total, the SASB standards provide industry-specific standards for 77 different industries, enabling a comprehensive assessment of sustainability issues (e.g., diversity and inclusion or water management) for both green and brown industries. For each industry, SASB ranks sustainability issues by level of interest, such as the number of mentions in media reports and 10-Ks (Grewal et al., 2016). In addition, SASB assesses whether the management (or potential mismanagement) of these issues may affect a company's valuation or its operational or financial performance (Sustainability Accounting Standards Board, 2017). From an investor's perspective, these standards represent the relative priority of sustainability issues for each industry, allowing different KPIs to be compared and contrasted across industries. The SASB standards are increasingly used in academic research to assess the materiality of sustainability issues (see, for example, Khan et al. (2016); Grewal et al. (2016)). KPIs are assigned a value of 0 if they do not address material sustainability issues as defined by SASB. If the KPIs only partially address material topics, they receive a score of 0.5. KPIs that are tied to ESG ratings represent a special case. If KPIs in the form of ESG ratings appear individually within an SLL, rather than in combination with other individual and company-specific KPIs, they can only receive a score of 0, as it is not possible to assess the consistency of an ESG rating with this

dimension.

The third dimension examines whether the KPIs are measurable or quantifiable. To satisfy this dimension, the KPIs must be specific (e.g., expressed with a clear numerical value) and target sustainability aspects that can be objectively quantified (Loan Market Association, 2023a). In particular, the SLLP recommends specifying the applicable scope of KPIs as well as their calculation method (Loan Market Association, 2023a). An example of a KPI that would not receive a full score on this dimension is a social impact KPI defined as “the number of people positively impacted by the company” and measured “in good faith”.

While the third dimension assesses the ability to objectively quantify and measure a borrower’s performance, the fourth dimension involves verifying that a KPI is benchmarked against an external reference, which is an important feature to facilitate an assessment of the overall level of ambition. The SLLP recommend a range of benchmarking approaches, including the use of industry initiatives and standards, science-based scenarios, and country targets (Loan Market Association, 2023b). Therefore, KPIs that are explicitly linked to a benchmark, such as the Science Based Targets initiative, receive a value of 1. In addition, it is important to note that all KPIs in our sample that meet this fourth dimension also fulfill the third dimension and are therefore measurable. However, measurability alone is no guarantee that a KPI is benchmarked.

The pricing mechanism in terms of interest rate adjustments is assessed in the fifth dimension. A key feature of SLLs is that the margin can be reduced if the borrower meets its sustainability targets as measured by pre-defined KPIs. SLLs can also be designed to require the borrower to pay higher interest rates if it fails to meet its sustainability targets. To address this fifth dimension, SLL margin adjustments should explicitly include not only a bonus (i.e., margin reduction) but also a malus (i.e., margin premium). With a malus system, borrowers demonstrate an even stronger commitment to their sustainability objectives by facing the possibility of paying higher interest rates. In general, penalties have been shown to be more effective incentives than rewards (Andreoni et al., 2003). Since KPIs linked only to a bonus system create weaker incentives, they are given a score of 0.5, while a neutral bracket in which no margin adjustment



applies does not create a credible incentive and is given a score of 0. In addition, KPIs receive a score of 0 if no bonus or malus system is clearly mentioned. As the SLLP point out, transparency is “of particular value in this market” (Loan Market Association (2023b), p.4), and borrowers are therefore encouraged to publicly report information on such loan characteristics.

Although we consider the design of the pricing mechanism, we do not assess the actual level of interest rate adjustments in basis points (bps) as this information is often confidential and data for most SLLs in our sample is lacking.<sup>5</sup> We assume that the larger the adjustment in basis points, the greater the incentive for borrowers to meet their sustainability targets. A few cases in our sample suggest that such adjustments are often limited to 5 basis points. In rare cases, they can reach up to 10 basis points. This is consistent with Du et al. (2023), who conclude that the size of margin discounts is not economically large enough to make loan spreads of SLLs significantly lower than those of non-SLLs. Overall, the potential benefit to borrowers so far appears to be economically small (Du et al., 2023).

The final dimension assesses whether the KPIs are subject to independent third-party verification. According to the SLLP, borrowers should have an independent and external review of their performance against each sustainability objective at least once a year. To be credible, this review should be conducted by a qualified external verifier, such as an auditor, by way of limited or reasonable assurance, or a rating agency (Loan Market Association, 2023b). For example, if the KPIs are linked to ESG ratings, they receive a score of 1 as external rating agencies monitor and review these ratings at least annually. However, if there is only a one-time certification of progress, or if only one of several underlying KPIs is subject to an explicit external review, such as a reasonable assurance review, the dimension is only partially met.

Table II.9 shows the pairwise correlations between all six dimensions of our KPI score. The highest correlation is between strategic relevance and materiality (0.53), indicating a moderate relationship. However, all other correlations are weak, under-

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<sup>5</sup>This is particularly the case for EU SLLs. In contrast, 8-K forms tend to include information on the actual amount of interest rate adjustments.

Table II.9: Correlations between KPI score dimensions.

| Score dimension         | Score dimension               |                    |                           |                          |                             |                           |
|-------------------------|-------------------------------|--------------------|---------------------------|--------------------------|-----------------------------|---------------------------|
|                         | (1)<br>Strategic<br>relevance | (2)<br>Materiality | (3)<br>Measur-<br>ability | (4)<br>Bench-<br>marking | (5)<br>Pricing<br>mechanism | (6)<br>External<br>review |
| (1) Strategic relevance | 1.000                         |                    |                           |                          |                             |                           |
| (2) Materiality         | 0.530                         | 1.000              |                           |                          |                             |                           |
| (3) Measurability       | 0.040                         | −0.002             | 1.000                     |                          |                             |                           |
| (4) Benchmarking        | −0.187                        | −0.177             | 0.088                     | 1.000                    |                             |                           |
| (5) Pricing mechanism   | −0.063                        | 0.032              | −0.007                    | 0.021                    | 1.000                       |                           |
| (6) External review     | −0.359                        | −0.104             | 0.072                     | 0.231                    | 0.143                       | 1.000                     |

*Remark:* This table presents the pairwise correlation coefficients between the dimensions of our KPI score. The sample consists of 364 SLLs issued between 2017 and 2022.

scoring the importance of including all six dimensions in our KPI analysis. In particular, we find that strategic relevance has a modest positive correlation with measurability (0.040), while it is negatively correlated with benchmarking, pricing mechanism, and external review. Although one might expect measurability to be positively correlated with both benchmarking and external audit, the corresponding pairwise correlations between measurability and external audit (0.072) and between measurability and benchmarking (0.088) are rather weak. In addition, we find that the pricing mechanism is only weakly correlated with the other five dimensions. Overall, the correlation matrix suggests that each of these dimensions captures unique and different information and together contribute to a comprehensive understanding of the KPIs.

## II.4.2 Score results and distribution

Figure II.1 shows the distribution of KPI scores for each score dimension. Overall, the results show significant differences between the various dimensions. Panel A presents the results for the assessment of the strategic relevance of the KPIs. We find that 218 out of 364 SLLs (60% of our sample with KPI information) are structured around KPIs that are explicitly part of an existing strategy. The majority of borrowers refer to the objectives associated with the KPIs in their reference documents such as annual or sustainability reports. On the other hand, 22% of the SLLs in the sample have

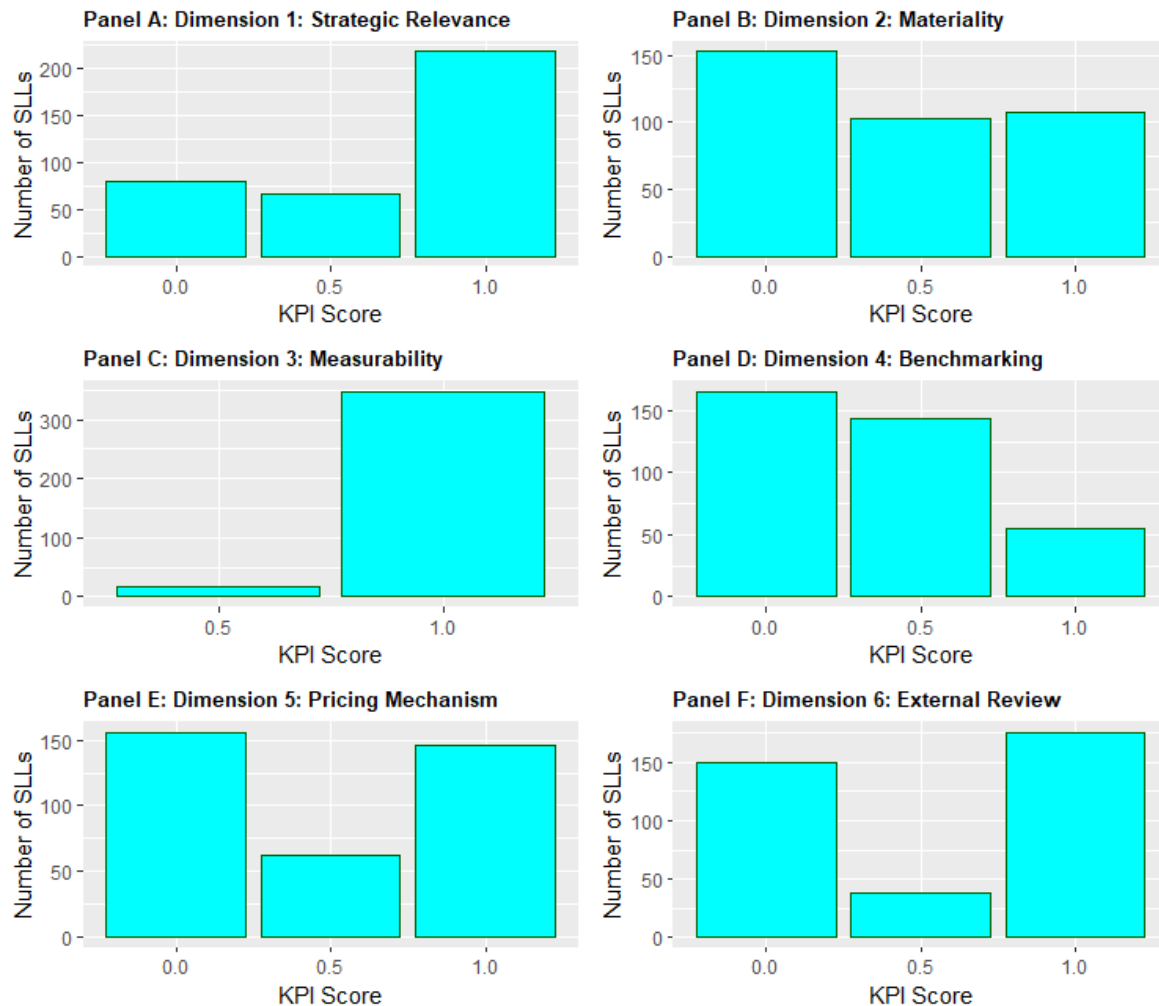
KPIs that do not align with the borrowers' stated sustainability goals or priorities. In addition, a few companies do not explicitly reference a sustainability strategy in their reporting. In general, the results suggest that borrowers are using SLLs as a means to further embed existing sustainability goals in their organizations.

Panel B shows the results of the materiality assessment using the SASB standards. We find that 153 SLLs, or 42% of our sample, are tied to sustainability goals that are not financially material, while 30% of SLLs fully meet this criterion and 28% are only partially tied to material KPIs. This finding is consistent with Loumioti and Serafeim (2022), who report that only about half of the SLLs in their sample include material KPIs. Given that the goal of the SASB Materiality Map is to highlight the sustainability issues that are most likely to impact the company's financial performance, this suggests that a large portion of the KPIs in ESG-linked loan agreements do not target improvements in the sustainability areas that are most important to investors.

Turning to the third dimension of our score, our results in Panel C show that 95% of SLLs are tied to measurable and quantifiable metrics. Perhaps not surprisingly, this suggests that most of the SLLs in our sample are based on goals that include a specific and objectively quantifiable metric that allows lenders to track performance against the pre-defined goals. On the other hand, only 17 SLLs (5%) in our sample are tied to KPIs whose measurability is subject to interpretation, such as the number of people positively impacted by the business and measured "in good faith". Since lenders must approve the selected KPIs, setting targets that are not measurable would not only make it difficult to evaluate performance, but could also damage the lenders' reputation. Measurable KPIs are therefore critical to ensuring the integrity of SLLs and mitigating reputational risks for lenders.

In contrast, the results in Panel D show that only 55 SLLs, or 15% of the sample, contain a clear reference to a benchmark, while 144 loans (40%) are partially benchmarked and 165 (45%) contain no form of benchmark. The lack of benchmarks for the selected KPIs makes it difficult to compare and contrast their level of ambition. Even ESG ratings, which can be considered a form of benchmark as they are based on a standardized scale, tend to differ from each other, limiting their comparability (Berg

Figure II.1: Assessment of KPI score per dimension.



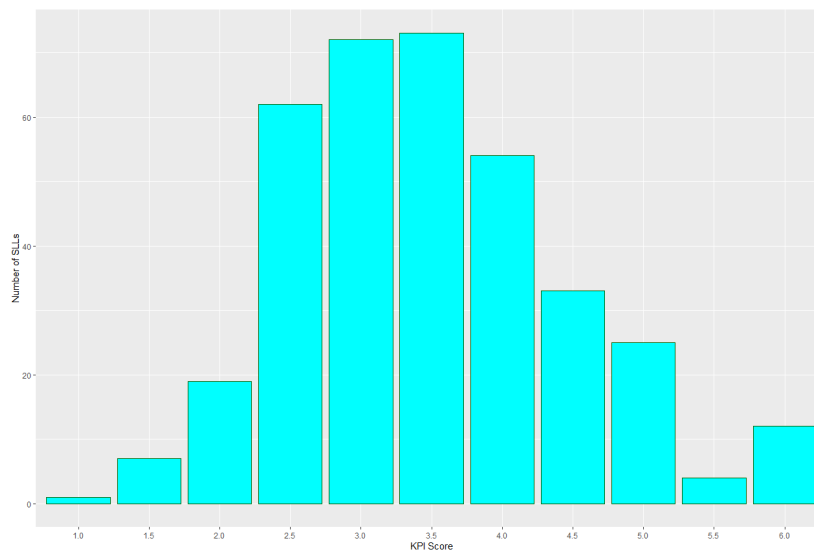
*Remark:* This figure shows the frequency of loans with specific KPI scores on each scoring dimension. Dimension 1 (strategic relevance) refers to the relevance of the KPIs to the borrower's strategy and sustainability objectives. Dimension 2 (materiality) assesses whether the KPIs address financially material issues based on the SASB Materiality Map. Dimension 3 (measurability) assesses whether the KPIs are measurable or quantifiable on a transparent methodological basis. Dimension 4 (benchmarking) examines whether the KPIs are benchmarked against relevant standards or targets. Dimension 5 (pricing mechanism) refers to the existence of a bonus and malus system related to interest rate adjustments. Dimension 6 (external review) refers to an external independent verification of performance against the KPIs. The sample includes a total of 364 SLLs with KPI information. Each loan is given a score of either 0, 0.5 or 1 in each of the six dimensions.

et al., 2022b). However, this may also be due to a lack of appropriate benchmarks, especially since many of the industry standards, science-based targets, or other proxies proposed by the LMA (Loan Market Association, 2023a) primarily address the environmental dimension and do not necessarily serve as appropriate benchmarks for social and governance KPIs.

Panel E shows the results for the fifth dimension, which relates to the pricing mechanism. We find that about 40% of SLLs include a malus mechanism that requires borrowers to pay higher interest rates if they do not meet their sustainability targets. In comparison, 17% of SLLs include only a bonus mechanism, suggesting that borrowers can benefit from a lower interest rate if they meet their targets, but do not have to pay a financial penalty if they do not. This finding is consistent with Carrizosa and Ghosh (2022), who report for their sample that most ESG-linked loan contracts include interest rate reductions in response to positive sustainability performance, but only half of the contracts include interest rate increases when performance is negative. In our case, 156 out of 364 SLLs, or 43% of the sample, indicate that the loan margin is linked to sustainability KPIs, but do not provide further details. While the exact amount of the adjustment in basis points can be considered confidential, it is noteworthy that SLLs tend to exhibit limited disclosure of bonus and/or malus provisions.

Finally, we find mixed results with respect to the annual external review of the selected KPIs, as shown in Panel F. We report that almost half (48%) of the SLLs in our sample are tied to KPIs that are subject to explicit external review at least once a year, which is consistent with previous literature on SLLs (Carrizosa and Ghosh, 2022). In these cases, the independent third party is explicitly mentioned in the documentation and/or the KPIs are part of annual reporting subject to limited or reasonable assurance. In addition, KPIs linked to ESG ratings are, by their nature, also subject to annual review. However, we also note that 150 SLLs (41%) do not satisfy this fifth dimension. In particular, many borrowers do not specifically mention a mandated third party and/or do not report on their performance against the KPIs in the years following issuance by including performance review information in the form of limited or reasonable assurance audits. This suggests that the disclosures of SLL borrowers are

Figure II.2: Number of SLLs by KPI score.



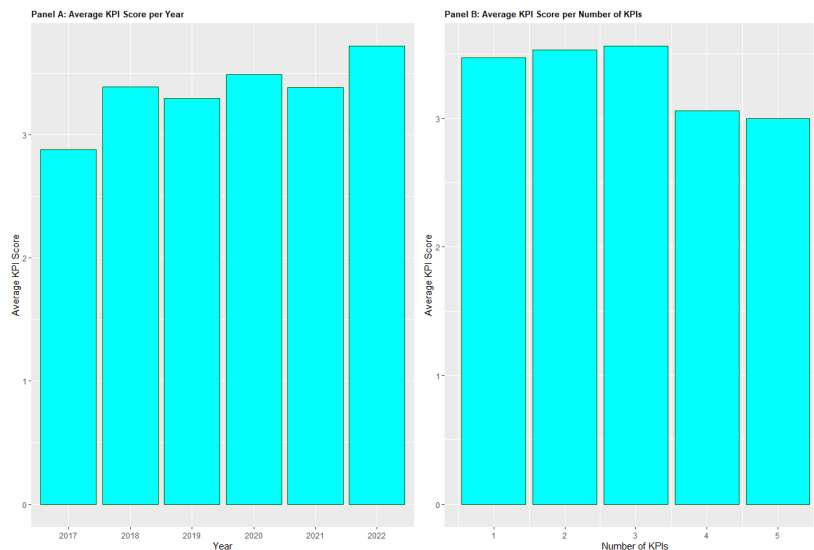
*Remark:* This figure shows the distribution of the total KPI score. The total KPI score for each loan is the sum of the individual scores for the six dimensions. The sample consists of 364 SLLs issued between 2017 and 2022.

often insufficient to meaningfully review and assess performance against targets.

In a next step, we examine the distribution of the KPI score across our sample. Figure II.2 shows the overall KPI score distribution. This distribution follows a Gaussian-like bell curve, which validates our methodology as we expect data points near the mean to have a higher frequency than those farther from the mean. The average KPI score in our sample is 3.47 and the median is 3.50, and while there is no loan that achieved the lowest possible score of 0, only 11 loans achieve a maximum score of 6 points. The majority of loans in our sample have a score of 3.5 or less, suggesting that these loans are only partially designed to incentivize sustainability efforts by their borrowers.

Panel A in Figure II.3 shows the evolution of the average KPI score over time. The score improves over time, starting with an average of 2.88 in 2017 and increasing to 3.71 in 2022, suggesting that SLLs are becoming more stringent in terms of their ESG incentives. However, it is also important to note that the number of SLLs has increased over time, so the higher overall average at the end of our sample period could also be due to a larger sample size. We also find in Panel B that a higher number of KPIs per SLL does not necessarily lead to a higher KPI score. While focusing on a limited

Figure II.3: Average KPI score per year and number of KPIs.



*Remark:* Panel A shows the average total KPI score per year. Panel B presents the average total KPI score per number of KPIs included in an SLL. The sample consists of 364 SLLs issued between 2017 and 2022.

number of sustainability targets may prevent SLL borrowers from meeting the needs and interests of all their stakeholders, simply multiplying KPIs also seems to make such instruments less effective in strengthening sustainability incentives. This “multitasking problem” (Bebchuk and Tallarita, 2022), which has also been documented in the earlier literature on ESG-based compensation, further corroborates the challenges companies face in identifying and defining value-relevant and measurable metrics.

## II.5 Empirical results

### II.5.1 Firm-level data and matching procedure

Our prior KPI analysis provides insights into the design of SLLs and casts doubt on their effectiveness in incentivizing corporate sustainability efforts. In this section, we explore this question further by empirically examining how firms’ ESG performance, measured by their different ESG scores, evolves following the issuance of SLLs. Following the methodology in Kim et al. (2023), we contrast changes in the ESG ratings of SLL borrowers and a set of control firms that also borrowed over the same period but not

through SLLs.

As there could be structural differences between SLL borrowers and other firms, we apply the 1:1 nearest-neighbor matching method following Rubin (1973) to find comparable firms to SLL borrowers as control firms and run the regressions on this matched sample. To examine the development of firms' ESG performance following the issuance of SLLs, we match the SLL borrowers in our sample with conventional borrowers based on one-year lagged values for profitability, leverage, size, book-to-market ratio, ESG score as well as industry and region. To ensure a comprehensive dataset for conventional borrowers, we retrieve data from Refinitiv DealScan's database. SLL borrowers and conventional borrowers are matched in the years of loan origination. For example, firms that concluded an SLL in 2019 are matched with firms that obtained a conventional loan in 2019. In the context of this study, we define a conventional borrower as a firm that acquired a loan in a specific year but did not issue any SLL throughout the sample period. We perform the matching without replacement so that each control firm is unique, and drop unmatched firms from our sample to avoid any bias from inadequate comparison.

As shown in Table II.10, treated and control firms display differences before matching. We observe that SLLs are generally issued by firms that exhibit above-average ESG performance and have significantly higher ex-ante ESG scores than borrowers of conventional loans. In addition, SLL borrowers are typically characterized by larger company sizes, higher book-to-market ratios, and lower levels of leverage and profitability. Our matching procedure results in 187 unique SLL borrowers and 225 unique matched peers and significantly reduces the observed differences between treated and control firms.<sup>6</sup>

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<sup>6</sup>The mean values correspond to the time of matching. Although they represent a large fraction of SLL borrowers, firms that issued a SLL in 2022 were not matched, as their ex-post ESG performance, e.g., in year 2023, cannot yet be assessed.



Table II.10: Differences between treatment and control firms.

| Pre-matching                      |                       |                         |            |                | Post-matching         |                         |            |                |
|-----------------------------------|-----------------------|-------------------------|------------|----------------|-----------------------|-------------------------|------------|----------------|
| <i>Panel A: Sample sizes</i>      |                       |                         |            |                |                       |                         |            |                |
| <i>N</i> firms                    | 274                   | 1,683                   |            |                | 187                   | 225                     |            |                |
| <i>Panel B: Control Variables</i> |                       |                         |            |                |                       |                         |            |                |
|                                   | Mean SLL<br>borrowers | Mean conv.<br>borrowers | Difference | <i>t</i> -stat | Mean SLL<br>borrowers | Mean conv.<br>borrowers | Difference | <i>t</i> -stat |
| Leverage                          | 0.334                 | 0.535                   | -0.201     | -0.999         | 0.326                 | 0.314                   | 0.012      | 0.848          |
| Book to market                    | 0.760                 | 0.594                   | 0.166      | 1.840          | 0.601                 | 0.585                   | 0.016      | 0.457          |
| Size                              | 22.871                | 22.107                  | 0.764***   | 7.960          | 23.300                | 23.400                  | -0.100     | -0.757         |
| Profitability                     | 3.825                 | 5.745                   | -1.920***  | -5.470         | 3.930                 | 4.000                   | -0.070     | -0.172         |
| ESG Score                         | 6.500                 | 4.901                   | 1.599***   | 11.300         | 6.670                 | 6.110                   | 0.560***   | 2.840          |

*Remark:* This table reports the differences in firm characteristics between SLL borrowers (treated) and conventional borrowers (control) before and after matching. We match SLL borrowers with conventional borrowers based on lagged (1 year) values for profitability, leverage, size, book-to-market ratio, ESG rating as well as industry and region. Control firms are matched to borrower firms using 1:1 nearest-neighbor matching method following Rubin (1973). We match each borrower on the year prior to the issuance of SLL without replacement and drop non-matched firms from our sample.

Table II.11 presents the key ESG and financial data for the matched sample of treated and control firms. Panel A reports the descriptive statistics of the overall ESG score, its three main pillars, and the climate score. We obtain the ESG scores from the MSCI database to capture borrowers' ESG performance before and after loan origination. To be included in the sample, we require at least one year of MSCI ESG score in each of the pre- and post-issuance periods.

In our analyses, we use different types of ESG data, including industry-adjusted scores, environmental and social pillar scores, and climate change scores. These scores capture sustainability aspects that also play a key role in the selection of KPIs in ESG-linked loan agreements. In particular, the industry-adjusted scores allow us to consider the importance of environmental, social, and governance performance indicators for different industries and borrowers. Environmental and social pillar scores are calculated based on the weighted average of key aspects such as carbon emissions, biodiversity and land use, raw material sourcing, health, and safety of employees within each pillar. The climate change score falls under the environmental category and assesses a company's exposure to climate change and its efforts to manage that exposure.

MSCI rates firms' ESG performance on a scale of 0 to 10, with 10 representing the highest performance. Such ratings are updated at least annually. Ongoing or structural controversies lead to score deductions. For the purpose of our analyses, MSCI ratings offer several advantages over other data providers. First, MSCI is the largest provider of ESG ratings globally, resulting in broader coverage of companies relative to other providers, as reported in previous studies (Eccles and Strohle, 2018; Pástor et al., 2022). In addition, MSCI ESG ratings are of significant importance in the context of US ESG fund holdings, as shown in recent research (Berg et al., 2022a). Given their influential role in the market, investors are therefore more likely to react to fluctuations in these specific ratings. Finally, while ESG ratings from other providers such as Asset4 appear to have been subject to backward revisions (Berg et al., 2020), there is currently no evidence that this is also the case for MSCI ESG ratings.

As shown in Table II.11, the average SLL borrower in our matched sample has an overall ESG score of 6.48. We also present summary statistics for the ESG data of the

EU and US subsamples. The average SLL borrower in the EU has a higher overall ESG score of 6.89, indicating particularly strong environmental and corporate governance performance. In contrast, the average SLL borrower in the US scores a comparatively lower overall ESG score of 5.43, indicating weaker performance on environmental, social and governance aspects compared to their European counterparts.

Table II.11: Summary statistics (matched sample).

|                                | SLL borrowers (treated) |        |           |        |        | Conventional borrowers (control) |        |           |        |        |
|--------------------------------|-------------------------|--------|-----------|--------|--------|----------------------------------|--------|-----------|--------|--------|
|                                | <i>N</i>                | Mean   | Std. dev. | Min.   | Max.   | <i>N</i>                         | Mean   | Std. dev. | Min.   | Max.   |
| <b>Panel A: ESG Data</b>       |                         |        |           |        |        |                                  |        |           |        |        |
| ESG score                      | 1,217                   | 6.476  | 2.137     | 0.000  | 10.000 | 1,427                            | 6.093  | 2.057     | 0.000  | 10.000 |
| E score                        | 1,246                   | 6.021  | 2.061     | 0.000  | 10.000 | 1,459                            | 5.917  | 2.102     | 0.100  | 10.000 |
| S score                        | 1,246                   | 4.959  | 1.800     | 0.000  | 10.000 | 1,459                            | 4.847  | 1.730     | 0.000  | 10.000 |
| G score                        | 1,246                   | 5.951  | 1.377     | 0.300  | 9.400  | 1,459                            | 5.637  | 1.298     | 0.800  | 9.500  |
| Climate score                  | 1,063                   | 7.512  | 2.658     | 0.000  | 10.000 | 1,244                            | 7.485  | 2.357     | 0.000  | 10.000 |
| <i>EU Sample</i>               |                         |        |           |        |        |                                  |        |           |        |        |
| ESG score                      | 870                     | 6.894  | 1.966     | 0.000  | 10.000 | 795                              | 6.541  | 1.931     | 0.000  | 10.000 |
| E score                        | 892                     | 6.101  | 2.127     | 0.000  | 10.000 | 818                              | 5.869  | 2.146     | 0.700  | 10.000 |
| S score                        | 892                     | 5.125  | 1.680     | 0.000  | 10.000 | 818                              | 5.114  | 1.705     | 0.000  | 10.000 |
| G score                        | 892                     | 6.135  | 1.411     | 0.300  | 9.400  | 818                              | 5.935  | 1.335     | 0.800  | 9.500  |
| Climate score                  | 762                     | 7.504  | 2.792     | 0.000  | 10.000 | 698                              | 7.538  | 2.255     | 0.000  | 10.000 |
| <i>US Sample</i>               |                         |        |           |        |        |                                  |        |           |        |        |
| ESG score                      | 347                     | 5.429  | 2.191     | 0.300  | 10.000 | 632                              | 5.530  | 2.057     | 0.000  | 10.000 |
| E score                        | 354                     | 5.820  | 1.873     | 1.600  | 10.000 | 641                              | 5.978  | 2.045     | 0.100  | 10.000 |
| S score                        | 354                     | 4.542  | 2.015     | 0.000  | 10.000 | 641                              | 4.505  | 1.703     | 0.000  | 9.800  |
| G score                        | 354                     | 5.488  | 1.170     | 1.200  | 8.000  | 641                              | 5.256  | 1.142     | 1.900  | 8.400  |
| Climate score                  | 301                     | 7.534  | 2.286     | 0.000  | 10.000 | 546                              | 7.417  | 2.481     | 0.000  | 10.000 |
| <b>Panel B: Financial Data</b> |                         |        |           |        |        |                                  |        |           |        |        |
| Size                           | 1,296                   | 23.243 | 1.453     | 18.971 | 27.570 | 1,547                            | 23.389 | 1.659     | 18.606 | 27.696 |
| Leverage                       | 1,294                   | 0.302  | 0.143     | 0.000  | 0.706  | 1,545                            | 0.305  | 0.167     | 0.000  | 0.805  |
| Profitability                  | 1,216                   | 0.051  | 0.051     | -0.160 | 0.374  | 1,416                            | 0.047  | 0.056     | -0.358 | 0.458  |
| Book to market                 | 1,280                   | 0.630  | 0.518     | 0.006  | 6.330  | 1,526                            | 0.622  | 0.561     | 0.004  | 8.265  |

*Remark:* This table reports the summary statistics for ESG and financial data employed in our sample of SLL borrowers (treated) and conventional borrowers (control). Panel A reports the ESG data for treated and control firms. The ESG data is provided for the whole sample as well as for the EU and US samples separately. The *ESG score*, the *climate score* as well as the *environmental-, social- and governance-score* are taken from MSCI. Panel B reports the firm-level financial data for the treated and control firms. *Firm size* is defined as the natural logarithm of the firm's total assets, *leverage* is measured as the firm's total liabilities divided by total assets, *profitability* is the firm's net income prior to financing costs divided by total assets and *book-to-market ratio* is a company's book value per share divided by its stock price. Our total sample contains a total of 2,884 firm-year observations. The firm-level controls are winsorized at 1% and 99%.

As other factors may influence the development of ESG performance subsequent to the issuance of ESG-linked loans, we control for several measures of financial performance by including firm-specific variables obtained from Refinitiv. Specifically, we account for *firm size*, defined as the natural logarithm of the firm’s total assets, and *leverage*, measured as the firm’s total liabilities divided by total assets. We also account for *profitability*, calculated by dividing the firm’s net income prior to financing costs by total assets. Finally, we incorporate the *book-to-market ratio*, calculated by dividing a company’s book value per share by its stock price. To eliminate outliers, we winsorize firm-level control variables at the 1<sup>st</sup> and 99<sup>th</sup> percentiles. As shown in Table II.11, the average SLL borrower in our sample has a size of \$23.24 billion in total assets (log-transformed values are shown), a mean profitability (ROA) of around 5%, a mean leverage ratio of 0.30 and a book-to-market ratio of 0.63. Our total sample contains a total of 2,884 firm-year observations.

## II.5.2 SLL issuance and ex-post ESG performance

To determine the relationship between SLL issuance and ex-post ESG performance, we use a two-way fixed effects (TWFE) model to estimate our difference-in-differences design. Using this approach, we examine treated firms that issued SLLs and compare them to a control group of firms that took conventional loans both before and after the treated firms issued an SLL for the first time. Specifically, we estimate the following model:

$$\begin{aligned} \text{ESG Score}_{i,t} = & \beta_1 \text{Post Loan Issuance}_t + \beta_2 \text{SLL Borrower}_i \\ & + \beta_3 \text{SLL Borrower}_i \times \text{Post Loan Issuance}_t + \chi_t + \iota_{in} + \rho_c + \epsilon_{it} \quad (\text{II.1}) \end{aligned}$$

where  $\text{ESG Score}_{i,t}$  is the ESG score of borrower  $i$  in time period  $t$ .  $\text{SLL Borrower}_i$  is an indicator variable that equals 1 if borrower  $i$  received an SLL at least once in the sample period, and 0 otherwise.  $\text{Post Loan Issuance}_t$  is an indicator variable equal to 1 for years after the year of first loan issuance, and 0 otherwise. The model accounts for year ( $\chi_t$ ), industry ( $\iota_{in}$ ) and country ( $\rho_c$ ) fixed effects. To ensure that our results are

not sensitive to different permutations of fixed effects, we also include firm, industry-by-year and country-by-year fixed effects in several specifications.  $\epsilon_{it}$  is the error term. All standard errors are clustered at the firm level. We also estimate our model at the firm-year level in further specifications.

Table II.12 presents the results for the matched sample of treated and control firms for equation (1). Specifications (1) - (3) rely on the whole sample, specifications (4) - (6) are based on all SLLs with at least one environmental KPI, specifications (7) - (9) consist of all issued SLLs with at least one social KPI, specifications (10) - (12) rely on all SLLs with at least one CO2-related KPI and specifications (13) - (15) comprise all SLLs with a high KPI score of at least 3.5.

Table II.12: ESG performance following the issuance of sustainability-linked loans (matched sample).

| Dependent variable        | ESG score |          |          | E-score |         |         | S-score |         |         | Climate score |         |         | ESG score |         |         |
|---------------------------|-----------|----------|----------|---------|---------|---------|---------|---------|---------|---------------|---------|---------|-----------|---------|---------|
|                           | (1)       | (2)      | (3)      | (4)     | (5)     | (6)     | (7)     | (8)     | (9)     | (10)          | (11)    | (12)    | (13)      | (14)    | (15)    |
| SLL borrower $\times$     | 0.289*    | 0.166    | 0.078    | -0.055  | 0.021   | 0.004   | -0.062  | -0.032  | 0.062   | 0.329         | -0.204  | -0.050  | 0.178     | -0.039  | -0.063  |
| Post-loan issuance        | (0.132)   | (0.121)  | (0.119)  | (0.208) | (0.128) | (0.114) | (0.304) | (0.242) | (0.224) | (0.328)       | (0.300) | (0.232) | (0.098)   | (0.166) | (0.151) |
| Post-loan issuance        | 0.164     | -0.200** | -0.188** | 0.382   | 0.065   | 0.025   | -0.016  | -0.199  | -0.192  | 0.056         | 0.006   | -0.092  | 0.247     | -0.120  | -0.140  |
|                           | (0.131)   | (0.099)  | (0.090)  | (0.211) | (0.123) | (0.094) | (0.296) | (0.179) | (0.157) | (0.352)       | (0.239) | (0.189) | (0.179)   | (0.135) | (0.122) |
| Firm FE                   | No        | Yes      | Yes      | No      | Yes     | Yes     | No      | Yes     | Yes     | No            | Yes     | Yes     | No        | Yes     | Yes     |
| Year FE                   | Yes       | No       | Yes      | Yes     | No      | Yes     | Yes     | No      | Yes     | Yes           | No      | Yes     | Yes       | No      | Yes     |
| Industry FE               | Yes       | No       | No       | Yes     | No      | No      | Yes     | No      | No      | Yes           | No      | No      | Yes       | No      | No      |
| Country FE                | Yes       | No       | No       | Yes     | No      | No      | Yes     | No      | No      | Yes           | No      | No      | Yes       | No      | No      |
| Industry $\times$ Year FE | No        | Yes      | No       | No      | Yes     | No      | No      | Yes     | No      | No            | Yes     | No      | No        | Yes     | No      |
| Country $\times$ Year FE  | No        | Yes      | No       | No      | Yes     | No      | No      | Yes     | No      | No            | Yes     | No      | No        | Yes     | No      |
| Observations              | 2,637     | 2,637    | 2,637    | 1,504   | 1,504   | 1,504   | 752     | 752     | 752     | 987           | 987     | 987     | 1,172     | 1,172   | 1,172   |
| Adjusted R-squared        | 0.217     | 0.829    | 0.823    | 0.128   | 0.874   | 0.882   | 0.237   | 0.750   | 0.757   | 0.278         | 0.780   | 0.769   | 0.196     | 0.805   | 0.802   |

*Remark:* This table presents firm ESG performance after the issuance of SLLs using quasi difference-in-differences panel regressions on the matched sample. We match borrowers to their control firms in the year prior the issuance. SLL Borrower is a firm-invariant indicator variable equal to one if the borrower obtains a sustainability-linked loan during the full sample period and zero otherwise, Post Loan Issuance an indicator variable equal to one for the years after the loan issuance and zero otherwise and SLL Borrower  $\times$  Post Loan Issuance denotes their interaction. The dependent variable is either the overall ESG score, the environmental score, the social score or the climate score of the borrower in a given year. The final sample consists of 2,637 firm-year observations. We also run the regression on different subsamples. Specifications (1) - (3) are based on the full sample of SLLs, specifications (4) - (6) on all SLLs with at least one environmental KPI, specifications (7) - (9) on all SLLs with at least one social KPI, specifications (10) - (12) on all SLLs with at least one CO2-related KPI and specifications (13) - (15) on all SLLs with a high KPI score as described in section II.4. The model accounts for firm, year, country, industry, industry-by-year and country-by-year fixed effects. Robust standard errors in parentheses are clustered at the firm-year level in columns (1), (4), (7), (10) and (13) and at the firm level otherwise. \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level, respectively.



Specifications (1) to (3) show positive coefficients, but statistical significance is only observed in specification (1) at the 10% level. For specifications (4) to (6) focusing on SLLs with environmental KPI, and specifications (7) to (9) considering SLLs with social KPIs, there is no clear evidence of a significant impact on the environmental and social scores of the SLL borrowers, respectively. Likewise, specifications (10) to (12) examining SLLs with CO2-related KPIs do not indicate a positive effect on the climate scores of the borrowers. Finally, specifications (13) to (15) analyze SLLs with a high KPI score, zeroing-in on the “high-transparency” group in Kim et al. (2023). Again, the results do not indicate any significant positive effect on the borrowers’ overall ESG scores, confirming the results of Kim et al. (2023).

Overall, the coefficients for  $\text{SLL borrower}_i \times \text{Post Loan Issuance}_t$  indicate that there is no consistent and strong evidence to support the idea that the issuance of SLLs leads to higher ESG performance for the borrowing firms. The coefficients are generally small and often statistically insignificant, suggesting that the relationship between SLLs and ESG performance is weak or inconclusive.

These findings are in line with those of Du et al. (2023), who also report that SLL borrowers do not improve their ESG performance in the years after SLL origination. In addition, they confirm the findings of Kim et al. (2023), who document that the issuance of SLLs with verifiable information on KPIs is not associated with significant improvements or declines in borrowers’ ESG scores. In contrast, Kim et al. (2023) also find a post-loan deterioration in ESG performance for borrowers with low-transparency SLLs. It is important to note, however, that differences in matching procedures and the choice of borrowers’ sustainability scores can significantly affect the results of the analyses, as documented by Du et al. (2023) and previous studies on ESG ratings (Berg et al., 2022b). Due to considerations highlighted in Section II.5.1, including backward revisions in Asset4 ESG scores (Berg et al., 2020), we choose to rely on MSCI in our analyses.

A recent literature shows that estimating equation (1) as a conventional event study, that is, by ordinary least squares (OLS) with two-way fixed effects and some lags, produces estimates that are not reliable (see e.g., de Chaisemartin and D’Haultfœuille,

2020; Baker et al., 2022). This is because the TWFE estimator compares firms that received an SLL later in the sample period with firms treated earlier, thus creating a “bad comparison” problem (Baker et al., 2022). One way to address concerns about the reliability of the TWFE estimator is to measure the weighted group-time average treatment effect on the treated (ATT), as proposed by Callaway and Sant’Anna (2021). This procedure is more robust to heterogeneity in the treatment effect resulting from differences in the timing of SLL issuance (Callaway and Sant’Anna, 2021).

Table II.13 presents the group-time ATTs along with 95% confidence bands. In Column (1), we report the ATT for all samples. First, we use the entire sample of borrowers and test whether issuing an SLL is associated with an increase in the ESG score. We then repeat the analysis with different subsamples of borrowers and analyze whether the sustainability dimensions captured by the KPIs are linked to a change in the corresponding sustainability scores. In other words, we analyze the relationship between SLLs with environmental, social, or climate change KPIs and environmental, social, or climate change scores, respectively. The ATT coefficients are all statistically non-significant, confirming our results above and suggesting that SLLs are not associated with a change in corporate sustainability performance and that the KPIs included in an SLL are not related to an increase in the respective ESG pillar score. Finally, we also examine the subsample of SLL borrowers with a high KPI score. Our results may be heterogeneous due to SLLs that score poorly in all six KPI dimensions. However, even when using a subset of all borrowers whose SLLs have a score of at least 3.5 and their respective control firms, we still find no statistical significance.

Taken together, these results support the hypothesis that SLL issuance is not associated with a significant change, i.e., neither deterioration nor improvement, in borrowers’ ESG profiles ex-post. While existing studies have produced mixed results regarding the impact of SLLs on ESG improvements (Kim et al., 2023; Du et al., 2023; Dursun-de Neef et al., 2023), our methodology for assessing the quality of KPIs in SLLs contributes to a deeper understanding of the underlying factors that can explain the observed non-existent relationship between SLL issuance and sustainability performance. In addition to the lack of credible incentives provided by the KPIs, another possible explanation

Table II.13: Weighted average treatment effects of sustainability-linked loan issuance on ESG performance (matched sample).

|                        | ATT    | SE    | Lower CI | Upper CI |
|------------------------|--------|-------|----------|----------|
| Dependent variable     | (1)    | (2)   | (3)      | (4)      |
| <u>Whole sample</u>    |        |       |          |          |
| ESG score              | -0.156 | 0.111 | -0.373   | 0.061    |
| <u>E KPI sample</u>    |        |       |          |          |
| E Score                | -0.082 | 0.092 | -0.263   | 0.099    |
| Climate score          | 0.020  | 0.111 | -0.197   | 0.238    |
| <u>S KPI sample</u>    |        |       |          |          |
| S score                | -0.055 | 0.179 | -0.406   | 0.296    |
| <u>CO2 KPI sample</u>  |        |       |          |          |
| Climate score          | -0.036 | 0.121 | -0.274   | 0.203    |
| <u>High KPI sample</u> |        |       |          |          |
| ESG score              | -0.183 | 0.142 | -0.462   | 0.095    |

*Remark:* The table presents the weighted group-time average treatment effect on the treated following Callaway and Sant'Anna (2021). Standard errors (SE), lower and upper 95% confidence intervals (CI) are adjusted for multiple testing and calculated using bootstrapped standard errors. \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level, respectively.

for our results could be that firms receiving SLLs already have above-average ESG performance before the loan is even issued, as shown in the data from II.5.1. Thus, SLLs appear to simply sustain the current level of ESG performance rather than significantly improving it in the years following the issuance.

### II.5.3 Stock market reactions to SLL issuance announcements

One of the reasons often cited in the literature for issuing sustainable debt is the signaling effect (see e.g., Flammer, 2021; Kim et al., 2023), which states that borrowers seek to signal their ESG commitment by obtaining sustainable debt instruments from established lenders. In this section, we explore this question by analyzing stock market reactions to SLL announcements. Such announcements may be perceived positively by investors, leading to positive market reactions. However, there are also several reasons to believe that stock markets may respond negatively or be indifferent to the issuance of SLLs.

First, assuming that stock prices reflect all the information available at a given

point in time, SLLs may not provide investors with new information that is not already included in companies' annual reports or sustainability strategies. Second, the selected KPIs often fail to address issues that are financially material, as shown by our KPI analysis. Therefore, it is likely that the issuance of SLLs does not provide any new information about a company's financial performance, which is the primary driver of stock prices. In addition, the financial incentives tied to SLLs may not have an immediate and strong effect on firms' financial performance, making it difficult for investors to assess the potential financial benefits of SLLs. Moreover, in an equilibrium, the more sustainable stocks of greener firms tend to exhibit lower *ex ante* CAPM alphas (Pástor et al., 2022). Finally, SLLs are also typically costly due to the additional reporting and monitoring requirements in the short run,<sup>7</sup> while the longer-term nature of their sustainability goals may not align with the short-term focus of the equity market (Pedersen et al., 2021).

In our analyses, we make use of the fact that the Refinitiv DealScan database contains the announcement date of the SLLs, i.e. the day on which a company announced the closing of a loan. The announcement date is the relevant date for our event study because it captures the day when the information is released to the market. However, for most SLLs in our sample, we find that the announcement date and the financial close date are similar, suggesting that the market is generally informed about an SLL issuance as soon as the loan agreement is successfully closed. In our analyses, we use unique events and consider each announcement of one or more SLLs on a single day as one event.

To conduct the event study, we employ the standard market-model methodology using an estimation window of 120 trading days that ends 30 days prior to the event. The abnormal returns are computed using STOXX Europe 600 and S&P 500 as our relevant benchmarks for SLL borrowers in the EU and the US, respectively. In addition, we consider the following four event windows:  $[-1,1]$  and  $[-1,5]$ ,  $[1,3]$  and  $[1,10]$ , which account both for the possibility that some information may have been known to the

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<sup>7</sup>Kim et al. (2023) show that SLL borrowers do not enjoy pricing benefits at issuance from obtaining SLLs.

Table II.14: Borrower stock returns around sustainability-linked loan issuance announcements.

| Event window       | All SLLs |                |          | E KPI  |                |          | S KPI |                |          |
|--------------------|----------|----------------|----------|--------|----------------|----------|-------|----------------|----------|
|                    | CAR      | <i>t</i> -stat | <i>N</i> | CAR    | <i>t</i> -stat | <i>N</i> | CAR   | <i>t</i> -stat | <i>N</i> |
| Panel A: EU sample |          |                |          |        |                |          |       |                |          |
| [-1,1]             | -0.11    | -0.55          | 436      | -0.24  | -0.81          | 214      | -0.38 | -1.24          | 112      |
| [-1,5]             | -0.26    | -0.91          | 436      | -0.25  | -0.63          | 214      | -0.43 | -0.87          | 112      |
| [1,3]              | -0.19    | -0.78          | 436      | -0.13  | -0.16          | 214      | -0.31 | -0.68          | 112      |
| [1,10]             | -0.77**  | -2.22          | 436      | -0.88  | -1.78          | 214      | -0.51 | -0.78          | 112      |
| Panel B: US sample |          |                |          |        |                |          |       |                |          |
| [-1,1]             | -0.49*   | -1.81          | 148      | -0.74* | -1.75          | 67       | -0.92 | -1.61          | 27       |
| [-1,5]             | -0.51    | -1.14          | 148      | -0.71  | -0.89          | 67       | -0.54 | -0.75          | 27       |
| [1,3]              | -0.44    | -1.64          | 148      | -0.93  | -1.55          | 67       | -0.82 | -0.97          | 27       |
| [1,10]             | -0.92    | -1.33          | 148      | -1.54* | -1.89          | 67       | -1.31 | -0.86          | 27       |

*Remark:* This table reports average cumulative abnormal stock returns (CARs) of SLL borrowers for different time windows around public announcements of SLL issuance. The overall sample consists of 584 SLL issuance events. CARs are computed from a market model using the Stoxx Europe 600 in Panel A and the S&P 500 in Panel B as the market benchmark for the 120 trading day period ending 30 trading days prior to the loan announcement date. We report average CARs around different event windows for the whole sample and subsamples of SLLs with either environmental and/or social KPIs. CARs are reported in %. \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level, respectively.

public prior to the announcement and for a staggered response.

In Table II.14, we report the average cumulative abnormal stock returns (CARs) expressed as a percentage for each event window. In Panel A, we report the average CARs for the subsample of EU SLL borrowers, comprising 436 issuance events. As shown, the results indicate that the CARs are insignificant, with the exception of the larger event window  $[0,10]$ , where the CARs are negative and significant at the 5% level. While this suggests that the stock market reacts negatively to the issuance of SLLs, the results could also be due to unrelated trends around the event date. In a next step, we report the average CARs for the subsample of loan issuances with at least one environmental KPI and the subsample of loan issuances with at least one social KPI. In both subsamples, the CARs are insignificant for all event windows.

Panel B of Table II.14 presents the average CARs for the US subsample, comprising a total of 148 issuance events. In this case, we document a significant negative market reaction with cumulated abnormal returns of  $-0.49\%$  in the event window  $[-1,1]$ , symmetrically surrounding the announcement date of issuance. This result also holds when considering only the subsample of US firms issuing SLLs with a least one environmental KPI. These firms exhibit CARs of  $-0.74\%$  in the event window  $[-1,1]$  and  $-1.54\%$  in the event window  $[1,10]$ .

In Table II.15, we present the average CARs for subsamples of issuance events associated with high KPI (at least 3.5) or low KPI score (below 3.5). The CARs are insignificant in all intervals, except for US firms issuing SLLs with a high KPI score which exhibit negative CARs of  $-2.40\%$  in the event window  $[1,10]$ .

Overall, our results suggest that stock markets are rather indifferent to the issuance of SLLs by EU firms. In contrast, announcements of SLL issuance in the US are met with caution by investors, especially when the loans include environmental KPIs. There are several possible interpretations for these observations. First, investors may remain skeptical about the value of integrating ESG factors into investment decisions, which could contribute to the observed lack of positive response (see e.g., Edmans, 2023b). This is particularly the case in the US, where growing ESG sentiment, especially in Republican states, has led to restrictions on state funds from investing in ESG products.

Table II.15: Borrower stock returns around high- and low-quality KPI loan announcements.

| Event Window       | High KPI score |                |          | Low KPI score |                |          | Difference | <i>t</i> -stat |
|--------------------|----------------|----------------|----------|---------------|----------------|----------|------------|----------------|
|                    | CAR            | <i>t</i> -stat | <i>N</i> | CAR           | <i>t</i> -stat | <i>N</i> |            |                |
| Panel A: EU sample |                |                |          |               |                |          |            |                |
| [-1,1]             | -0.23          | -0.54          | 91       | -0.21         | -0.74          | 126      | -0.02      | -0.03          |
| [-1,5]             | -0.30          | -0.52          | 91       | -0.13         | -0.40          | 126      | -0.17      | -0.24          |
| [1,3]              | -0.02          | -0.03          | 91       | -0.34         | -1.04          | 126      | 0.32       | 0.67           |
| [1,10]             | -0.81          | -1.14          | 91       | -0.75         | -1.35          | 126      | -0.06      | -0.07          |
| Panel B: US sample |                |                |          |               |                |          |            |                |
| [-1,1]             | -0.78          | -1.56          | 35       | 0.13          | 0.29           | 33       | -0.91      | -1.19          |
| [-1,5]             | -0.99          | -0.98          | 35       | 1.60          | 1.34           | 33       | -2.59**    | -2.07          |
| [1,3]              | -0.65          | -0.98          | 35       | 0.36          | 0.07           | 33       | -1.01      | -1.39          |
| [1,10]             | -2.40*         | -1.75          | 35       | -0.11         | -0.39          | 33       | -2.29      | -1.28          |

*Remark:* This table reports average cumulative abnormal stock returns (CARs) of SLL borrowers for different time windows around public announcements of SLL issuance. The sample consists of 285 SLL issuance events. CARs are computed from a market model using the Stoxx Europe 600 in Panel A and the S&P 500 in Panel B as the market benchmark for the 120 trading day period ending 30 trading days prior to the loan announcement date. We report average CARs around different event windows for subsamples of SLLs with high and low KPI scores. We report the difference of means between the two subsamples as well as the associated *p*-value. CARs are reported in %. \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level, respectively.

Second, investors may be also wary of possible greenwashing practices, which have become more prevalent in recent years (Kim et al., 2023). Third, SLLs have higher costs than conventional loans due to additional reporting and monitoring requirements, which may also discourage investors from responding positively to their issuance.

In a next step, we investigate whether specific loan characteristics may explain the observed stock market reactions described above. While our KPI analysis helps explain the nonexistent relationship between SLL issuance and borrowers' ex-post sustainability performance, it may also shed light on the different stock market reactions to SLL announcements. Thus, we estimate the following basic equation using ordinary least squares (OLS):

$$CAR_i = \beta_0 + \beta_1 \text{Number of KPIs}_i + \beta_2 \text{KPI Score}_i + \gamma' \mathbf{x}_i + \epsilon_i \quad (\text{II.2})$$

where  $CAR_i$  is  $CAR(-1, 1)$  for firm  $i$  measured using the market model abnormal returns,  $\text{Number of KPIs}_i$  is the number of KPIs per loan,  $\text{KPI Score}_i$  corresponds to the KPI score for each loan. We either consider the total KPI score or each of the score dimensions separately.  $\mathbf{x}_i$  is a vector of additional control variables, which are described in Section II.5.1.  $\epsilon_i$  is the error term.

Table II.16 reports results from estimating equation (2) for the sample of SLLs with KPI information. The coefficient for  $\text{Number of KPIs}_i$  is significant and negative in columns (1) and (2). This result is consistent with the previous findings indicating that investors are vigilant against the issuance of SLLs, especially when such loans involve a high number of KPIs. In column (3) we find further evidence of a negative association between a higher number of KPIs and market responses to loan issuance. More precisely, the relationship becomes negative once a SLL has four KPIs. This is consistent with our findings in II.1 where the average KPI score in the sample drops significantly after four KPIs. This is also in line with Carrizosa and Ghosh (2022), who document a negative relationship between the number of KPIs and  $CAR(-1, 1)$ .

In contrast, we do not find clear evidence that stock markets respond to SLL design characteristics. In column (1), *Total KPI Score* has a negative coefficient, while it has



a positive coefficient in column (2). In both cases, the coefficients are not statistically significant. Similarly, there is no clear association between the dimensions of the KPI score and CARs, as shown in column (4), with the exception of *Measurability*, which appears to be positively linked to CAR (-1,1).

Overall, our results are consistent with Carrizosa and Ghosh (2022), who document negative and mostly insignificant market reactions to SLL issuances. They also corroborate the findings of Kim et al. (2023), who report negative market reactions for low-transparency loans.

## II.6 Conclusion

In this paper, we contribute to the emerging literature on ESG lending by conducting a comprehensive analysis of the characteristics of SLLs, with a particular focus on their underlying KPIs. The selection and design of KPIs are critical aspects of ESG-linked loan contracts. Therefore, a detailed analysis of the KPIs is essential to draw conclusions about the ability of SLLs to incentivize corporate sustainability efforts.

As a first step, we propose a new framework that examines KPIs in SLL agreements along six dimensions: strategic relevance, materiality, measurability, benchmarking, pricing, and external review. By examining KPIs along each dimension, our framework provides a detailed understanding of the strengths and weaknesses of SLLs. In particular, our results show that KPIs often have strategic relevance and are based on measurable and quantifiable metrics. However, KPIs frequently lack materiality and are not always subject to external, independent review. In addition, we find that KPIs are only occasionally developed against a specific benchmark and that failure to meet KPIs does not consistently result in financial penalties in the form of interest rate increases. Overall, SLL borrowers appear to enter into such agreements to showcase their existing sustainability practices rather than to incentivize further ESG improvements through stringent KPIs.

In a second step, we empirically analyze whether the issuance of SLLs is associated with a change in borrowers' ex-post ESG performance using a difference-in-differences

Table II.16: CAR determinants of sustainability-linked loan announcements.

| Dependent variable              | CAR (-1,1)           | CAR (-1,1)          | CAR (-1,1)          | CAR (-1,1)         |
|---------------------------------|----------------------|---------------------|---------------------|--------------------|
|                                 | (1)                  | (2)                 | (3)                 | (4)                |
| Number of KPIs                  | -0.007***<br>(0.002) | -0.007**<br>(0.003) |                     |                    |
| Total KPI Score                 | -0.001<br>(0.002)    | 0.001<br>(0.003)    |                     |                    |
| 2 KPIs                          |                      |                     | -0.011<br>(0.008)   |                    |
| 3 KPIs                          |                      |                     | -0.009<br>(0.008)   |                    |
| 4 KPIs                          |                      |                     | -0.033**<br>(0.013) |                    |
| 5 KPIs                          |                      |                     | -0.006<br>(0.029)   |                    |
| KPI Score - Strategic Relevance |                      |                     |                     | -0.044<br>(0.008)  |
| KPI Score - Materiality         |                      |                     |                     | 0.010<br>(0.010)   |
| KPI Score - Measurability       |                      |                     |                     | 0.041**<br>(0.021) |
| KPI Score - Benchmarking        |                      |                     |                     | -0.002<br>0.010    |
| KPI Score - Pricing Mechanism   |                      |                     |                     | 0.004<br>(0.007)   |
| KPI Score - External Review     |                      |                     |                     | 0.001<br>(0.010)   |
| Controls                        | No                   | Yes                 | Yes                 | Yes                |
| Observations                    | 347                  | 167                 | 167                 | 167                |
| Adjusted R-squared              | 0.019                | 0.005               | 0.005               | 0.006              |

*Remark:* This table reports the OLS estimations for different samples of SLLs issued from January 1, 2017 to December 31, 2022. The sample consists of 579 SLL issuance events. CAR(-1,1) is the cumulative abnormal return with an event window of one day before the event to one day after. We estimate the market model using value-weighted market returns for the 120 trading day period ending 30 trading days prior to the loan announcement date. CARs are reported in %. Robust standard errors are in parentheses. \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level, respectively.

design. Our results confirm the results of our KPI analysis and suggest that the issuance of an SLL does not have a significant impact on the firms' ex-post ESG performance. We also examine stock market reactions to public announcements of SLLs by conducting an event study. Our results suggest that the issuance of SLLs by EU firms has no significant impact on their stock prices, while US firms experience a significant negative market reaction, especially when their loans include environmental KPIs.

Our study has several practical implications for market participants. First, lenders and borrowers should be careful when designing KPIs for SLLs, as lax KPIs can damage their reputation and raise greenwashing concerns. This applies not only to the sustainability targets associated with the KPIs, but also to their implementation and independent verification over the life of the loan. Although SLLs have the potential to promote sustainability, our findings suggest that they are not effective in significantly improving ESG performance in the short term. Instead, SLLs may be more effective in sustaining the already high level of ESG performance of borrower firms, rather than significantly improving it. Borrowers and lenders should therefore have reasonable expectations about the potential impact of SLLs as an incentive for sustainable practices.

Overall, our study contributes to the growing literature on ESG lending. Due to the novelty of SLLs, current studies typically suffer from small sample sizes. As more data become available, future research could examine the long-term sustainability impacts of SLL issuance on borrowers. Additionally, while transitioning away from use-of-proceeds-based debt instruments can help democratize sustainable finance, hurdles remain for companies with lower ESG profiles and for small and medium-sized enterprises. In particular, firms that lack specific sustainability resources or expertise may stay out of the SLL market, despite potentially having a greater need for new forms of sustainability incentives. Therefore, a more inclusive approach to sustainable finance instruments may be needed — one that does not compromise on design rigor and allows all market actors to contribute to addressing critical societal challenges.

# Chapter III

## Looking beyond ESG preferences: The role of sustainable finance literacy in sustainable investing

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# Looking beyond ESG preferences: The role of sustainable finance literacy in sustainable investing

## Abstract

We assess how sustainable finance literacy affects people's sustainable investment behavior, using a pre-registered experiment. We find that an increase in sustainable finance literacy leads to a 4 to 5% increase in the probability of investing sustainably. This effect is moderated by sustainability preferences. In the absence of moderate sustainability preferences, any additional increase in sustainable finance literacy is at minimum irrelevant, and we find some weak evidence that it might even reduce sustainable investments. Our findings underscore the role of knowledge in shaping sustainable investment decisions, highlighting the importance of factors beyond sustainability preferences.

**JEL Classification:** G11, G18, G53

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## III.1 Introduction

The number of sustainable investment products, i.e., products considering environmental, social and governance (ESG) factors in portfolio selection and management, has risen substantially in recent years (GSIA, 2021).<sup>1</sup> However, according to a study by the German Institute for Retirement Provision, there exists “widespread uncertainty about how retail investors understand and evaluate sustainable investments and how these affect their investment decisions in detail” (DIA, 2020).

While retail investors often express a clear preference for sustainable choices, sustainable finance products currently account for only a small portion of their portfolios (DIA, 2020). In surveys, investors frequently cite a lack of product transparency and insufficient knowledge as barriers to sustainable investing (DIA, 2020; Dumas and Louche, 2015; Friede et al., 2015; Gutsche and Zwergel, 2020; Phillips and Johnson, 2019). In fact, retail investors wanting to invest sustainably are often faced with complex and at times intransparent information. As a result, making sustainable investment decisions typically involves additional layers of information complexity that prevent these investors from being able to align their investment choices with their stated sustainability preferences (Filippini et al., 2024b; Paetzold and Busch, 2014; Anderson and Robinson, 2021).

Financial decisions in general are largely influenced by specific knowledge and experience (Lusardi and Mitchell, 2014). Consequently, it is reasonable to infer that sustainable financial decisions require not only financial knowledge, but also a solid understanding of the sustainability criteria applied to corresponding financial products. For example, a person who has a comprehensive understanding of ESG is more likely to respond to ESG information and make investment decisions based on such information than someone who has never heard of the acronym. Following Filippini et al. (2024b), we refer to this concept as “sustainable finance literacy”, which these authors define as the “knowledge of regulations, norms, and standards about financial products that have

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<sup>1</sup>In this paper, the terms “sustainable investments”, “sustainable funds”, “sustainable financial products”, “ESG funds”, “ESG financial products” etc. are all used synonymously. In addition, we use terms such as “sustainable investing”, “ESG investing”, “sustainable investment decisions” and “sustainable investment behavior” synonymously.

sustainable characteristics”. In this paper, we explore the effects of sustainable finance literacy on sustainable investing. Motivated by the importance of preferences for investment decisions (Bauer et al., 2021; Brodback et al., 2019; Hong and Kostovetsky, 2012; Riedl and Smeets, 2017a; von Wallis and Klein, 2014), we also examine the relationship between sustainability preferences and sustainable finance literacy, and their role in shaping sustainable investment behavior.

To investigate the causal effect of sustainable finance literacy on ESG investing, we run a pre-registered experiment with a large sample of German participants. We randomly assign our participants either to a treatment group, which receives a brochure with simple information on key aspects of sustainable investing, or to a control group, which does not receive any information. The information in the brochure focuses on three key dimensions: ESG criteria, sustainable investment strategies, and regulation of sustainable investments in the European Union (EU), and is thus consistent with Filippini et al. (2024b)’s definition of sustainable finance literacy.

In the context of our experiment, participants in both treatments, i.e., the brochure treatment and the control treatment, have to make four investment decisions. For each round of investment decision, they have to choose one out of three funds from a given selection of sustainable and conventional funds. Investment decisions are incentivized by a bonus mechanism that leads to potential real payoffs for the participants. The funds to choose from are actual financial products. We present these funds using the web interface of a large direct bank offering retail banking products and services.<sup>2</sup> In addition to a variety of financial information, this web interface also provides sustainability information for each fund. Finally, we include several questions aimed at measuring not only sustainable finance literacy, but also other important factors influencing sustainable investment decisions, including financial literacy, economic and sustainability preferences, environmental literacy, and perceived impact (Lusardi and Mitchell, 2014; Falk et al., 2023; Anderson and Robinson, 2021; Heeb et al., 2022).

German retail investors are particularly well-suited to study the effects of sustainable finance literacy on investment decisions as they are directly impacted by the Sustainable

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<sup>2</sup>We use the interface of ING-DiBa AG, which is part of the Dutch ING Group.

Finance Disclosure Regulation (SFDR). This regulation, which applies to all financial firms that market their financial products in the European Union (EU), classifies financial products such as mutual funds and exchange-traded funds (ETFs) according to the extent to which ESG objectives are pursued and promoted. This categorization is reviewed and enforced by the German Federal Financial Supervisory Authority (BaFin). One key objective of this regulation is to increase transparency of sustainable investment products and provide investors with additional ESG-related information. In our experiment, this regulation allows us to verifiably differentiate between conventional and ESG funds, which is necessary for the construction of our dependent variables.

Our analysis delivers the following key findings: First, we provide evidence that sustainable finance literacy plays a key role in shaping investment choices. Providing some basic information about ESG criteria and portfolio selection strategies can have a substantial effect on individuals' knowledge of sustainable products and, consequently, on their probability of engaging in such investments. As a starting point, we analyze the effect of our brochure treatment using three different model classes (simple, medium, complex), which incorporate different sets of control variables. We find that the total effect of the treatment is an increase in the probability of choosing a sustainable fund of around 9%. We examine this result further using a causal mediation analysis and argue that 4 to 5% of this increase can be directly attributed to an increase in sustainable finance literacy. Similarly, we find that the brochure treatment increases the share of participants who claim to use ESG criteria in their investment decisions, for which around 12-14% can be directly attributed to an increase in sustainable finance literacy.

Second, we investigate the relationship between sustainability preferences and sustainable financial literacy and how both influence sustainable investment behavior. We show that sustainable financial literacy must be coupled with at least a moderate level of sustainability-oriented preferences to positively influence ESG investments. In the absence of moderate sustainability preferences, any additional increase in sustainable finance literacy is at minimum irrelevant, and we find some weak evidence that it might even reduce sustainable investments.

Finally, we show that for the participants who choose sustainable over conventional



funds, an increase in sustainable finance knowledge increases the probability of investing in the more sustainable fund out of two ESG funds. In particular, we find that participants who possess the required knowledge to distinguish “dark green” (SFDR Article 9) funds from “light green” (SFDR Article 8) funds have an around 12% increased probability to choose the dark green over the light green fund. This increase is again moderated by the level of ESG preferences. In other words, without at least a moderate level of sustainability preferences, sustainable investment behavior is not influenced by knowledge.

We take several measures to ensure the robustness of our findings. During the experiment, we control for the possibility of an experimenter demand effect (EDE). EDE refers to a phenomenon in experiments in which the subjects form beliefs about the experimental objectives and adapt their actions in the direction most congruent to such objectives (Zizzo, 2009). Therefore, we divide the treatment group into two different random subgroups: “High EDE” and “Low EDE”. Each subgroup gets to read different statements about our expectations with regard to their investment behavior, i.e., “we expect that participants in the experiment who read these instructions will be less (more) likely to invest in sustainable funds than they normally would” (de Quidt et al., 2018). In contrast, the control group does not get any particular statement. We run several tests and provide evidence that our results are not driven by an EDE. Furthermore, we perform a battery of robustness checks and show that our baseline results are robust to alternative model specifications.

Our paper complements the nascent literature on sustainable finance literacy. So far, only one recent study by Filippini et al. (2024b) has investigated the relationship between sustainable finance literacy and financial decisions. Using survey data from Switzerland, their analysis shows that sustainable finance literacy is relatively rare, but it nevertheless has an important influence on whether people own sustainable finance products. We build on this study in three different ways: First, we conduct an experiment in which participants not only indicate whether they own sustainable assets, but also have to make active investment decisions from a given selection of conventional and sustainable funds. Second, we are the first to provide causal evidence for the effect of

sustainable finance literacy on investment behavior by exogenously increasing the level of sustainable finance literacy of one group of participants (treatment) relative to another group (control). Third, we extend the set of questions proposed by Filippini et al. (2024b) to measure sustainable finance literacy by formulating nine questions focusing on general (ESG criteria, sustainable investment strategies) and local (EU regulation) issues.

Our study also contributes to the growing stream of literature on the determinants of sustainable investing. Previous studies show that investors value sustainability and respond to corresponding information when making investment decisions (Hartzmark and Sussman, 2019; Ceccarelli et al., 2019). Several studies focus on institutional investors (e.g., pension funds) and discuss how such investors should align their investment practices with their clients' preferences (Bauer et al., 2021). However, the findings of such studies are not directly applicable to retail investors, who form a distinct subset of non-professional investors with distinct characteristics, motivations, and constraints.

Among prior studies that take the viewpoint of retail investors, Anderson and Robinson (2021) analyze Swedish households and find that households with stronger pro-environmental values do not necessarily hold greener portfolios. Briere and Ramelli (2021) observe that the offering of responsible investment options increases the propensity of left-wing and pro-social individual investors to invest in equity products due to a better alignment with their own personal values. Finally, Heeb et al. (2022) investigate the investment behavior of experienced private investors. They find that investors are willing to pay for sustainable investments, but that this willingness does not increase with the additional impact generated by such investments. Except for the aforementioned study by Filippini et al. (2024b), these studies do not include an indicator of the knowledge of retail investors about sustainable finance products as an explanatory variable. Yet, as our results show, knowledge about sustainable financial products has a causal impact on financial decisions.

Another contribution of our paper is to provide and complement a comprehensive set of survey questions gathered from the existing literature on the determinants of ESG investments. Appendix D provides an overview of these questions and shows which

thematic modules we complement. While several studies have examined different determinants of socially responsible investments (SRI) individually, our work attempts to systematically analyze all of these dimensions in the context of one single experiment. This allows us to truly narrow down the specific effect that sustainable finance literacy plays in this context. More precisely, our study contains questions on risk, trust and time preferences developed by Falk et al. (2023), on financial literacy by Lusardi and Mitchell (2014), on financial experience by Gutsche and Zwergel (2020) and Anderson and Robinson (2021), on sustainable finance literacy by Filippini et al. (2024b), on perceived impact by Heeb et al. (2022), on financial expectations with respect to ESG financial products by Riedl and Smeets (2017a) and Bauer et al. (2021), and on environmental literacy by Anderson and Robinson (2021), Geiger and Holzhauer (2020), and Zwickle and Jones (2018). All these factors provide complementary information and together contribute to a comprehensive understanding of sustainable investment decisions.

A final contribution is our proposed design of choice environment, which conveys a high degree of external validity to our experiment. There are some experiments studying sustainable investments in the laboratory (e.g., Barreda-Tarrazona et al., 2011; Bassen et al., 2018; Gutsche and Ziegler, 2019; Heeb et al., 2022), but these studies usually employ imaginary funds using stylized financial and sustainable features, which are designed for the purpose of the study. In contrast, our participants decide between funds that actually exist. We use screenshots of a real web interface of a large direct bank, and each fund conveys the information exactly as it is presented in the field. We also link bonus payments to the actual performance of these funds, including a time window of approximately half a year between the investment decision and the disbursement. While other experiments in prior literature have some of these features, to the best of our knowledge, our study is the only one that incorporates all of them. Thus, it simulates the actual decision with one of the highest degrees of credibility yet achieved in a laboratory or online experiment.

A key implication of our findings is that fostering sustainable choices and a “green” transformation goes beyond merely understanding investors’ ESG preferences. In re-

cent years, regulatory authorities have actively sought to channel capital flows towards green assets, for example by increasing disclosure and transparency of investment funds' ESG strategies. Such initiatives have been shown to have an impact on institutional investors (see e.g., Scherer and Hasaj, 2023). However, when considering retail investors, the success of such initiatives is dependent on investors' capacity to not only understand their preferences, but also actively translate these preferences into appropriate investment decisions, an aspect that cannot be assumed as a given. In terms of practical implications, our paper therefore highlights the need for educational initiatives and information campaigns on sustainable investments.

Understanding what kind of knowledge and preferences lead individuals to invest in certain ways is important not only to academics but also to investment professionals who invest on behalf of individuals. This is particularly true in the EU, where the revised Markets in Financial Instruments Directive (MiFID) II now mandates investment professionals to gather information about clients' sustainability preferences and integrate such preferences into the investment process. It is therefore becoming increasingly important for institutional investors to understand the sustainability preferences of their clients. At the same time, such sustainability preferences are likely to be influenced by these clients' knowledge and understanding of sustainable investment products, highlighting the importance of understanding the linkages between sustainable finance literacy, sustainability preferences and investment behavior among retail investors.

The rest of this paper is organized as follows. Section 2 presents the theoretical background of our paper. Section 3 describes the study design and provides descriptive statistics. Section 4 presents the empirical results. Section 5 discusses the limitations and implications of our paper, and Section 6 concludes.

## **III.2 Literature background and brochure development**

Sustainable investing is an investment approach that considers environmental, social and governance (ESG) criteria in portfolio selection and management (GSIA, 2021).

Much of the recent literature explains the demand for sustainable investing as taste-based. Several theoretical models incorporate types of agents who derive utility from investing sustainably (Pástor et al., 2021; Pedersen et al., 2021; Oehmke and Opp, 2020), and a large body of empirical literature finds evidence for this family of explanations (e.g., Riedl and Smeets, 2017a; Hartzmark and Sussman, 2019; Barber et al., 2021; Bauer et al., 2021; Bofinger et al., 2022; Heeb et al., 2022). However, this literature usually focuses on establishing a link between preferences and demand, while rarely investigating how this link is mediated, or under which conditions this relationship holds. In particular, while the number of sustainable investment products has grown rapidly in recent years, the literature on whether and how such products are understood and perceived by retail investors remains limited. Compared to institutional investors, retail investors often have fewer resources and less expertise at their disposal. Therefore, it is crucial to shed light on how retail investors engage with such products, given their inherent complexity.

There is little literature that investigates the role of literacy in the context of sustainable investments, which seems surprising given the important role of financial literacy in financial decision-making as a whole (Lusardi and Mitchell, 2014). Aristei and Gallo (2021) and Bethlendi et al. (2022) investigate the influence of financial literacy on sustainable investing and find a positive relationship. Bethlendi et al. (2022) find a similar result for green, or environmental, literacy. In contrast, Anderson and Robinson (2021) and Filippini et al. (2024b) do not find any influence of environmental or sustainability literacy.

However, from a theoretical point of view, it is not quite clear why financial literacy or environmental literacy, i.e., knowledge about concepts such as inflation, compound interest, the influence of carbon dioxide on the earth's climate, or the natural habitat of polar bears (see Anderson and Robinson (2021)), should influence the tendency to invest sustainably, other than via a correlation with some other aspects of sustainable investing, such as preferences or specific knowledge. This is why Filippini et al. (2024b) develop the concept of sustainable finance literacy, which is tailored to this specific knowledge, and defined as the “knowledge of regulations, norms, and standards about

financial products that have sustainable characteristics.” The authors find that this special knowledge, while in general not widespread among individuals, nonetheless predicts the probability of sustainable investing in an observational study in Switzerland. To measure sustainable finance literacy, the authors develop a set of eight questions that cover several topics, including the definition of ESG, rules and certifications of ESG products, the difference between sustainability characteristics and ecology, and the difference between sustainable investing and impact investing.<sup>3</sup>

Our paper aims to provide evidence that there is a causal relationship between sustainable finance literacy and investment behavior. To this end, and in contrast to Filippini et al. (2024b), we use an experiment. Our treatment consists of a short educational brochure with key information for retail investors based on the definition developed by Filippini et al. (2024b). Specifically, the brochure is organized around three central dimensions: (1) the definition and components of ESG criteria, (2) the various investment strategies incorporating these criteria, and (3) the EU regulation governing such investments. A copy of the brochure can be found in Appendix E.<sup>4</sup> The terminology and several examples cited in the brochure follow a book written by the Stiftung Warentest, a foundation originally established by the German Bundestag with the aim of giving guidance to consumers by providing impartial and objective information (Mulke, 2023).

Following Filippini et al. (2024b)’s definition, which emphasizes the importance of norms and standards, the first part of our brochure explains the acronym “ESG” and addresses the specific components that fall under each of the three pillars, which together contribute to the assessment of the sustainability “profile” of a company or stock. The second part of our brochure highlights how such ESG criteria are applied in various investment strategies. Examples of these strategies include “negative screens,” which deliberately avoid investing in certain stocks that do not meet pre-defined criteria. Moreover, the brochure elaborates on alternative strategies such as the “best-in-class”

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<sup>3</sup>As their study focuses on Swiss investors, several of their questions are framed to fit the Swiss context.

<sup>4</sup>Please note that the brochure in the Appendix is an English translation. The original document used in the experiment was in German.

screening. Unlike negative screening, this approach seeks to invest in companies that are industry leaders in sustainability, irrespective of whether the industry itself is inherently “green” (Gutsche and Ziegler, 2019). Consequently, the second part of the brochure also helps explain why some investment portfolios classified as sustainable may still include stocks of companies in industries that are not necessarily inherently environmentally-friendly. This is important because a lack of knowledge about the investment strategies underlying sustainable investments often leads to misconceptions about stock selection in these portfolios.

The third part of the brochure is dedicated to the regulation of such investment products in the EU. As highlighted by Filippini et al. (2024b)’s definition of sustainable finance literacy, an understanding of regulations is crucial in the context of sustainable investing. This is particularly the case in the EU where the SFDR, which took effect in 2021, imposes a set of mandatory disclosure requirements on asset managers and other financial market participants.<sup>5</sup> An important aspect of this regulation is the classification of investment products according to three different categories: Article 6, Article 8 and Article 9 financial products (European Parliament and Council of the European Union, 2019). Each of these three categories comes with its own disclosure requirements, resulting in more ESG-related information for retail investors.

Article 6 funds do not have sustainable investment as their objective. Nevertheless, the incorporation of sustainability risks into investment decision-making and the impact of sustainability risks on the fund’s returns must be described in the fund’s pre-contractual disclosures (European Parliament and Council of the European Union, 2019). When a fund manager does not consider sustainability risks in the decision-making process, the disclosure should explain why, under the principle of “comply or explain”. In contrast, Article 8 products (also referred to as “light green” funds) promote investments with environmental or social characteristics, or a combination of those characteristics, provided that the companies in which the investments are made follow good governance practices (European Parliament and Council of the European Union,

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<sup>5</sup>This regulation also applies to all US financial firms that market their financial products in the EU. Thus, US companies that sell to EU-based clients or are domiciled in the EU must also adhere to SFDR requirements for each fund.

2019). While sustainable investment is not the primary objective of Article 8 products, it remains an aspect of the investment process. Finally, Article 9 products (also referred to as “dark green” funds) have a sustainable investment as their objective. In this context, a sustainable investment means an investment in an economic activity that contributes to an environmental objective, as measured, for example, by key resource efficiency indicators and greenhouse gas emissions, or an investment in an economic activity that contributes to a social objective, such as tackling inequality (European Parliament and Council of the European Union, 2019). Such products must also comply with the “do no significant harm” principle by demonstrating that they do not in any way significantly harm any other important sustainability objectives. Furthermore, the investee companies also have to follow good governance practices with respect to management structures, employee relations, remuneration and tax compliance.

Taken together, the SFDR regulation results overall in an increase in ESG information available to retail investors, especially regarding the characteristics and strategies applied by these financial products.

In addition to our brochure, we create nine survey questions that aim to test and measure sustainable finance literacy. We divide these questions into two distinct categories, which we refer to as “global” and “local”. Within the “global” category, we include five questions related to ESG considerations, as well as investment strategies that hold relevance across the globe. For instance, the incorporation of ESG criteria and the application of positive or negative screens for sustainable investments are practices embraced by investment firms worldwide, and are therefore not limited to only the EU. However, since regulations and norms about financial products differ between regulatory contexts, we argue, in line with Filippini et al. (2024b) that sustainable finance literacy cannot be measured by relying only on questions that measure aspects that are identical across jurisdictions. Thus, we add questions centered around the regulatory context of the EU’s SFDR. Specifically, we include in the “local” category four questions on issues related to the SFDR’s Articles 6, 8 and 9, which are specific to the EU context.

We hypothesize that increasing sustainable finance literacy has two effects: First, we



expect that increasing sustainable finance literacy increases the probability of investing sustainably (H1), as such knowledge allows to translate sustainable preferences into action. Second, based on the aforementioned literature on ESG preferences (Riedl and Smeets, 2017a; Hartzmark and Sussman, 2019; Barber et al., 2021; Bauer et al., 2021; Bofinger et al., 2022; Heeb et al., 2022), we only expect this effect if combined with a sufficiently high level of sustainable preferences (H2). If participants do not have any sustainable preferences, the family of preference explanations for sustainable investing predicts no effect of sustainable finance literacy.

### III.3 Study design

#### III.3.1 Brochure treatment and experimenter demand effect

We address the question of the relationship between sustainable finance literacy and investment behavior using a preregistered experimental procedure.<sup>6</sup> The experiment was conducted in June 2023 with a sample of 1,000 participants recruited from the Prolific platform. To ensure the relevance and contextual validity of the results, the experiment was carried out specifically in German and targeted German residents within the Prolific platform.<sup>7</sup>

The treatment in our experimental setting is a brochure containing information on ESG criteria, sustainable investment strategies and the SFDR regulation. Participants are randomly assigned to either the treatment group, which gets to read this brochure, or the control group, which does not get to see the brochure. To ensure that the treatment group actually reads the brochure, the participants are required to remain on the appropriate page for at least three minutes before moving on to the next page of the experiment. The actual average time spent reading the brochure was 328 seconds, i.e., approximately 5.5 minutes. Our experimental procedure is displayed in Figure III.1.

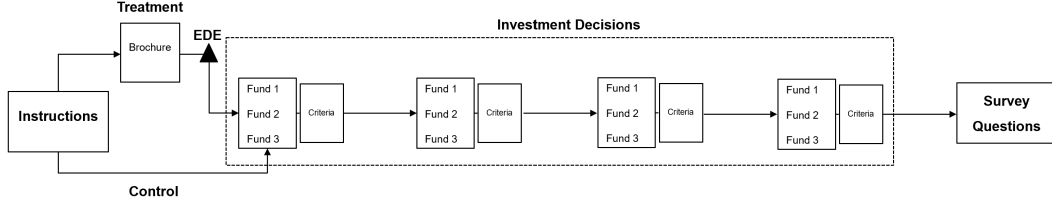
To increase the internal validity of our experiment, we control for the possibility of

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<sup>6</sup>The experiment was preregistered with the American Economic Association (AEA). For preregistration details, see Auzepy et al. (2023), <https://doi.org/10.1257/rct.11325-2.0>.

<sup>7</sup>For a discussion of Prolific, see Palan and Schitter (2018); for an empirical investigation of the data quality on Prolific, see Douglas et al. (2023).

Figure III.1: Experimental procedure.



*Remark:* This figure provides an illustration of the various steps of the experimental procedure we use in our experiment. Participants are randomly assigned either to the treatment group with the brochure or the control group without the brochure. The experiment contains four rounds of investment decisions. In each round, participants have to choose one of three funds and indicate which criteria were relevant to their investment decision. We test for the presence of an experiment demand effect (EDE).

experimenter demand effects (EDE) and socially desirable responses in several ways. An experimenter demand effect refers to a phenomenon in experimental research in which survey participants unintentionally modify their behavior or responses based on cues and expectations they perceive from the experimenter or the experimental setting (Zizzo, 2009). To account for the possibility that participants may change their behavior to conform to what they believe we expect in the study, we divide our treatment group into three subgroups. This is represented by the black triangle in Figure III.1.

The first pool is presented with a short introductory text prior to the investment decisions. The text reads as follows: “We expect that participants in the experiment who read these instructions will be less likely to invest in sustainable funds than they normally would.” We refer to this subsample as the “Low EDE” treatment. The second pool receives the following sentence: “We expect that participants in the experiment who read these instructions will be more likely to invest in sustainable funds than they normally would.” We call this subsample the “High EDE treatment”. Finally, the last pool did not get to read any of these sentences.

By communicating these expectations, we aim to induce experimenter demand effects<sup>8</sup>. We test the presence of an EDE in several model specifications and robustness checks. In addition, we perform a mediation analysis, as described in Section III.4.2, in order to isolate the effects of a change in sustainable finance literacy from other

<sup>8</sup>This procedure follows de Quidt et al. (2018). These instructions are not deceiving. In other words, based on an experimenter demand argument, we *truly* expect participants whom we tell to invest more sustainably to actually invest more sustainably, and vice versa for the Low EDE group.

potential effects induced by the brochure, such as experimenter demand effects. This allows us to precisely disentangle the impact of the brochure on sustainable investment behavior via the sustainable finance literacy channel.

### III.3.2 Investment decisions

Our experiment includes four rounds of investment decisions. In each round, the participants have to choose one out of three different funds or ETFs. These funds are real funds from actual asset management companies commonly known to German retail investors. Appendix E provides an overview of the different funds used in our experiment.

The information provided for each fund is taken directly from an online account of ING, Germany's largest direct bank, and therefore reflects the information that a retail investor would typically access online. The details presented for each fund follow a standard format and include the fund's provider, its name, a performance chart showing the fund's performance over the past year, the issuing company, Morningstar's risk rating, whether it distributes or reinvests gains, the currency used, the fund's size, costs and ongoing charges, its major holdings, its exposure to different countries and industries. Additionally, the fund information includes the fund's SFDR article<sup>9</sup> and a textual description of the fund's investment strategy. Finally, participants have the option to download the fund's full fact sheet.

Based on the information provided, in each round the participants have to choose a single fund to invest 200 Euro. In the first three decisions, participants are given a choice between two conventional investments and one sustainable investment offered by the same asset management company per decision round (taken from the asset management firms of the three banking groups with large customer bases in Germany). The funds are not explicitly labeled as sustainable or conventional, but with sufficient knowledge, it is possible to infer this from the information provided (e.g., the fund's name, the SFRD article, and the description of the investment strategy). In the final

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<sup>9</sup>At the time of the experiment, out of the largest German online investing platforms, the ING platform was one of the few that explicitly displayed the fund's SFDR article. This was another reason why we chose this particular platform for our experiment.

round, participants have the choice between two sustainable investment options (SFDR Article 8 and Article 9) and one conventional investment option (SFDR Article 6). To ensure that the sustainable investments are objectively more sustainable than the conventional funds, we reviewed their Morningstar Sustainability Rating, Carbon Risk Score, and share of fossil fuel companies prior to selecting them. Furthermore, we made sure that the sustainable funds that we selected did not exhibit strikingly more favorable risk-return profiles or cost attributes compared to the conventional funds in order to maintain fairly comparable sets of funds for each round of investment decisions.

We use these investment decisions as one of our dependent variables in several model specifications, measuring the likelihood that participants choose sustainable over conventional investments. A description of this dependent variable is provided in Appendix D.

After each investment round, participants are asked to indicate which of the displayed pieces of information about the funds played a role in their investment decision. The participants can select specific aspects from a list of pre-defined criteria that we provide, or write additional criteria in a text box. Our pre-defined list of criteria is based on standard information available for all funds. For example, we ask the participants whether they considered the fund's provider, the fund's name, its risk and return profile, past performance, size, top holdings, country exposure, industry exposure, and costs. We also ask whether sustainability-related information played a role in their decision. We use this information as a second dependent variable, which measures the conscious part in the decision-making process. Specifically, we measure the number of cases in which sustainability information was reported as one of the criteria for the investment decision after each investment round.

### **III.3.3 Incentives**

In the initial phase, participants receive comprehensive instructions about the experiment, including information about their compensation. The compensation per participant is 4.50 pounds (about 5.20 euros). To increase data quality, compensation is only paid if participants answer two attention questions correctly. These attention questions

are easy to identify, and we have provided clear instructions on how to answer them. If a participant answers both of these questions differently from the instructions, we reject the submission.<sup>10</sup>

In order to increase the chances of measuring actual investment behavior, we follow Heeb et al. (2022) as well as Bauer et al. (2022) and include a bonus payment, which every participant is also informed about before making the first investment decision. The bonus payment takes the form of a lottery. For 20 participants, we implement one randomly selected investment choice each. After half a year, we pay out the value of this investment to the selected participants. Since the payout is affected by both gains and losses, this makes the investment decisions more realistic and increases the stakes of the experiment.

The bonus calculation utilizes a simplified net return, representing the raw return earned by the fund minus the fund's ongoing costs for six months. For simplicity, other cost factors, such as performance fees and sales charges, are disregarded. For instance, if a selected fund achieved a 10.5% return by December 1, 2023, with ongoing expenses of 0.5%, the net return is 10%, resulting in a bonus payment of 220 euros. Conversely, in the case of a loss of 9.3% and running costs of 0.7%, the net return would be -10%, leading to a 180 euro bonus. In our experiment, the maximum payout is capped at 300 euros. Additionally, a floor is established, guaranteeing a minimum payout of 100 euros even if the investment's value is lower on the cut-off date.

### III.3.4 Survey questions and control variables

To complete our dataset, we collect additional data on the survey participants. First, we collect standard demographic data on age, gender, years of education, and household income. Due to the linkages between political views and sustainability preferences found in previous literature, we ask the participants for which party they would vote in a hypothetical upcoming general election. Anderson and Robinson (2021) measure pro-environmental attitudes using Green Party voting records. Briere and Ramelli (2021)

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<sup>10</sup>This happened in only 5 cases. These participants do not count for our goal of 1,000 participants and are excluded from each analysis.

report that responsible stock funds provide incentives for left-leaning individuals to increase their stock market participation given that such funds are more in line with their personal values.

Second, we collect data on other variables that are also likely to influence investment decisions. Specifically, we collect data on individual preferences, financial literacy, financial experience, environmental literacy, sustainable finance literacy, perceived impact, and expectations regarding sustainable investment products. We made the deliberate choice to rely on a large set of questions that have already been used and validated in previous literature. All questions discussed in this section are grouped into thematic modules summarized in Appendix D. In addition, this appendix also provides a detailed description of each variable derived from these questions.

Regarding individual preferences, we focus on two types of preferences: economic preferences related to risk, time, trust and altruism, and sustainability preferences. We measure economic preferences using the experimentally validated survey module introduced by Falk et al. (2023) and previously employed in related literature (e.g., Heeb et al., 2022). In total, we use five questions to determine how risk-averse the participants are, how much they discount time by preferring present rewards to future ones, and how willing they are to trust and share with others. Each of these questions is on a 10-point scale. To further elicit intrinsic social preferences, the preference module uses the responder behavior in an ultimatum game.

In order to measure sustainability preferences, we use questions that are political in nature and involve implicit individual cost-benefit trade-offs. To this end, we select seven statements from the so-called Wahl-O-Mat, a publicly accessible online tool of the German Federal Agency for Civic Education (“Bundeszentrale für politische Bildung”) that contains political statements from various political parties and is intended to help citizens understand how political parties align with their own preferences on various issues. We select a set of statements intended to measure environmental and social preferences in a German context. Participants can indicate how much they agree on a 5-point scale with statements about climate neutrality, the planned phase-out of coal-fired power generation, combustion engines, subsidies for organic farming, expansion of

rail transportation, mandatory photovoltaic systems for new housing, and an increase in the minimum wage. Since the answers are not labeled with numbers, we code them as ranging from 0 to 4 for convenience. From these seven questions, we calculate the average and refer to this variable as the “ESG Pref Score”.

To assess the financial literacy of the participants, we use the standard test developed by Lusardi and Mitchell (2014). Specifically, we employ their three core questions (often referred to as the “Big-3”), which assess the knowledge of interest rates, inflation, and portfolio diversification. Each question can be answered correctly or incorrectly. Following the literature (e.g., Filippini et al., 2024b), we construct a financial literacy indicator by summing the correct answers given by the participants to each of the three questions. In addition, we ask them about their agreement with the statement developed by Riedl and Smeets (2017a), “I often talk with other people about investments” to measure signaling effects. Furthermore, we try to capture the extent to which participants are financially active by measuring self-assessed investment experience. We also ask whether they make financial decisions for themselves or whether someone else does (Gutsche and Zwergel, 2020). Finally, to measure financial self-monitoring, we collect information on how often participants check their investment portfolio and in which financial products (e.g., stocks, savings accounts) they are or were invested (Anderson and Robinson, 2021; Gutsche and Zwergel, 2020).

As shown by Anderson and Robinson (2021) and Filippini et al. (2024b), it is also important to account for the environmental literacy of the participants, as it differs from both sustainability preferences and financial literacy. Thus, we ask five questions designed to capture households’ knowledge about climate change and the environmental costs of different consumption choices. To this end, we begin with a question on the definition of sustainable development and sustainable forestry, which was developed by Zwickle and Jones (2018) and adopted by Filippini et al. (2024b). We also add a question on energy use related to heating or cooling homes, proposed by Anderson and Robinson (2021). Finally, we add questions about carbon footprints (Geiger and Holzhauer, 2020) and the rise in global temperatures. Each question has several answers, out of which only one is right. We sum up the number of correct answers.

An important alternative mechanism through which the brochure might alter participants' investment choices is attention. We see two major reasons: First, the brochure could trigger mental associations related to ESG, including prior knowledge, attitudes or expectations. Thus, it is possible that the brochure induces a so-called “priming” effect, i.e., it could simply increase the level of attention paid to ESG criteria among participants in the treatment group, without a similar priming effect in the control group. Consequently, this increased attention to ESG might increase the importance of ESG criteria for the investment decision, in a way that is not directly caused by an increased sustainable finance literacy. Second, a similar argument could be made for the Experimenter Demand Effect, where the mere display of the brochure could be indicative of our research hypothesis, motivating participants in the treatment group to invest more sustainably, while the control group has no additional motivation to do so. While we control for the EDE using the experimental design, we measure the importance channel using three different questions about how important environmental, social and governance aspects are, on a scale from 1 (Not important) to 5 (Very important).

We follow Riedl and Smeets (2017a) and elicit return expectations and risk perceptions regarding sustainable investment products compared to conventional investment products. We ask the participants how they assess the returns of sustainable investments compared to conventional investments on a scale that ranges from “much lower” and “somewhat lower”, to “same”, “somewhat higher” and “much higher”. We then ask the same question about the risk of sustainable investments compared to conventional investments.

In addition to risk and return expectations, we account for the perceived impact of certain investment decisions. As shown in previous literature (Heeb et al., 2022), positive emotions derived from choosing sustainable investments are also an important driver of sustainable investing. To capture the extent to which participants perceive their investments as making a meaningful contribution to addressing societal challenges, we ask them after each of the four investment decisions to rate their investment in terms of perceived impact on a scale from 0 (“no contribution”) to 5 (“very positive contribu-



tion”). In a separate question, we ask the participants which of the following dimensions are important to them, in general, when investing: returns, risk, environment, social, and governance. The participants can provide a response ranging from “not important” to “very important” for each dimension.

Finally, we take into account the perceived skepticism towards sustainable investments and ask the participants whether they think that “sustainable financial products are just greenwashing”. Respondents can give an answer ranging from “strongly disagree” to “strongly agree”.

Tables III.1, III.2 and III.3 present descriptive statistics for our sample, categorized by measurement scale (nominal plus ordinal; metric plus Likert  $\geq 10$  scale points; and Likert = 5 scale points, respectively). In this section, we discuss the key descriptive statistics extracted from these three tables.

Table III.1: Demographic breakdown.

|                                                                    |                 |
|--------------------------------------------------------------------|-----------------|
| Gender                                                             | Total $N = 995$ |
| Female                                                             | 378             |
| Male                                                               | 601             |
| Non-binary                                                         | 16              |
| Frequency Portfolio Checks                                         | Total $N = 999$ |
| Weekly                                                             | 431             |
| Monthly                                                            | 221             |
| Several times per year, but less frequently than monthly           | 97              |
| Once a year                                                        | 11              |
| More rarely                                                        | 21              |
| Never                                                              | 5               |
| Only when I create an investment account, or change it             | 9               |
| I don't have a investment account                                  | 204             |
| Financial Decision Maker                                           | Total $N = 998$ |
| I do not decide but someone else does (e.g., partner, parents)     | 60              |
| I decide together with my partner                                  | 314             |
| Monthly Net Income                                                 | Total $N = 943$ |
| Less than 500€                                                     | 43              |
| 500€to less than 1000€                                             | 115             |
| 1000€to less than 2000€                                            | 154             |
| 2000€to less than 3000€                                            | 212             |
| 3000€to less than 4000€                                            | 153             |
| 4000€to less than 5000€                                            | 119             |
| 5000€to less than 6000€                                            | 65              |
| 6000€to less than 7000€                                            | 48              |
| 7000€or more                                                       | 34              |
| Party Preference                                                   | Total $N = 950$ |
| CDU/CSU                                                            | 60              |
| SPD                                                                | 123             |
| Green Party                                                        | 307             |
| FDP                                                                | 116             |
| The Left                                                           | 98              |
| AfD                                                                | 26              |
| Other Party                                                        | 100             |
| Would not vote                                                     | 57              |
| I am not eligible to vote because I do not have German citizenship | 63              |

*Remark:* This table reports the demographics and sample proportions of several key survey questions. The total sample consists of 1000 survey participants. Total  $N$  contains all responses minus refused responses.

Table III.2: Summary statistics.

| Variable                     | N    | Min | Max  | Median | Mean  | Std. Dev. |
|------------------------------|------|-----|------|--------|-------|-----------|
| Financial Literacy           | 998  | 0   | 3    | 3.00   | 2.67  | 0.63      |
| Environmental Literacy       | 996  | 0   | 5    | 3.00   | 3.30  | 0.89      |
| Perceived Impact             | 989  | 0   | 5    | 2.75   | 2.68  | 1.01      |
| ESG Pref Score               | 993  | 0   | 4    | 3.00   | 2.91  | 0.72      |
| Questionnaire Time (in sec.) | 1000 | 251 | 4857 | 1247   | 1358  | 587       |
| Data Usable                  | 996  | 2   | 10   | 10.00  | 9.49  | 1.09      |
| Age                          | 988  | 18  | 72   | 28.00  | 29.86 | 8.44      |
| Years of Education           | 996  | 8   | 23   | 16.00  | 14.70 | 2.97      |
| Risk Preference              | 999  | 0   | 10   | 5.00   | 4.94  | 2.19      |
| Time Preference              | 998  | 0   | 10   | 7.00   | 6.94  | 1.96      |
| Trust                        | 999  | 0   | 10   | 5.00   | 4.83  | 2.43      |
| Social Preferences           | 997  | 0   | 10   | 7.00   | 6.58  | 2.03      |
| Social Preferences, costly   | 998  | 0   | 10   | 6.00   | 5.70  | 2.24      |
| Minimal Acceptance in UG     | 997  | 0   | 100  | 50.00  | 41.33 | 15.10     |
| Financial Experience         | 1000 | 1   | 22   | 6.00   | 9.32  | 6.64      |

*Remark:* This table reports the summary statistics for metric variables, aggregated indices, and Likert scales with  $\geq 10$  scale points. The total sample consists of 1000 survey participants. Total  $N$  contains all responses minus refused responses.

Table III.3: Answers for Likert scales.

| Variable               | Total $N$ | Much lower        | Somewhat lower     | Same                       | Somewhat higher | Much higher    | I don't know |
|------------------------|-----------|-------------------|--------------------|----------------------------|-----------------|----------------|--------------|
| Expected return        | 996       | 37                | 529                | 238                        | 141             | 24             | 27           |
| Expected risk          | 997       | 24                | 191                | 386                        | 324             | 51             | 21           |
| Variable               | Total $N$ | Strongly disagree | Rather disagree    | Neither agree nor disagree | Rather agree    | strongly agree |              |
| Greenwashing           | 999       | 72                | 303                | 410                        | 177             | 37             |              |
| Talks often about inv. | 999       | 192               | 339                | 235                        | 190             | 43             |              |
| Variable               | Total $N$ | Not important     | Slightly important | Moderately important       | Important       | Very important |              |
| Importance returns     | 998       | 10                | 31                 | 148                        | 441             | 368            |              |
| Importance risk        | 982       | 1                 | 67                 | 221                        | 420             | 273            |              |
| Importance E           | 982       | 94                | 224                | 301                        | 279             | 94             |              |
| Importance S           | 969       | 95                | 199                | 302                        | 278             | 95             |              |
| Importance G           | 997       | 63                | 189                | 298                        | 299             | 148            |              |

*Remark:* This table reports the number of answers for Likert scales with 5 scale points. The total sample consists of 1000 survey participants. Total  $N$  contains all responses minus refused responses.

### III.3.5 Sample and descriptive statistics

Out of the survey participants who indicated their gender, 601 individuals identify as male, 378 as female, and 16 as non-binary. The median age of the respondents is 28 years, and their education level is 16 years, which is slightly higher than a high school diploma but lower than a fully completed bachelor's degree. As the experiment replicates investment decisions made online, using screenshots from a web interface of a large direct bank, our sample aligns with a younger demographic that is more likely to favor digital investment options over traditional banking advice.

The “Frequency Portfolio Checks” variable in Table III.1 indicates that the individuals in our sample exhibit a diverse range of financial monitoring behaviors. The majority of respondents engage in weekly portfolio checks (431), indicating a frequent and active interest in their financial situation. This is also in line with the “Talks often about Investments” variable in Table III.3, where 339 respondents selected “rather agree”, indicating an inclination towards engaging in frequent discussions on the topic. A substantial number prefer monthly checks (221), reflecting a somewhat less intensive approach. In contrast, a smaller portion of respondents opt for more infrequent checks, with 97 individuals doing so several times per year but less frequently than monthly, and only 11 respondents checking once a year. Moreover, a minimal number never engages in portfolio checks (5), and 204 respondents mentioned not having an investment portfolio.

The majority of respondents (624) make financial decisions independently (“Financial Decision Maker”) or in conjunction with their partner (314). On the other hand, 60 respondents do not make financial decisions themselves but delegate this responsibility to someone else. The “Monthly Net Income” variable reports the income distribution among the respondents. Notably, the largest group of respondents falls into the income category of 2000€ to less than 3000€, comprising 212 individuals. In addition, the second largest group of respondents belongs to the adjacent income groups, with 154 individuals earning between 1000€ and less than 2000€ per month, and 153 individuals earning between 3000€ to less than 4000€. Lastly, the “Party Preference” variable provides insights into the political preferences of the respondents and the political diversity

within the surveyed population. The data reveals a range of political affiliations, with the Green Party being the most popular choice (307), followed by the SPD (123), FDP (116), and The Left (98). Smaller numbers of respondents align with CDU/CSU (60), AfD (26), or other parties (100).

Table III.2 shows that our participants are relatively young (mean and median age both below 30) and well educated – 14.7 years of education on average implies college level. The financial literacy is relatively high as well, while the environmental literacy is about medium level. Ex-post it might have been a better decision to include more financial literacy questions, to capture more variance. The participants have relatively high ESG preferences, and have experience with 6 (median) to around 9 (mean) different investment classes.

Table III.3 presents the summary statistics for several control variables with a Likert scale of five points. The table presents responses related to “Return expectations” and “Risk expectations” of ESG financial products as compared to conventional products. In the case of return expectations, the majority of participants (529) rated it as “somewhat lower”, followed by 238 respondents who felt the returns were “the same”. On the other hand, for risk expectations, a substantial portion (386) indicated that the risk was “the same”, while 324 participants felt it was “somewhat higher”. Regarding greenwashing behind ESG financial products, a notable number (410) chose the “neither agree nor disagree” option, while 303 respondents “rather disagreed” indicating that a majority of respondents do not necessarily associate ESG products with greenwashing.

Additionally, the table highlights respondents’ perceptions of the importance of various factors, including returns, risk and ESG considerations when making investment decisions. Notably, for “Importance of Returns,” a majority found it “important” (441) or even “very important” (368), indicating a strong emphasis on financial returns. In contrast, the “Importance of Risk” is somewhat weaker, with 420 participants saying risk is rather “important” and 273 participants considering it a “very important” dimension.

Interestingly, participants exhibited a more diverse range of opinions when assessing the importance of environmental, social, and governance factors. While 279 individuals indicated that environmental factors were “important”, 301 considered them to be

“moderately important”, and 224 respondents felt they were only “slightly important”. A similar pattern emerges with regard to the importance of social factors. Of the 969 respondents, 278 individuals rated social factors as “important”, 302 considered them “moderately important” and 199 respondents found social factors to be only “slightly important”. The importance of governance factors also drew varied responses. Interestingly, a large number of respondents (148) regarded governance factors as “very important”. Relatively speaking, more respondents seemed to rate governance factors as “very important” compared to environmental and social factors. Furthermore, 299 participants rated governance factors as “important” and 298 as “moderately important”.

### III.4 Empirical specification and results

The analysis is structured as follows: As an initial step, we examine the impact of the brochure. Our analysis demonstrates that the brochure effectively enhances both sustainable finance literacy and sustainable investment behaviors. By randomizing the distribution of the brochure, we ensure that these observed effects are causal.

However, while these findings imply a causal effect of the brochure, they do not necessarily imply that this effect is mediated by sustainable finance literacy. In the second step, we therefore explore whether the brochure’s impact on sustainable investing is causally mediated by sustainable finance literacy. We address this question in the experimental design and econometrically, by designing treatments to control for experimenter demand, by including a host of control variables to block alternative channels, and by running a causal mediation analysis (Imai et al., 2011). These analyses suggest that around half of the brochure’s total effect can be attributed to sustainable finance literacy.

In the third step, we show that the effects of the brochure depend on the participant’s ESG preferences. We will refer to the first two steps as “hypothesis 1” (or H1), and to the third step as “hypothesis 2” (or H2).

### III.4.1 Does the brochure treatment increase sustainable finance literacy and sustainable investments?

We start by analyzing whether the brochure is indeed successful in increasing sustainable finance literacy. As highlighted in Section III.2, and in contrast to financial literacy, there is no established procedure to measure sustainable finance literacy so far. As a result, we adopt Filippini et al. (2024b)'s definition of sustainable finance literacy and develop a set of nine questions that address general ESG considerations as well as more specific considerations that relate primarily to the EU's SFDR regulation. An overview of these questions can be found in Appendix D.

For the treatment to be effective, we expect the treatment group, which gets to read the brochure, to answer significantly more questions correctly than the control group, which does not get to see the brochure. In order to test this, we use the nine questions referred to above and add up the number of correct answers per participant in a sum index. Figure III.2 shows that the median in the treatment group answers on average 6 out of 9 sustainable finance literacy questions correctly. In contrast, the median in the control group answers only 1 out of 9 questions correctly.

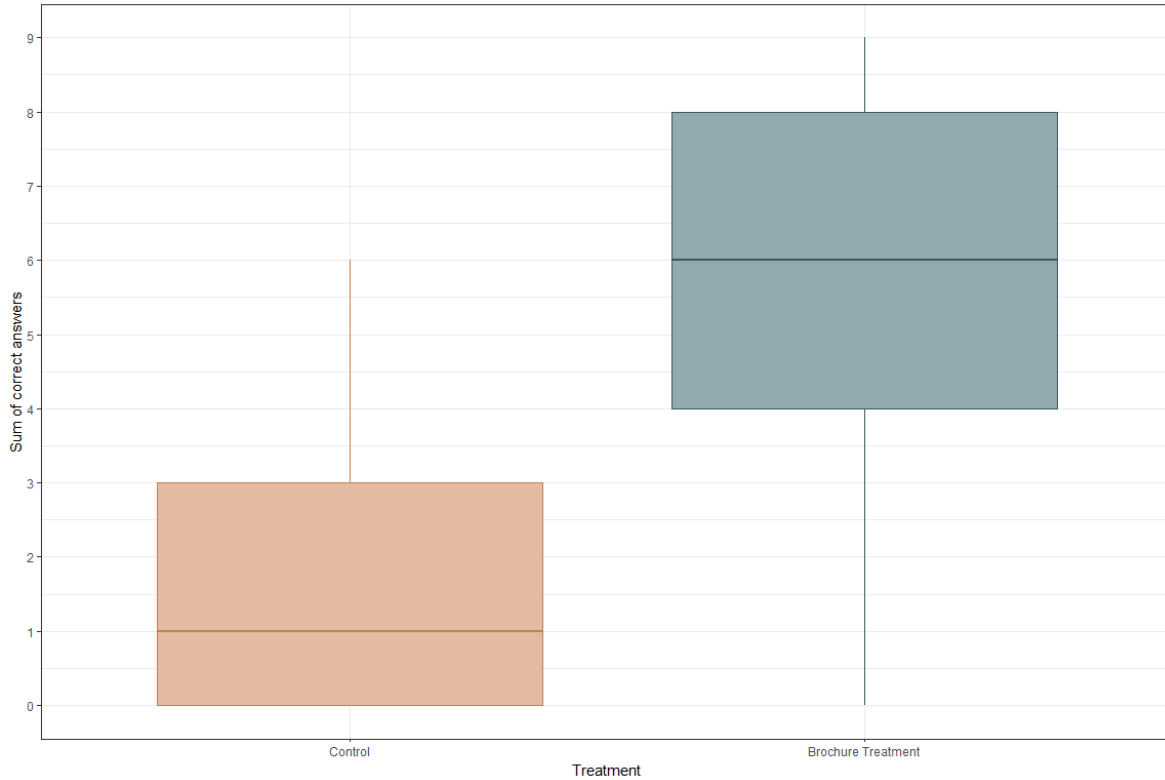
To determine whether the difference between the two groups is also statistically significant, we further investigate our results in an untabulated OLS regression analysis where we regress the sum index on the brochure treatment variable. The coefficient of the brochure treatment corresponds to 4 more correct answers, and is significant at the 1% level. In addition, the explanatory power of the brochure is high: The  $R^2$  of this simple regression is 0.38. We conclude that the treatment effect is both statistically and economically significant and substantially increases sustainable finance literacy.

We continue by analyzing whether the brochure treatment leads to a higher probability of investing in sustainable funds and to base investment decisions on ESG-related information. Figure III.3 illustrates the results, showing bar plots for both dependent variables, split by treatment condition.

Panel A shows the relative frequencies of sustainable investment decisions for the control and treatment groups. As can be seen, sustainable investment decisions, i.e., the



Figure III.2: Participants' responses to the sustainable finance literacy questions.

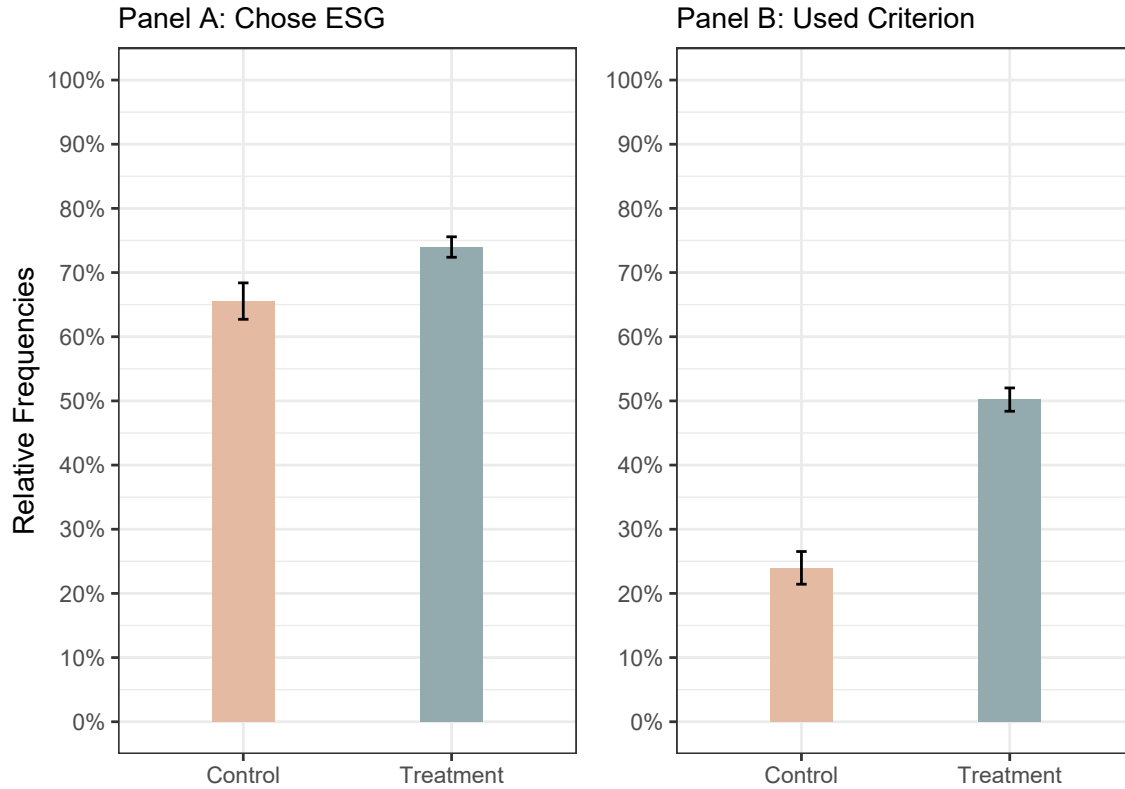


*Remark:* This figure shows the results of the treatment and control groups in relation to our 9 questions on sustainable finance literacy. The correct answers are added to form a sum index, where 9 means that all 9 questions were answered correctly and 0 means that none of the questions was answered correctly.

choice of a sustainable fund in a specific investment round from the available fund selection, account for about 65% of the total number of investment decisions made by the control group. In contrast, sustainable investment decisions account for approximately 74% of total investment decisions made by the treatment group, which represents an increase of 9 percentage points compared to the control group.

In Panel B we show the relative frequencies of participants in both the control and treatment groups who reported taking ESG criteria into account in their investment decisions. In particular, in the control group, ESG criteria played a role in about 25% of investment decisions. In stark contrast, the brochure treatment group had a significantly higher usage rate, with ESG criteria used in about 50% of their investment decisions. Thus, the stated use of an ESG criterion roughly doubles from the control treatment to the brochure treatment.

Figure III.3: Illustration of results for Hypothesis 1.



*Remark:* This figure illustrates the results of H1, showing bar plots for both dependent variables (“Chose ESG” and “Used Criterion”), split by treatment condition. Panel A shows the relative frequencies of sustainable investment decisions for the control and treatment groups. Panel B reports the relative frequencies of participants in both the control and treatment groups who reported taking ESG criteria into account in their investment decisions.

Comparing Panel A and Panel B also indicates that participants often pick sustainable funds even though they do not explicitly state using ESG criteria. This is particularly true for the control group. The control group is less likely to show a conscious tendency to select sustainable funds based on ESG criteria. In contrast, the brochure group appears to make more decisions in favor of sustainable investments and tends to base its decisions more consciously on corresponding ESG information. Overall, this indicates that the control group relies less on ESG information than the brochure group.

The regression models confirm these results. Specifically, we estimate the following

equations, using a logistic regression:

$$\text{Dependent Variable}_{i,p} = \beta_1 \text{Brochure Treatment}_p + \beta_2 \text{controls}_{i,p} + \alpha_p + \epsilon_{i,p} \quad (\text{III.1})$$

where *Dependent Variable*<sub>*i,p*</sub> is either the indicator variable *Chose ESG*<sub>*i,p*</sub>, which is equal to 1 if the decision *i* of participant *p* is to invest in a sustainable fund and 0 otherwise, or *Used Criterion*<sub>*i,p*</sub>, an indicator variable which equals 1 if the participant *p* indicated the use of an ESG criterion in decision *i* and 0 otherwise. *Brochure Treatment*<sub>*p*</sub> is an indicator variable that equals 1 if the participant *p* received the brochure treatment, and 0 otherwise. In our regression results, the coefficient  $\beta_1$  represents the variable of interest as it captures the effect of the brochure treatment on investment decisions.  $\alpha_p$  is a random intercept for each participant *p*, which accounts for the fact that we observe four decisions per participant, and  $\epsilon_{i,p}$  is the error term. Furthermore, *controls*<sub>*i,p*</sub> is an optional vector of additional control variables, depending on the complexity of the model, which we will introduce in the next section.

Table III.4: Results for Hypothesis 1.

|                    | Chose ESG,<br>simple<br>(1) | Chose ESG,<br>medium<br>(2) | Chose ESG,<br>complex<br>(3) | Used criterion,<br>simple<br>(4) | Used criterion,<br>medium<br>(5) | Used criterion,<br>complex<br>(6) |
|--------------------|-----------------------------|-----------------------------|------------------------------|----------------------------------|----------------------------------|-----------------------------------|
| <b>Logits</b>      |                             |                             |                              |                                  |                                  |                                   |
| Brochure treatment | 0.480***<br>(0.106)         | 0.263*<br>(0.104)           | 0.248*<br>(0.106)            | 2.134***<br>(0.217)              | 1.511***<br>(0.194)              | 1.436***<br>(0.189)               |
| Intercept          | 0.757***<br>(0.090)         | -1.143*<br>(0.458)          | -2.719*<br>(1.289)           | -2.116***<br>(0.191)             | -8.125***<br>(0.837)             | -11.995***<br>(2.228)             |
| <b>Margins</b>     |                             |                             |                              |                                  |                                  |                                   |
| Brochure treatment | 0.093***<br>(0.021)         | 0.049*<br>(0.020)           | 0.043*<br>(0.019)            | 0.306***<br>(0.028)              | 0.214***<br>(0.026)              | 0.198***<br>(0.025)               |
| Controls           | none                        | correlated                  | all                          | none                             | correlated                       | all                               |
| N                  | 3993                        | 3934                        | 3438                         | 4000                             | 3936                             | 3440                              |
| $R^2$ marg.        | 0.01                        | 0.06                        | 0.19                         | 0.10                             | 0.28                             | 0.43                              |
| $R^2$ cond.        | 0.21                        | 0.21                        | 0.24                         | 0.65                             | 0.66                             | 0.67                              |

*Remark:* This table presents the results for Hypothesis 1, and reports the logits and margins of mixed models regressions with a random intercept on the decision level, using two different dependent variables as the measure for ESG Investment decision. “Chose ESG” is a Dummy that captures whether a sustainable fund was chosen or not. This measure does not differentiate between Article 8 funds (“light green”) and Article 9 funds (“dark green”). “Used Criterion” is a dummy that captures whether a participant reported to have used any ESG criterion for their decision. “Simple” models do not include any control variables. “Medium” models only include control variables that significantly correlate with the Brochure Treatment variable. “Complex” models include all control variables. Participant-clustered standard errors in parentheses.  $*p < 0.05$ ;  $**p < 0.01$ ;  $***p < 0.001$ .

Table III.4 reports the logit coefficients and margins (average marginal effects, i.e., the average effect of the brochure, given that the effect of the brochure for a given decision is nonlinear and also depends on the control variables) of random effects models using “Chose ESG” and “Used Criterion” as dependent variables, respectively. Here we interpret the simple models in columns (1) and (4), without any control variables. The regression results for both dependent variables are both statistically significant and economically meaningful. The margins imply that the brochure treatment leads to an increase in the probability of choosing a sustainable over a conventional fund by around 9%. They also show that the share of participants relying on ESG information increases by around 31%. Both effects are significant at the 0.1% level.

### **III.4.2 Discussing the effects of sustainable finance literacy on investment decisions**

Currently, there is no method to directly randomize an individual’s knowledge; we must rely on indirect approaches, such as distributing our informational brochure. This limitation means we cannot test the causal effects of sustainable finance literacy with the same level of certainty as we can for the brochure’s direct effects. While we can demonstrate that the brochure enhances sustainable finance literacy and increases sustainable investments, we cannot conclusively show that the brochure increases sustainable investments through improved sustainable finance literacy alone. Other variables, such as heightened attention to ESG products, may also mediate the brochure’s effects on sustainable investments.

This situation leads to two potential issues: First, these mediators could provide an alternative explanation for the changes in sustainable investments, independent of sustainable finance literacy. Second, they might simultaneously influence both sustainable investments and sustainable finance literacy. Ignoring these mediators can create a spurious correlation between sustainable finance literacy and sustainable investments. Given the impossibility of directly randomizing knowledge, we cannot entirely eliminate these alternative mediators through our design. The next best approach is to

present multiple arguments supporting the causal effect of sustainable finance literacy on sustainable investments. While no single argument may be sufficient to establish causality, collectively they make this interpretation the most plausible. We address this by comparing the results of a multiple regression, where we control for all identified mediators, with those from a mediation analysis.

### Statistical control

Controlling for mediators blocks their channels. We leverage this by controlling for all variables collected in the post-experiment questionnaire. The goal is to test whether the treatment retains significant explanatory power even after accounting for these variables. If it does, this suggests support for our proposed sustainable finance channel. However, it is important to note that while this approach controls for all observed variables and unobserved variables that correlate more closely with the control variables than with sustainable finance literacy, multiple regression alone is insufficient to establish causality definitively.

For each dependent variable, we run three model types with different degrees of complexity: In the *simple* model type, we do not include any control variable at all. This model type measures the net effect of the brochure itself on the dependent variables, and we have already interpreted them in the previous section. In the *complex* model type, we include all control variables as outlined in Section III.3.4. The advantage of the complex model type is to directly block as many possible channels as we can. However, the complex model type appears to often overfit the data, as indicated by singularity problems (Bates et al., 2015, 2018). Overfitting is not a major concern in our setting because we do not use the models to predict out of our sample, but it might bias estimates for the sustainable finance literacy coefficient due to idiosyncratic relationships in our sample. A common solution for that problem is to develop a reduced model (Matuschek et al., 2017).

We account for this with the *medium* model type, where we strive for a balance between controlling for the most important potential alternative mediators, while also keeping the model as simple as possible. By definition, an alternative mediator has

to be caused by the brochure, and therefore should be correlated with the treatment variable. Thus, this model only includes control variables that significantly correlate with the treatment variable, as shown in Table III.5. These variables are “perceived impact”, “importance S”, “data usable” and “trust”. The medium model type is simple enough not to cause overfitting, at the cost of potentially overlooking more complex mediations such as several mediators canceling each other out, which would lead to zero-correlations with the treatment.

We want to emphasize that while unobserved variables may positively bias the estimates for sustainable finance literacy, our approach partially mitigates this issue. By controlling for every variable, we might also block variables associated with the sustainable finance literacy channel, therefore we potentially underestimate this channel’s effect. This is particularly relevant for the variable ‘perceived impact’, as shown in Table III.5. The brochure might increase the perceived impact of sustainable financial products independently of sustainable finance literacy. However, it is equally plausible that a better understanding of these products leads to a higher perceived impact. If this latter channel exists, it, along with similar channels, is blocked in our medium and complex regression models.

We also want to emphasize that two of the three variables designed to control for a potential increase in attention to ESG products caused by the brochure, the ‘importance E/G’ variables, are not significantly higher in the brochure treatment group. This finding argues against the notion that the brochure enhances attention toward ESG investments. While this does not entirely eliminate the possibility (since attention effects could be unconscious, and there is a small correlation with the treatment for the ‘S’ variable), we find only weak supporting evidence. Based on our data, this explanation appears implausible.

The results in columns (2), (3), (5) and (6) in Table III.4 show that the coefficients for the brochure treatment drop in both the medium and complex model type for both dependent variables, but stay significant. The choice of sustainable products drops to around half of the original effect size, from an increase of around 9 percentage points to

Table III.5: Correlation coefficients.

| Variable                                                                                  | Correlation | P-Value  |
|-------------------------------------------------------------------------------------------|-------------|----------|
| <b>Pearson correlation coefficients of “Treatment” with numeric and nominal variables</b> |             |          |
| Perceived impact                                                                          | 0.23        | 0.000*** |
| Importance S                                                                              | 0.07        | 0.028*   |
| Data usable                                                                               | -0.07       | 0.038*   |
| Trust                                                                                     | 0.06        | 0.042*   |
| Party preference NA                                                                       | 0.06        | 0.072    |
| Greenwashing                                                                              | -0.05       | 0.129    |
| Social preferences                                                                        | 0.04        | 0.154    |
| Importance E                                                                              | 0.04        | 0.163    |
| Gender non binary                                                                         | 0.04        | 0.187    |
| Importance risk                                                                           | -0.04       | 0.194    |
| Importance returns                                                                        | -0.04       | 0.226    |
| Gender female                                                                             | 0.03        | 0.291    |
| Party not eligible                                                                        | -0.03       | 0.291    |
| Party Greens                                                                              | 0.03        | 0.301    |
| Time preference                                                                           | 0.03        | 0.319    |
| Party FDP                                                                                 | -0.03       | 0.375    |
| Ln UG min. demand                                                                         | -0.03       | 0.379    |
| Importance G                                                                              | -0.03       | 0.403    |
| Party none                                                                                | 0.03        | 0.406    |
| Party AfD                                                                                 | -0.03       | 0.416    |
| ESG pref score                                                                            | 0.03        | 0.419    |
| Risk preference                                                                           | 0.02        | 0.514    |
| Ln interview time                                                                         | 0.02        | 0.529    |
| Talks often about inv.                                                                    | -0.02       | 0.578    |
| Party The Left                                                                            | 0.02        | 0.629    |
| Financial literacy                                                                        | 0.01        | 0.673    |
| Party other                                                                               | 0.01        | 0.709    |
| Gender NA                                                                                 | 0.01        | 0.724    |
| Ln age                                                                                    | 0.01        | 0.73     |
| Financial experience                                                                      | -0.01       | 0.752    |
| Social Preferences, costly                                                                | 0.01        | 0.851    |
| Years of education                                                                        | -0.00       | 0.949    |
| Environmental literacy                                                                    | -0.00       | 0.96     |
| Party SPD                                                                                 | -0.00       | 0.987    |
| <b>Spearman correlation coefficients of treatment with ordinal variables</b>              |             |          |
| Return expectations of ESG funds                                                          | -0.03       | 0.284    |
| Monthly net income                                                                        | -0.02       | 0.44     |
| Portfolio check count                                                                     | -0.02       | 0.563    |
| Risk expectations of ESG funds                                                            | -0.00       | 0.993    |

*Remark:* This table shows the correlation coefficients of each variable with the treatment variable, sorted by p-value. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .



around 4 to 5 percentage points. The conscious usage of ESG criteria drops by roughly 10 percentage points. These results suggest that the control variables indeed constitute alternative channels, but that they are not enough to explain all of the brochure’s effects.

### Mediation Analysis

Section III.4.2 shows that the brochure’s effect sizes drop substantially for both our dependent variables once we include control variables, but stay significant. This implies the existence of other mediators not included in the model — most prominently sustainable finance literacy. However, this argument simply assumes that the increase in sustainable investments is due to sustainable finance literacy; it does not show that. There might still be other mediators for which we did not control. This argument implies that the margins of the four medium and complex models of Table III.4 should best be interpreted as an upper limit for the isolated effects of sustainable finance literacy. At worst, sustainable finance literacy could have no effect at all.

To exclude this hypothesis and measure the effect of the brochure on sustainable investment behavior *only* via sustainable finance literacy, we conduct a causal mediation analysis following the approach of Baron and Kenny (1986), Imai et al. (2011) and Acharya et al. (2016), and recently used in research related to financial literacy (e.g., Carpena and Zia, 2020) and ESG (e.g., Zhou et al., 2022).<sup>11</sup> This approach is complementary to section III.4.2. There we blocked multiple possible channels and interpreted the “leftover” coefficient of the brochure treatment as evidence for the sustainable finance literacy channel. Now we focus only on this channel, by conducting a causal mediation analysis. A mediation analysis decomposes the total effect of a variable into different channels as well. These are the “indirect” effect, which quantifies the extent to which a treatment influences an outcome through a specific mediating variable of interest, in our case sustainable finance literacy, and the “direct” effect, which is the aggregate of any other possible mediator, including unobserved variables. The indirect effect is usually operationalized as the average causal mediation effect (ACME). While

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<sup>11</sup>We use the R package “mediation” (Tingley et al., 2014).

there is some complexity, in principle the ACME is calculated straightforwardly, using a two-stage regression. The first regression estimates the relationship between the brochure and sustainable finance literacy, while the second estimates the relationship between sustainable finance literacy and sustainable investment (both steps include control variables). Then the two coefficients are multiplied to obtain the ACME. Thus, we focus in this analysis on the ACME of sustainable finance literacy.

The idea is not simply to conduct a mediation analysis, but to test whether the results are similar to those of section III.4.2. Conceptually, they do not need to be. To illustrate why, let us decompose the total effect of the brochure on sustainable investments into three types of channels: First the sustainable finance literacy channel, second the observable channels for which we controlled in the former section, and third the unobservable channels. Controlling for the observable channels leaves a coefficient which is the combination of the other two types. Conducting a mediation analysis isolates the sustainable finance channel, although not necessarily causal. Therefore, the mediation analyses can result in a smaller estimate than the control approach. If the results are similar, however, this result speaks against the existence of unobservable channels.

Table III.6 shows the results, for both the nonlinear models from table III.4 and for linear models which we include as a robustness check, for both model types (medium and complex) and for both dependent variables.<sup>12</sup> For the “Chose ESG” variable, each total effect of the brochure is in line with the results from the earlier analyses, with estimates ranging from 4.3% to 5.6%. The ACME of sustainable finance literacy in the complex models is around 4 to 5%, which also confirms our initial results.

For the medium models, the analysis suggests that the effect of sustainable finance literacy is larger, at around 10%. This implies that the net effect of all alternative mediators combined would actually be negative, meaning that we underestimate the effect of sustainable finance literacy. We do not follow this interpretation since the medium models in the table might not incorporate some relevant effects while the complex

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<sup>12</sup>We conduct the mediation analysis only for the medium and complex models since we already know from the earlier analysis that the effect from the simple model drops to roughly half after controlling for other variables, indicating alternative mediators.

Table III.6: Estimations for total effects and average causal mediation effects (ACME).

| Dependent variable | Model type        | Total effect | ACME suflili |
|--------------------|-------------------|--------------|--------------|
| Chose ESG          | Medium nonlinear  | 0.056***     | 0.101***     |
| Chose ESG          | Medium linear     | 0.046*       | 0.097***     |
| Chose ESG          | Complex nonlinear | 0.047**      | 0.049***     |
| Chose ESG          | Complex linear    | 0.043*       | 0.044***     |
| Used criterion     | Medium nonlinear  | 0.217***     | 0.207***     |
| Used criterion     | Medium linear     | 0.188***     | 0.179***     |
| Used criterion     | Complex nonlinear | 0.197***     | 0.143***     |
| Used criterion     | Complex linear    | 0.177***     | 0.121***     |

*Remark:* This table shows the estimations for total effects and average causal mediation effects (ACME) for both dependent variables with sustainable finance literacy as the mediator, varied by which control variables and which regression formulas are used. Complex models include all control variables, medium models include Perceived Impact, Importance S, Trust, and Use Data. Linear models use mixed effects linear models on both stages. Nonlinear models use Poisson regressions for the mediator and logit regressions for the dependent variables.

models do. However, this provides more evidence that the effect size of the brochure via sustainable finance literacy is around 4 to 5% for the “Chose ESG” variable, and that alternative unobservable mediators such as increased attention or an experimenter demand effect cannot explain this finding away.

Next, we turn to the “Used Criterion” variable. The four models estimate the total effects to be around 17.7% to 21.7%, which is in line with the earlier results. The ACME estimates in the medium models are around the same size as the total effects, which implies that the brochure’s effect after controlling for observables is purely driven by sustainable finance literacy. The complex models, however, suggest that the ACME of sustainable finance literacy is smaller than the total effect. For these models, the ACMEs vary around 12.1% to 14.3%, which is around two-thirds of the total effects of the respective models. To err on the conservative side, we again champion the interpretation from the complex models. It suggests that while the brochure’s effect on the decision criteria is in part due to an increase in sustainable finance literacy, other mediators play a role as well. The channel through sustainable finance literacy still seems to be the most relevant, as it accounts for roughly two-thirds of the total effect both in the linear and nonlinear models.

In sum, the results from the mediation analysis provide additional support for our

initial results discussed in Section III.4.2 and confirm that the effect size of the brochure via sustainable finance literacy is around 4 to 5% for actual behavior. However, we do see that the brochure has some unmeasured influences beyond sustainable finance literacy regarding the conscious usage of ESG criteria.

We now examine the various effects of sustainable finance knowledge combined with sustainability preferences on investment behavior (H2). We argue that the effect of the brochure depends on the level of ESG preferences.

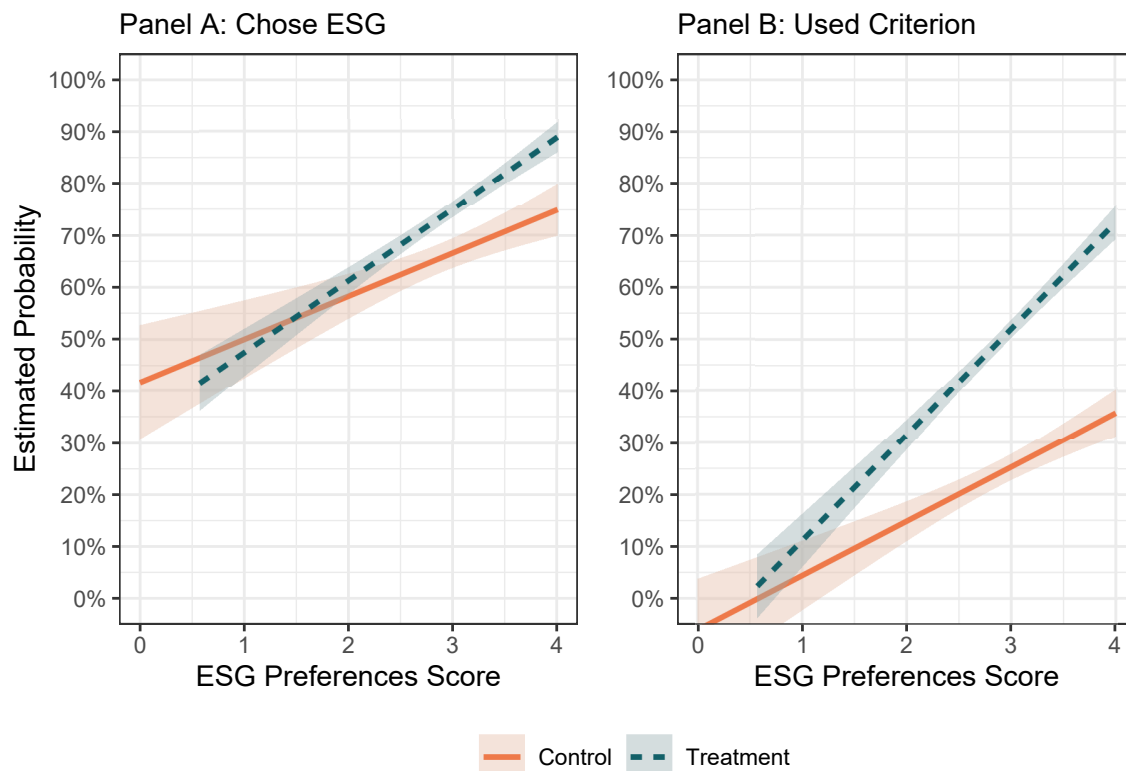
### **III.4.3 Does an increase in sustainable finance literacy, combined with high ESG preferences, lead to an increase in the probability of investing sustainably?**

Does the brochure work for all the participants in the same way, and what role do ESG preferences play in this context? A person who is knowledgeable about ESG and sustainable investing but has no strong environmental and/or social preferences could make a conscious decision *not* to invest in sustainable finance products. Conversely, a person with strong environmental and/or social preferences but insufficient knowledge of sustainable investing may have difficulty effectively translating those preferences into actionable investment decisions. As a next step, we therefore explore the role of both sustainability preferences and sustainable finance literacy in shaping investment decisions. In other words, we focus on ESG preferences and interact such preferences with the brochure treatment.

We mirror the analysis for H1, but now include an interaction term between the treatment and the ESG pref score. We investigate models with control variables, because the ESG preferences are measured, not randomized. Specifically, we estimate the following model based on a logistic regression:

$$\begin{aligned} \text{Dependent Variable}_{i,p} = & \beta_1 \text{Brochure Treatment}_p + \beta_2 \text{ESG Pref Score}_p \\ & + \beta_3 \text{controls}_{i,p} + \alpha_p + \epsilon_{i,p} \quad (\text{III.2}) \end{aligned}$$

Figure III.4: Interaction plot for Hypothesis 2.



*Remark:* This figure is an interaction plot illustrating the results of H2. It plots the relationships between ESG preferences and the two dependent variables “Chose ESG” and “Used Criterion” for the control and treatment groups. Panel A shows the relationship between the probability of investing sustainably and ESG preferences. Panel B plots the relationship between the incorporation of ESG criteria into investment decisions and ESG preferences.

All the variables and model types (simple, medium, complex) stay the same as for H1, and in addition the ESG Pref Score<sub>*p*</sub> is the average answer from participant *p* for the seven ESG preference questions. These questions are five-point Likert scales, but the labels for the points do not include any numeric values. Thus, we scale the variable as a number between 0 and 4, which conveniently gives the coefficient  $\beta_1$  for the brochure treatment in the regression model a meaningful interpretation: It is the effect of the brochure for the participants with the lowest sustainability preferences.

Figure III.4 is an interaction plot that illustrates the results. It plots the relationship between ESG preferences and the two dependent variables “Chose ESG” and “Used

Criterion” for each of the two experimental groups. Our second hypothesis (H2) implies that for these relationships, the slope for the brochure treatment should be steeper than for the control group. We find this result for both dependent variables. Panel A shows that the probability of investing sustainably increases with ESG preferences. The slope is steeper for the brochure treatment group compared to the control group, and both groups start to differ significantly as the ESG preferences score increases. Panel B shows that this pattern also holds for the incorporation of an ESG criterion into the decision-making process, and the differences become significant at a slightly lower level of ESG preferences.

Table III.7 corroborates these findings, primarily for the dependent variable “Chose ESG”. The table reports the logits<sup>13</sup> for each of the six models, which again are combinations of the two different dependent variables and the three model types. Columns (1) to (3) show the results for the actual behavior as a dependent variable. In each of the models, the interaction term is significant on the 1% level, with the predicted sign. However, for the “Used Criterion” variable, in columns (4) to (6), we find the predicted signs, but only the coefficient in the complex model is significant at the 5% level. We attribute this to the relatively large standard errors, which are approximately twice as large as for the “Chose ESG” variable. Thus, the “Used Criterion” variable appears to be noisier.

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<sup>13</sup>Unlike for H1, we do not report margins (AMEs) for H2 because we are interested in the interaction term. In this case, margins cannot be calculated because, unlike in a linear model, they are not assumed to be constant (Williams, 2012). We can, however, use the logits to infer the interaction term’s statistical significance.

Table III.7: Results for Hypothesis 2.

|                           | Chose ESG,<br>simple<br>(1) | Chose ESG,<br>medium<br>(2) | Chose ESG,<br>complex<br>(3) | Used criterion,<br>simple<br>(4) | Used criterion,<br>medium<br>(5) | Used criterion,<br>complex<br>(6) |
|---------------------------|-----------------------------|-----------------------------|------------------------------|----------------------------------|----------------------------------|-----------------------------------|
| Brochure treatment        | −0.644<br>(0.396)           | −0.827*<br>(0.387)          | −0.743<br>(0.392)            | 0.760<br>(0.860)                 | 0.095<br>(0.826)                 | −0.209<br>(0.797)                 |
| ESG pref score            | 0.412***<br>(0.110)         | 0.299**<br>(0.110)          | −0.032<br>(0.120)            | 1.135***<br>(0.244)              | 0.688**<br>(0.238)               | −0.030<br>(0.244)                 |
| Brochure * ESG pref score | 0.387**<br>(0.135)          | 0.385**<br>(0.132)          | 0.350**<br>(0.133)           | 0.452<br>(0.283)                 | 0.487<br>(0.270)                 | 0.550*<br>(0.260)                 |
| Intercept                 | −0.437<br>(0.323)           | −1.450**<br>(0.534)         | −2.108<br>(1.310)            | −5.374***<br>(0.756)             | −9.139***<br>(1.060)             | −10.960***<br>(2.308)             |
| Controls                  | none                        | correlated                  | all                          | none                             | correlated                       | all                               |
| N                         | 3969                        | 3910                        | 3438                         | 3972                             | 3912                             | 3440                              |
| $R^2$ marg.               | 0.07                        | 0.10                        | 0.19                         | 0.20                             | 0.33                             | 0.43                              |
| $R^2$ cond.               | 0.22                        | 0.22                        | 0.25                         | 0.66                             | 0.67                             | 0.67                              |

*Remark:* This table presents the results for Hypothesis 2, and reports the logits of mixed models regressions with a random intercept on the decision level, using two different dependent variables as the measure for ESG Investment decision. “Chose ESG” is a Dummy that captures whether a sustainable fund was chosen or not. This measure does not differentiate between Article 8 funds (“light green”) and Article 9 funds (“dark green”). “Used Criterion” is a dummy that captures whether a participant reported to have used any ESG criterion for their decision. “Simple” models do not include any control variables. “Medium” models only include control variables that correlate with the Brochure Treatment variable. “Complex” models include all control variables. The relevant variable is the interaction term. The ESG Pref Score is not centered. Participant-clustered standard errors in parentheses. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

Interestingly, we find in columns (1) to (3) a negative effect of the treatment variable, which is even significant at the 5% level in the medium model in column (2). Since we deliberately mapped the ESG preferences score on a scale from 0 to 4, this coefficient represents the behavior of the participants with the lowest ESG preferences. Therefore, it might even be argued that, for individuals with low ESG preferences, the brochure reduces sustainable investments. This seems reasonable because if sufficient sustainable finance literacy makes it possible to identify sustainable funds, this very literacy combined with low preferences might help such individuals to actively avoid sustainable funds. In addition, it could also be that individuals who have a negative view of ESG issues in general may have a negative reaction to the brochure treatment. This could be related not only to anti-ESG sentiment, but also to the perception of sustainable financial products as a form of greenwashing.

However, further research would be needed to underpin this finding. Admittedly, we do not find this pattern in the case of the other dependent variable, which should be the case if the decision to avoid sustainable funds were a conscious one. Furthermore, the results are based on relatively few observations. Only 125 participants in both groups combined have an ESG preference score of 2 or less, and only 1 participant has a value of 0. Nevertheless, these results might point to a more nuanced understanding of sustainable finance literacy to be explored in later studies.

In sum, we conclude that we find strong evidence for H2 for the behavior and weaker, more mixed evidence for the conscious use of ESG criteria. Specifically, a higher level of sustainable finance literacy, combined with high ESG preferences, leads to a higher probability of choosing an ESG fund. This suggests that sustainable finance literacy helps individuals to better align their preferences with their investment decisions. However, the effectiveness of the brochure seems limited among individuals who have low ESG preferences and could potentially have unintended negative effects in some cases.

#### **III.4.4 Robustness checks**

We conduct an array of additional tests to check the robustness of our baseline results. First, we estimate the nonlinear models with a probit link function (“probits”) instead



of logits. Second, we also run a linear model (“LPM”), which we not only use as a robustness check, but also as a second method to estimate effect sizes. Third, we restrict the sample to participants who gave a score of at least 5 out of 10 to the statement “I have given my answers and made my decisions carefully and to the best of my knowledge, and therefore think that my data should be used for the study” (“Use data 5”). We also run a robustness check excluding the fastest and slowest 2.5% of the participants (“Time 95%”). Finally, we check for the presence of an EDE, as described in Section III.3.1.

Table III.8 shows the results of the robustness checks for H1. In the probit models, the effect of the brochure treatment remains consistent with the baseline results. The treatment has a positive and statistically significant effect on both “Chose ESG” and “Used Criterion” across all levels of model complexity (simple, medium, complex) in columns (1) to (6). The LPM model results also show a consistent positive effect of the brochure treatment on ESG investment decisions: The treatment is statistically significant and positively associated with “Chose ESG” and “Used Criterion” across all columns, and the coefficients have a similar, but slightly smaller size as the margins in Table III.4. When restricting the sample to participants who gave a score of at least 5 out of 10 for their data use statement, the positive effect of the brochure treatment on ESG decisions remains robust. Similarly, excluding the fastest and slowest 2.5% of participants from the sample does not substantially alter the results.

Table III.8: Margins for each robustness check for Hypothesis 1.

| Variables              | <i>Dependent Variable, Model</i> |                             |                              |                                  |                                  |                                   |
|------------------------|----------------------------------|-----------------------------|------------------------------|----------------------------------|----------------------------------|-----------------------------------|
|                        | Chose ESG,<br>simple<br>(1)      | Chose ESG,<br>medium<br>(2) | Chose ESG,<br>complex<br>(3) | Used criterion,<br>simple<br>(4) | Used criterion,<br>medium<br>(5) | Used criterion,<br>complex<br>(6) |
| <b>Probits</b>         |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | 0.094***<br>(0.021)              | 0.051*<br>(0.020)           | 0.046*<br>(0.019)            | 0.307***<br>(0.027)              | 0.216***<br>(0.026)              | 0.198***<br>(0.024)               |
| <b>LPM</b>             |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | 0.084***<br>(0.019)              | 0.045*<br>(0.019)           | 0.042*<br>(0.019)            | 0.262***<br>(0.026)              | 0.190***<br>(0.025)              | 0.181***<br>(0.025)               |
| <b>Use data 5</b>      |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | 0.095***<br>(0.021)              | 0.052*<br>(0.020)           | 0.046*<br>(0.019)            | 0.314***<br>(0.028)              | 0.220***<br>(0.026)              | 0.202***<br>(0.025)               |
| <b>Time 95%</b>        |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | 0.100***<br>(0.022)              | 0.057**<br>(0.020)          | 0.054**<br>(0.019)           | 0.309***<br>(0.029)              | 0.210***<br>(0.027)              | 0.200***<br>(0.026)               |
| <b>EDE</b>             |                                  |                             |                              |                                  |                                  |                                   |
| High EDE-<br>treatment | -0.017<br>(0.025)                | -0.025<br>(0.024)           | -0.012<br>(0.023)            | 0.054<br>(0.037)                 | 0.046<br>(0.034)                 | 0.062*<br>(0.032)                 |
| Low EDE-<br>treatment  | -0.036<br>(0.026)                | -0.022<br>(0.024)           | -0.010<br>(0.022)            | -0.033<br>(0.037)                | 0.000<br>(0.034)                 | 0.021<br>(0.032)                  |

*Remark:* This table summarises the margins for each robustness check for Hypothesis 1. We estimate the nonlinear models with a probit link function (“Probits”). We also run a linear model (“LPM”). We restrict the sample to participants who gave a score of at least 5 out of 10 to the statement “I have given my answers and made my decisions carefully and to the best of my knowledge, and therefore think that my data should be used for the study” (“Use data 5”). We also run a robustness check excluding the fastest and slowest 2.5% of the participants (“Time 95%”). Finally, we check for the presence of an experimenter demand effect (EDE). “Chose ESG” is a dummy that captures whether a sustainable fund was chosen or not. “Used Criterion” is a dummy that captures whether a participant reported to have used any ESG criterion for their decision. “Simple” models do not include any control variables. “Medium” models only include control variables that correlate with the Brochure Treatment variable. “Complex” models include all control variables. Participant-clustered standard errors in parentheses. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

Table III.9 reports the results of the robustness checks for H2, where we interact the brochure treatment with the sustainability preferences. The results from the probit and LPM models generally confirm the direction of effects observed in Table III.7, although there are differences in the magnitude and statistical significance of some coefficients. Specifically, for the probit models in columns (1) to (3), the interaction term retains its significance ( $p < 0.01$ ) and remains consistent with the main results. For the LPM, the coefficients are generally smaller but remain statistically significant, except in column (3). The results also hold in the robustness checks “Use data 5” and “Time 95%”. Thus, all four types of robustness checks (probits, LPM, Use data 5 and Time 95%) provide strong and consistent support for the results of H2 with “Chose ESG” as the dependent variable.

Turning to columns (4) to (6) with “Used Criterion” as the dependent variable, the results are more contrasted. The coefficient of the interaction term keeps its significance ( $p < 0.05$ ) in the complex model in column (6) for the probit models, and even becomes strongly significant ( $p < 0.001$ ) across all three columns in the LPM models. The results hold consistently in the “Time 95%” robustness check, but not entirely when considering the “Use data 5” check where the statistical coefficient remains in the complex model in Column (3) and disappears in the others. Overall, the results of the four robustness checks confirm the main results and even provide some evidence that the main analyses for H2 with “Used Criterion” as a dependent variable might underestimate the significance of the interaction term. We find significant results for models (4) and (5) in two out of four robustness checks. To err on the conservative side, however, we conclude that the evidence for H2 with “Used criterion” as the dependent variable is weaker than that for the “Chose ESG”.

Table III.9: Margins for each robustness check for Hypothesis 2.

| Variables              | <i>Dependent Variable, Model</i> |                             |                              |                                  |                                  |                                   |
|------------------------|----------------------------------|-----------------------------|------------------------------|----------------------------------|----------------------------------|-----------------------------------|
|                        | Chose ESG,<br>simple<br>(1)      | Chose ESG,<br>medium<br>(2) | Chose ESG,<br>complex<br>(3) | Used criterion,<br>simple<br>(4) | Used criterion,<br>medium<br>(5) | Used criterion,<br>complex<br>(6) |
| <b>Probits</b>         |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | −0.381<br>(0.236)                | −0.497*<br>(0.230)          | −0.446<br>(0.231)            | 0.561<br>(0.493)                 | 0.072<br>(0.470)                 | −0.146<br>(0.456)                 |
| Brochure *             | 0.230**                          | 0.232**                     | 0.211**                      | 0.229                            | 0.282                            | 0.331*                            |
| ESG pref<br>Score      | (0.080)                          | (0.078)                     | (0.078)                      | (0.162)                          | (0.154)                          | (0.149)                           |
| <b>LPM</b>             |                                  |                             |                              |                                  |                                  |                                   |
| Brochure-<br>treatment | −0.080<br>(0.073)                | −0.110<br>(0.072)           | −0.090<br>(0.073)            | −0.033<br>(0.100)                | −0.119<br>(0.093)                | −0.129<br>(0.095)                 |
| Brochure *             | 0.055*                           | 0.054*                      | 0.045                        | 0.100**                          | 0.108***                         | 0.107***                          |
| ESG pref<br>Score      | (0.025)                          | (0.024)                     | (0.024)                      | (0.034)                          | (0.031)                          | (0.031)                           |
| <b>Use data 5</b>      |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | −0.639<br>(0.398)                | −0.496*<br>(0.230)          | −0.717<br>(0.395)            | 0.919<br>(0.861)                 | 0.219<br>(0.832)                 | −0.134<br>(0.799)                 |
| Brochure *             | 0.390**                          | 0.232**                     | 0.345*                       | 0.410                            | 0.456                            | 0.534*                            |
| ESG pref<br>Score      | (0.136)                          | (0.078)                     | (0.134)                      | (0.283)                          | (0.272)                          | (0.260)                           |
| <b>Time 95%</b>        |                                  |                             |                              |                                  |                                  |                                   |
| Brochure<br>treatment  | −0.751<br>(0.415)                | −0.858*<br>(0.406)          | −0.648<br>(0.409)            | 0.400<br>(0.887)                 | −0.121<br>(0.849)                | −0.421<br>(0.816)                 |
| Brochure *             | 0.442**                          | 0.414**                     | 0.338*                       | 0.574*                           | 0.549*                           | 0.623*                            |
| ESG pref               | (0.142)                          | (0.138)                     | (0.139)                      | (0.292)                          | (0.278)                          | (0.267)                           |

Continued on next page...

| Variables              | <i>Dependent Variable, Model</i> |                             |                              |                                  |                                  |                                   |
|------------------------|----------------------------------|-----------------------------|------------------------------|----------------------------------|----------------------------------|-----------------------------------|
|                        | Chose ESG,<br>simple<br>(1)      | Chose ESG,<br>medium<br>(2) | Chose ESG,<br>complex<br>(3) | Used criterion,<br>simple<br>(4) | Used criterion,<br>medium<br>(5) | Used criterion,<br>complex<br>(6) |
| Score                  |                                  |                             |                              |                                  |                                  |                                   |
| <b>EDE</b>             |                                  |                             |                              |                                  |                                  |                                   |
| High EDE-<br>Treatment | −0.189<br>(0.591)                | −0.321<br>(0.573)           | −0.951<br>(0.605)            | −0.423<br>(1.067)                | −0.355<br>(0.578)                | −0.420<br>(1.038)                 |
| Low EDE-<br>treatment  | −0.953<br>(0.620)                | −0.789<br>(0.603)           | −1.242*<br>(0.614)           | −2.227<br>(1.138)                | −1.183<br>(0.618)                | −1.296<br>(1.078)                 |
| High EDE *             | 0.058<br>(0.204)                 | 0.082<br>(0.198)            | 0.302<br>(0.206)             | 0.300<br>(0.358)                 | 0.197<br>(0.194)                 | 0.293<br>(0.343)                  |
| ESG pref score         | 0.267<br>(0.211)                 | 0.228<br>(0.206)            | 0.410*<br>(0.208)            | 0.677<br>(0.375)                 | 0.394<br>(0.204)                 | 0.488<br>(0.352)                  |

*Remark:* This table summarises the margins for each robustness check for Hypothesis 2. We estimate the nonlinear models with a probit link function (“Probits”). We also run a linear model (“LPM”). We restrict the sample to participants who gave a score of at least 5 out of 10 to the statement “I have given my answers and made my decisions carefully and to the best of my knowledge, and therefore think that my data should be used for the study” (“Use data 5”). We also run a robustness check excluding the fastest and slowest 2.5% of the participants (“Time 95%”). Finally, we check for the presence of an experimenter demand effect (EDE). “Chose ESG” is a dummy that captures whether a sustainable fund was chosen or not. “Used Criterion” is a dummy that captures whether a participant reported to have used any ESG criterion for their decision. “Simple” models do not include any control variables. “Medium” models only include control variables that correlate with the Brochure Treatment variable. “Complex” models include all control variables. Participant-clustered standard errors in parentheses. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

In both Table III.8 and Table III.9, we find very little and inconclusive evidence for the presence of an EDE. Most coefficients are insignificant, and they often have the wrong sign. For example, the “High EDE” coefficients in Table III.8 should be positive because a stronger EDE should increase the probability to invest sustainably. Instead, the coefficients for the “Chose ESG” variable are all negative. Furthermore, we find that the interaction term in Table III.9 is significantly larger for the “Low EDE” group compared to the treatment group without any EDE manipulation. If there was an EDE, this coefficient should actually be smaller. The only result that speaks in favor of an EDE is the significant coefficient for the complex “Used Criterion” model in Table III.8. Therefore, we conclude that there is very little and weak evidence for the presence of an EDE affecting our baseline results.

### **III.4.5 Additional analysis: Does sustainable finance literacy lead to differentiation between light green and dark green funds?**

While little is known to date about how retail investors understand and are influenced by ESG information, there is clear empirical evidence that institutional investors respond to ESG information (e.g., Hartzmark and Sussman, 2019), particularly SFDR labels of funds (see e.g., Becker et al. 2022; Scherer and Hasaj 2023). Therefore, we examine whether sustainable finance literacy in combination with high sustainability preferences leads participants to differentiate between light green (SFDR Article 8) and dark green (SFDR Article 9) funds. Specifically, we hypothesize that individual investors with high sustainability preferences will deliberately invest in funds that explicitly pursue environmental or social objectives that are aligned with their preferences if they are able to identify information that allows them to recognize such funds.

To analyze this question, we focus on the fourth round of investment decisions, which includes all three types of SFDR funds: a dark green fund, a light green fund, and a conventional fund. We restrict the sample to the participants who chose one of the two sustainable funds. As the dependent variable we use a dummy variable which

indicates whether the light green or the dark green fund was chosen. As independent variables we use the treatment variable, and additionally, we focus on one particular question from the sustainable finance literacy module: “Sufili local 4”. This question specifically tests knowledge about financial products classified as SFDR Article 9.

If sustainable finance literacy influences the choice between article 8 and article 9 financial products, it should be the specific knowledge about the SFDR’s article 9 in particular that causes this choice, but not necessarily other aspects of sustainable finance literacy. Therefore, we expect this question to have the strongest influence on the decision between the two fund classes, while the other questions should not be as influential. We again expect an interaction with ESG preferences, for the same reasons as in the main analyses. Thus, we mirror our analyses from the main results, and label the different models as “H1” and “H2”. We only compute models with the full set of control variables.

Table III.11 provides support for both hypotheses. This table reports the results of logistic regressions as logits, for both hypotheses as well as for both independent variables. The brochure treatment increases the probability of choosing the article 9 fund over the article 8 fund (column 1), but this increase depends on the ESG preferences (column 2). Specific knowledge about the SFDR’s article 9 also increases the probability of choosing a corresponding fund over an article 8 fund (column 3), again moderated by ESG preferences (column 4). In both columns (2) and (4) the coefficients of the interaction terms taking ESG preferences into account become larger than the individual effects of the brochure and the Sufili local 4-question.

Calculating the margins, as reported in Table III.12, shows that the brochure treatment increases the probability of choosing the article 9 fund over the article 8 one by around 9.4%, and knowing the correct answer to the Sufili local 4-question by around 12.2%. The interaction terms have the predicted signs.

We conclude that sustainable finance literacy not only increases the probability of investing sustainably at all, but also increases the probability of choosing the more sustainable option out of several sustainable alternatives. Since the other sustainable finance literacy questions do not increase the probability of choosing a dark green fund,

Table III.11: Results for the additional analyses with logistic regressions.

|                    | Chose dark<br>green over light<br>green, H1<br>(1) | Chose dark<br>green over light<br>green, H2<br>(2) | Chose dark<br>green over light<br>green, H1<br>(3) | Chose dark<br>green over light<br>green, H2<br>(4) |
|--------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|
| Brochure treatment | 0.427*<br>(0.197)                                  | -1.193<br>(0.819)                                  |                                                    |                                                    |
| Brochure *         |                                                    | 0.547*<br>(0.269)                                  |                                                    |                                                    |
| ESG pref score     |                                                    |                                                    |                                                    |                                                    |
| Sufili local 4     |                                                    |                                                    | 0.567*<br>(0.234)                                  | -1.654*<br>(0.796)                                 |
| Sufili local 4 *   |                                                    |                                                    |                                                    | 0.764**<br>(0.262)                                 |
| ESG pref score     |                                                    |                                                    |                                                    |                                                    |
| ESG pref score     | -0.023<br>(0.163)                                  | -0.417<br>(0.253)                                  | -0.032<br>(0.166)                                  | -0.461*<br>(0.223)                                 |
| Sufili global 1    |                                                    |                                                    | 0.147<br>(0.240)                                   | 0.176<br>(0.242)                                   |
| Sufili global 2    |                                                    |                                                    | 0.028<br>(0.241)                                   | 0.036<br>(0.242)                                   |
| Sufili global 3    |                                                    |                                                    | -0.227<br>(0.272)                                  | -0.235<br>(0.274)                                  |
| Sufili global 4    |                                                    |                                                    | -0.179<br>(0.208)                                  | -0.202<br>(0.210)                                  |
| Sufili global 5    |                                                    |                                                    | 0.176<br>(0.205)                                   | 0.144<br>(0.207)                                   |
| Sufili local 1     |                                                    |                                                    | 0.002<br>(0.204)                                   | -0.075<br>(0.208)                                  |
| Sufili local 2     |                                                    |                                                    | -0.274<br>(0.231)                                  | -0.253<br>(0.232)                                  |
| Sufili local 3     |                                                    |                                                    | 0.075<br>(0.203)                                   | 0.073<br>(0.204)                                   |
| Intercept          | -1.059<br>(2.396)                                  | 0.144<br>(2.477)                                   | -0.888<br>(2.470)                                  | 0.367<br>(2.516)                                   |
| Controls           | all                                                | all                                                | all                                                | all                                                |
| N                  | 714                                                | 714                                                | 709                                                | 709                                                |
| Pseudo $R^2$       | 0.11                                               | 0.12                                               | 0.12                                               | 0.13                                               |

*Remark:* This table presents the results for the additional analyses of whether participants with higher sustainable finance literacy prefer article 9 funds (“dark green”) over article 8 funds (“light green”), and reports the logits of logistic regressions. The sample is limited to decision 4, and only includes the decisions for any of the two sustainable funds. The dependent variable in each model is a dummy variable which equals 1 if participants chose the article 9 fund, and 0 if they chose the article 8 fund. The models differ in whether the main explanatory variable is the treatment or a question that specifically measures knowledge about article 9 funds (“Sufili local 4”), and whether this variable is interacted with the ESG Preferences Score. Each model includes all control variables. The ESG Pref Score is not centered. Participant-clustered standard errors in parentheses. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$



Table III.12: Results for the additional analyses with margins of logistic regressions.

|                    | Chose dark green over<br>light green, H1 | Chose dark green over<br>light green, H1 |
|--------------------|------------------------------------------|------------------------------------------|
| Brochure treatment | 0.094*<br>(0.043)                        |                                          |
| Sufili local 4     |                                          | 0.122*<br>(0.050)                        |
| ESG pref score     | -0.005<br>(0.036)                        | -0.007<br>(0.036)                        |
| Sufili global 1    |                                          | 0.032<br>(0.052)                         |
| Sufili global 2    |                                          | 0.006<br>(0.052)                         |
| Sufili global 3    |                                          | -0.049<br>(0.059)                        |
| Sufili global 4    |                                          | -0.039<br>(0.045)                        |
| Sufili global 5    |                                          | 0.038<br>(0.044)                         |
| Sufili local 1     |                                          | 0.000<br>(0.044)                         |
| Sufili local 2     |                                          | -0.059<br>(0.049)                        |
| Sufili local 3     |                                          | 0.016<br>(0.044)                         |
| Controls           | all                                      | all                                      |

*Remark:* This table presents the results for the additional analyses of whether participants with higher sustainable finance literacy prefer article 9 funds (“dark green”) over article 8 funds (“light green”), and reports the margins of logistic regressions. The sample is limited to decision 4, and only includes the decisions for any of the two sustainable funds. The dependent variable in each model is a dummy variable which equals 1 if participants chose the article 9 fund, and 0 if they chose the article 8 fund. The models differ whether the main explanatory variable is the treatment or a question that specifically measures knowledge about article 9 funds (“Sufili local 4”). Each model includes all control variables. The ESG Pref Score is not centered. Participant-clustered standard errors in parentheses. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

it is reasonable to conclude that this effect is driven by specific knowledge about the SFDR's article 9 funds.

At first glance, this result might seem to contradict the main findings of Heeb et al. (2022), who show in their experiment that participants do not differentiate between different degrees of sustainable impact. Although article 9 funds are not necessarily impact funds and therefore may not necessarily achieve more impact compared to article 8 funds (Chesney and Lambillon, 2023), we would like to highlight a key difference between their experimental design and ours. While the treatments differ in how much of an impact the ESG fund has ("low impact" versus "high impact"), participants in Heeb et al. (2022)'s main experiment do not explicitly decide between two ESG funds directly. They either have to choose between a high-impact fund and a conventional fund, or a low-impact fund and a conventional fund.

In contrast, the participants in our experiment can decide between one conventional and two different ESG funds. A vast literature on preference construction and preference reversals emphasizes such contrasts in the choice environment as deciding factors. For an overview, see Dhimi (2016) and Lichtenstein and Slovic (2006). In our experiment, participants are able to compare both ESG funds, which may allow them to construct their preferences differently as the differences between these ESG funds become more apparent. A decision with only one ESG fund would not allow for that.

In an additional analysis, Heeb et al. (2022) actually find this "comparability" effect of an additional ESG fund as well. In their experiment, the participants decide between a conventional fund without any positive environmental impact, a second fund with a positive but relatively moderate impact, and a third fund with a relatively large positive impact. Heeb et al. (2022) conclude from their analyses that "the joint evaluation demonstrates that comparability creates some sensitivity to impact" (see p. 1765, Heeb et al. 2022), which is consistent with our results.

Interestingly, for participants with very low levels of ESG preferences, we again find some evidence that sustainable finance literacy can decrease sustainable investments. In the H2 models in columns (2) and (4), the main effects are negative, and even significantly negative ( $p < 0.05$ ) for the Sufli local 4-question.

### III.4.6 Additional analysis: Contrasting evidence on the determinants of ESG investing

In this section, we discuss further factors that influence ESG investment decisions by contrasting our results with the existing literature. The objective of this analysis is not to test established findings with our data,<sup>14</sup> but rather to analyze whether our dataset contains some of these established results in order to provide further evidence for the validity of our data. To this end, we use a correlation matrix, as shown in Table III.13, which reports the correlation coefficients between the “Chose ESG” variable and each of the control variables used in this study for which prior literature exists. We discuss whether these correlations are consistent with the literature in terms of coefficient sign and statistical significance. It is important to note, however, that there is no established consensus in the literature for several of the variables discussed below.

**Age** In our sample, age has a negative, but statistically insignificant correlation with the likelihood to invest in ESG funds. This is broadly in line with the literature, which usually finds that younger individuals invest more sustainably. Bauer et al. (2021), Bauer et al. (2022), Brodback et al. (2019), Giglio et al. (2025) and Gutsche and Zwergel (2020) observe a significant negative age effect. Bauer and Smeets (2015), Filippini et al. (2024b) and Riedl and Smeets (2017a) find a negative effect, but their results contain model specifications where age is not significant. In the context of a Swedish pension scheme, Anderson and Robinson (2021) derive a positive and significant correlation when the default investment option cannot be interpreted as having sustainable characteristics, and a negative and significant correlation when it can.

**Gender** While we find that gender predicts sustainable investments significantly, the evidence in the literature is rather mixed. Giglio et al. (2025) show that although women agree more with the fact that ESG investments are “the right thing to do” than men, they often do not translate these preferences into action. Bauer et al. (2021) analyze a Dutch pension fund that bases its sustainable investment policies on the decision of its members and find that women are more in favor of a sustainable investment

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<sup>14</sup>See Hünermund and Louw (2023) for why this would not be a feasible endeavor.

Table III.13: Correlation coefficients.

| Variable                                                                                          | Correlation | P-value  |
|---------------------------------------------------------------------------------------------------|-------------|----------|
| <b>Pearson correlation coefficients of “Chose ESG” with numeric and nominal control variables</b> |             |          |
| Perceived impact                                                                                  | 0.18        | 0.000*** |
| Party Greens                                                                                      | 0.12        | 0.000*** |
| Greenwashing                                                                                      | -0.10       | 0.000*** |
| Social preferences                                                                                | 0.09        | 0.000*** |
| Risk preferences                                                                                  | -0.09       | 0.000*** |
| Party FDP                                                                                         | -0.08       | 0.000*** |
| Talks often about inv.                                                                            | -0.08       | 0.000*** |
| Gender female                                                                                     | 0.07        | 0.000*** |
| Party AfD                                                                                         | -0.06       | 0.000*** |
| Financial literacy                                                                                | 0.05        | 0.001**  |
| Environmental literacy                                                                            | 0.05        | 0.001**  |
| Trust                                                                                             | 0.05        | 0.002**  |
| Social preferences, costly                                                                        | 0.04        | 0.008**  |
| Party The Left                                                                                    | 0.04        | 0.015*   |
| Time preferences                                                                                  | 0.03        | 0.084    |
| Ln age                                                                                            | -0.02       | 0.172    |
| Party SPD                                                                                         | -0.01       | 0.374    |
| Financial experience                                                                              | 0.00        | 0.777    |
| Years of education                                                                                | 0.00        | 0.786    |
| <b>Spearman correlation coefficients of “Chose ESG” with ordinal control variables</b>            |             |          |
| Expected risk of ESG funds                                                                        | -0.07       | 0.000*** |
| Monthly net income                                                                                | -0.04       | 0.034*   |
| Expected performance of ESG funds                                                                 | 0.00        | 0.957    |

*Remark:* This table shows the correlation coefficients of each control variable for which there exists literature with the “Chose ESG” variable, sorted by p-value. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

policy. Gutsche and Zwergel (2020) and Bauer et al. (2022) observe that women invest significantly more in sustainable funds. Other studies (e.g., Anderson and Robinson, 2021; Brodback et al., 2019; Filippini et al., 2024b; Riedl and Smeets, 2017a) do not find a significant gender difference, although the coefficient sign is usually in favor of women investing more sustainably.

**Education** We find that the correlation between education and the probability of investing sustainably is zero. This finding is also common in the literature. Some studies do not find any results for education (see e.g., Bauer et al. 2021; Gutsche and Zwergel 2020). For those who derive significant results, the effects are mixed. Filippini

et al. (2024b) present six models, out of which four have a positive relationship. Bauer and Smeets (2015) and Riedl and Smeets (2017a) both find that university education does not increase the absolute amount of sustainable investments, but on the contrary decreases their share in the portfolio. Finally, Bauer et al. (2022) find a positive relationship, but operationalize education as having a Ph.D., which limits generalizability.

**Income and wealth** While we observe a negative relationship between income and sustainable investments, the literature on income and wealth, as another measure of financial well-being, is very mixed. Anderson and Robinson (2021) exemplify this in their study, having significant correlations with income in both directions, depending on the model. Bauer and Smeets (2015) find no relationship for income, but a negative relationship for wealth. Bauer et al. (2021) and Filippini et al. (2024b) also find no relationship with income, but Filippini et al. (2024b) reports a positive correlation between wealth and sustainable investment. Giglio et al. (2025) show that the share of sustainable investments increases with wealth, while Riedl and Smeets (2017a) show the opposite. Finally, Brodback et al. (2019) and Gutsche and Zwergel (2020) find positive associations between income and ESG investing, while Bauer et al. (2022) find a negative relationship.

**Financial literacy and environmental literacy** We find positive associations for both financial literacy and environmental literacy. The literature on these relationships is contrasted. Filippini et al. (2024b) find no significant correlation for both these variables with sustainable investments. Similarly, Anderson and Robinson (2021) find no clear relationship for environmental literacy, and in the case of financial literacy, the relationship is in some models even significantly negative. In contrast, Aristei and Gallo (2021) find a positive relationship between financial literacy and sustainable investments, and Bethlendi et al. (2022) report a positive association between environmental literacy and ESG investing.

**Return expectations** In our data the correlation between expected returns of ESG investments and the likelihood to invest in ESG funds is zero. In a similar way, Heeb et al. (2022) find that neither investors' risk expectations nor their return expectations correlate significantly with their willingness to pay for sustainable investments. Bauer

et al. (2021) report that individuals favor sustainable investments independent of return expectations. Specifically, they find that the majority of respondents in their experiment chooses to expand sustainable investing at their pension fund, even those who have negative return expectations or are uncertain about what to expect in terms of returns. Furthermore, Anderson and Robinson (2021) note that a green pro-social value orientation is strongly related to the willingness to pay higher fees for environmentally sustainable funds. Overall, this combined evidence suggests that return expectations are not the primary determinant of ESG investment decisions. Finally, Giglio et al. (2025) conduct a survey of retail investors and report considerable heterogeneity among these investors in their ESG return expectations and motivations for ESG investing, with 25% of respondents saying they are primarily motivated by ethical considerations and only 7% by return expectations.

**Risk perception** We find an inverse and statistically significant relationship between the perceived risk of ESG investments and the probability of investing in ESG funds. This seems reasonable, as we expect survey respondents to invest less in sustainable funds if they perceive them to be riskier – even more so as returns do not appear to be their primary motive. In contrast, Gutsche and Zwergel (2020) do not find any relationship between perceived higher risks of sustainable funds and investments in sustainable funds. Bauer and Smeets (2015) investigate the risk perceptions of retail investors with regard to SRI funds and find that these investors do not expect higher risks from such investments compared to conventional funds. Rather, they expect such investments to have both higher returns and lower risk, indicating that investors might have a poor understanding of the relation between risk and return on securities, or that they are overconfident about sustainable investments.

**Political preferences** We find that Green Party and Left party voters are more likely to invest sustainably than CDU/CSU voters (i.e., the reference category in Table III.13), while voters from the pro-business party FDP and the far-right party AfD are less likely to do so. In general, these findings, in particular the effects observed for the Green Party voters, are in line with the literature. Based on an experiment with German households, Gutsche and Zwergel (2020) show that participants with an ecolog-

ical political identification invest more sustainably in a stated choice experiment. Briere and Ramelli (2021) demonstrate that French individuals living in regions with a high share of Green Party voters invest more sustainably. For the U.S., Giglio et al. (2025) find that there is a higher ESG participation by retail investors resident in predominantly Democratic areas compared to Republican ones. Even Anderson and Robinson (2021), who find no relationship between green attitudes and sustainable investment, still provide evidence for a strong association between voting in favor of the Swedish Green Party and ESG investing.

**Social preferences and trust** We show a positive and statistically significant relationship between social preferences (for both “social preferences” and “social preferences, costly”) and the probability of investing in ESG funds. Riedl and Smeets (2017a) and Gutsche et al. (2023) find that social preferences are key to investing in sustainable funds in general, but they do not explain how much wealth is allocated to these funds. Bauer et al. (2021) show that social preferences rather than financial beliefs drive the choice for more sustainability. Our results also show a positive correlation between trust and ESG investing. This is in line with Gutsche and Zwergel (2020), but not perfectly aligned with Filippini et al. (2024b), who do find positive correlations, but except for one model they are insignificant.

**Time and risk preferences** We find a positive, but statistically insignificant correlation between time preferences and the likelihood to invest in ESG funds. This is broadly consistent with Bauer et al. (2022) who report that individuals with a longer-term perspective are more significantly likely to invest in a sustainable funds. Turning to risk preferences, we find that such preferences negatively predict sustainable investments. This is in line with Bauer and Smeets (2015), but not fully consistent with Filippini et al. (2024b) who find a weakly positive relationship between risk preferences and ownership of sustainable financial products. Likewise, Riedl and Smeets (2017a) find a positive correlation between risk tolerance and the amount invested in sustainable equity funds, but no significant impact on the probability of investing in a sustainable manner.

**Financial experience** The correlation between financial experience and likelihood

of investing in ESG products is zero in our data. This suggests that having financial experience doesn't make one more or less likely to invest in ESG funds. Anderson and Robinson (2021) find that households that exhibit strong pro-environmental behaviors and beliefs are financially disengaged and generally uninterested in financial matters. In addition, Kaustia and Torstila (2011) show that left-wing investors are less inclined to invest in stocks because of their general aversion toward financial markets. Briere and Ramelli (2021) report that the offering of sustainable investment options increases the willingness of investors, including those with a strong pro-social orientation, to participate in financial markets due to a better value alignment. Thus, if these individuals do invest, their investments are likely more driven by environmental and social considerations than by financial expertise.

**Talks often about investments** Riedl and Smeets (2017a) use this variable as a proxy for social signaling and report that investors who talk more often about their investments are more likely to invest in a socially responsible way. In our experiment, we find the opposite result. However, as Riedl and Smeets (2017a) note, this variable is likely not a pure measure of social signaling. Instead, it may also be associated with other determinants of sustainable investing, such as financial experience or financial engagement. In particular, we expect that individuals who are more financially engaged are also more likely to talk about their investments with their peers. The observed negative relationship between the variable “talks often about investments” and the probability of investing in ESG funds seems to confirm this and might once again suggest that individuals with strong sustainability preferences are more disengaged from financial decisions.

**Perceived impact** We find a positive and statistically significant relationship between perceived impact and the likelihood of investing in ESG funds. This is consistent with studies using similar variables. Riedl and Smeets (2017a) report that people who perceive ESG funds as having a positive impact on society have a higher likelihood of holding ESG equity. Brodback et al. (2019) find such a positive relationship in a survey among retail investors on the relative importance of social responsibility. In addition, Heeb et al. (2022), find no effect of the actual impact in their main experiments



but some effect using the comparability treatments, which might point to the positive influence of perceived impact on sustainable investments.

In sum, the correlations found in our dataset are broadly in line with the patterns and relationships observed in the literature. This validates our dataset and strengthens its external validity, and consequently our main results.

## III.5 Discussion & implications

In this paper, we show that knowledge about sustainable investments combined with at least moderate sustainability preferences can significantly influence sustainable investment behavior. In particular, we show that an educational brochure designed to increase sustainable finance literacy increases the probability of investing in an ESG-labelled fund by around 9%, of which around 4 to 5% are causally mediated by an increase in sustainable finance literacy. We also show that the brochure leads participants to consciously use more ESG criteria in their investment decisions by around 20%. Around two-thirds of this effect size can be attributed to sustainable finance literacy. However, the brochure does not work for participants with low sustainability preferences, and there is some weak evidence that it might even reduce their willingness to invest sustainably. For participants who decided to invest sustainably, the brochure also increases the probability of investing in “dark green” article 9 funds, compared to “light green” article 8 funds, by around 12%.

Our study entails some limitations, which warrant careful consideration but also may highlight the potential for further research. One of the primary limitations of our study is that it relies on a sample of German participants recruited through Prolific, which may not fully represent the diversity of characteristics and preferences of retail investors worldwide. In particular, the financial literacy of our participants is uncharacteristically high. Future research could therefore extend our findings to additional geographical and cultural backgrounds, preferably by conducting field experiments in an actual financial context, and including a finer measure for financial literacy. This approach would provide a more complete understanding of the generalizability of our findings across

different investor demographics.

Furthermore, in keeping with Filippini et al. (2024b)'s definition of sustainable finance literacy, a portion of our brochure is focused on the regulatory context of the EU, and in particular, the SFDR. Future research could explore the adaptation of educational materials to other regulatory contexts. This approach would provide further insights into the definition of sustainable finance literacy and the effectiveness of tailored educational content in promoting sustainable investment behavior.

In addition, our study focuses on the immediate effects of providing an educational brochure on participants' investment decisions. While this is a faithful implementation of our research question, for practical purposes, it would be desirable to gain further insights into the longer-term impacts of sustainable finance literacy. Tracking participants' investment decisions over time could shed light on whether such a brochure treatment is effective in the long run and has a lasting impact on investment behavior.

By using screenshots of funds offered by a bank through an online financial account, the selection environment of our experiment has high external validity, but it is also accompanied by a simplified and standardized presentation of information. This selection may not be universally applicable, as some retail investors may face a broader range of ESG information in other investment situations. As Anderson and Robinson (2021) point out, one of the biggest challenges in making sustainable investment decisions is overcoming the informational hurdles associated with such decisions. In other words, in an environment with many different sources of information that are presented in a non-standardized way, the task of choosing a sustainable fund that matches one's sustainability preferences might be more difficult than in our environment. In addition, even the task of searching for reliable and trustworthy information can be daunting, which might deter investors from investing sustainably in the first place. Both these arguments suggest a larger role of sustainable finance literacy in the field, which we cannot capture in our experiment. Future research might delve into that aspect.

Our results, combined with this argument, also provide important implications for the way ESG-related information should be displayed and communicated to retail investors. The fund classification emerging from the SFDR lowers information hurdles

substantially. That such a simplification of the choice environment is useful might best be illustrated by the results of the additional analyses, where we show that the specific knowledge about the SFDR's article 9 increases the probability of choosing such funds. It is unlikely that we would find such results if the requirements behind article 9 were not condensed into such a concise format – the caveat being, of course, that such requirements are implemented and enforced faithfully, and that this classification does not degrade into a tool for greenwashing.

Our findings also have important implications for policymakers. Policymakers in the EU are increasingly emphasizing, for example through MiFID II, the need for financial professionals to assess and take into account their clients' sustainability preferences when making investment recommendations. While this focus on quantifying sustainability preferences is justified, our research highlights a potential pitfall of exclusively concentrating on preferences without considering individuals' knowledge of sustainable investments. In particular, our findings show that it is equally important to assess retail investors' knowledge of sustainable investments. Policymakers should therefore strive to strike a balance between measuring ESG preferences and promoting sustainable finance literacy. This entails ensuring that retail investors have access to educational resources and information that allow them to make informed decisions.

## III.6 Conclusion

We present evidence that investors' sustainable investment behavior is not only driven by their ESG preferences, but also by their knowledge of sustainable financial products. We arrive at this result using a pre-registered experiment based on a large sample of German participants recruited through the Prolific platform. Our findings have important implications for our understanding of how to model and predict investors' sustainable investment behavior. Moreover, our research bears implications for policymakers seeking to integrate sustainability considerations into the financial system and to steer capital flows towards sustainable investments.

# Chapter IV

## Raising their Voices: Shareholder Soft Engagement on ESG Issues at Annual General Meetings

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# Raising their voices: Shareholder soft engagement on ESG issues at annual general meetings

## Abstract

The right to speak and ask questions at annual general meetings (AGMs) represents one of the few avenues for shareholders to interact directly and publicly with the firm's management. We examine the tone and content of shareholder communication during AGMs with a focus on environmental, social, and governance (ESG) issues. Using AGM transcripts of U.S. companies between 2003 and 2022, we find that institutional shareholders are more vocal about sustainability issues than their non-institutional counterparts. Shareholders are especially vocal and critical at AGMs of firms with poor sustainability performance. The negative tone is associated with lower approval rates for management and director proposals, but not with higher approval rates for ESG proposals, illustrating that shareholders “walk the talk” to varying degrees. Overall, shareholder soft engagement at AGMs complements voting as part of a broader spectrum of shareholder activism.

**JEL Classification:** G03, G23, G34, G39

**Keywords:** Shareholder engagement, annual general meeting, ESG, textual analysis

## IV.1 Introduction

Annual general shareholder meetings (AGMs) at publicly listed companies are a key corporate governance ritual. Beyond voting on specific agenda items, AGMs provide shareholders with a platform to interact with management, discuss the company’s past performance and future strategy, ask questions and express their views — essentially exercising their “voice” (Cuñat et al., 2015). Although AGMs have been criticized as overly scripted events that simply rehash “old news” to shareholders (Short and Keasey, 1999), they offer a distinct advantage when used actively: they grant all shareholders, regardless of the size of their ownership stake, the right to engage in a public, direct, individual and therefore comparatively nuanced dialogue with the firm’s management (Monks et al., 2004).

Unlike other common engagement mechanisms, such as filing proposals or engaging in private negotiations — options generally only accessible to large investors (Gillan and Starks, 1998; Denes et al., 2015; McCahery et al., 2016; Hoepner et al., 2023) — the AGM dialogue stands out as a particularly cost-effective engagement option for shareholders seeking to voice their concerns and press for corporate reform (Van der Elst, 2011).<sup>1</sup> This form of communication is not only public and direct, but also unrestricted by specific time constraints, making it attractive for a wide range of shareholders. Different groups such as trade unions, religious organizations, non-governmental organizations (NGOs), as well as non-institutional shareholders, including employees and small individual shareholders, have increasingly embraced this “soft” form of engagement to “look managers and directors in the eye” and raise key concerns during AGMs. With shareholders able to submit questions remotely (e.g., via a chat), this trend has even persisted with the rise of digital and hybrid AGMs (Gao et al., 2020; Brochet et al., 2023).

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<sup>1</sup>For example, to file a proposal, shareholders are required to own at least \$2000 US in market value, or 1%, of the company’s securities for at least one year. In addition, shareholders may submit only one proposal, which has to be worded as a request or a recommendation, and may only address specific topics (O’Rourke, 2003). Thus, management often excludes proposals by citing limitations on permissible topics. In addition, non-institutional shareholders, who typically have fewer resources, may face the added challenge of hiring legal expertise or mobilizing other shareholders (Norli et al., 2014; Flammer et al., 2021).

Since statements made during an AGM are not only witnessed by other shareholders, but may also attract the attention of the financial media, this form of public engagement allows the views expressed to quickly gain wider visibility (Dimitrov and Jain, 2011). In addition, if management fails to adequately address the concerns raised, media reports may generate widespread discussions that could harm the firm’s reputation (O’Rourke, 2003; Cranenburgh et al., 2014; Gomez-Carrasco and Michelon, 2017; Benton and You, 2018). As a result, the possibility of facing sharp criticism from shareholders during AGMs represents a significant concern for managers (Cepuk, 2007).

The AGM dialogue gains particular relevance when considering that shareholders’ expectations have evolved considerably in recent years, moving beyond a sole focus on financial aspects to also encompass broader sustainability considerations. This shift is reflected in the growing number of sustainability-related proposals brought to a vote at AGMs, underscoring investors’ growing efforts to push environmental and social issues higher up the corporate agenda (Flammer et al., 2021; Grewal et al., 2016; Krueger et al., 2020; Hoepner et al., 2023). However, since shareholder proposals are non-binding and unlikely to be implemented (Levit and Malenko, 2011), their impact is often limited. Furthermore, these proposals, along with other forms of investor engagement, predominantly reflect the interests of large and sophisticated investors (Brochet et al., 2023; Barko et al., 2021; Flammer et al., 2021; Hoepner et al., 2023). As a result, shareholders with more limited resources may be increasingly turning to the AGM dialogue as a means of holding management accountable for their track record on sustainability issues. For example, a study on AGMs of Dutch listed companies found that sustainability-related questions and comments increased from about 2% in 2004 to over 20% in 2017 Lafarre and Van der Elst (2018). In this paper, we provide evidence that the AGM dialogue has emerged as an important channel for shareholders to engage on these issues.

While extensive research has examined various facets of shareholder engagement — such as the activities of large investors with portfolio companies, the submission of shareholder proposals, and voting behavior (see e.g., Cuñat et al., 2015; Aggarwal et al., 2019; Dikolli et al., 2022; Hoepner et al., 2023) — relatively little attention has been

given to the practice of shareholders voicing their concerns during AGMs as another form of engagement. In this paper, we use the term of “soft engagement” to describe the act by shareholders of making statements (e.g., by asking questions or sharing a comment) during AGMs. Our focus is specifically on shareholder soft engagement related to environmental, social and governance (ESG) issues. Motivated by the growing importance of sustainability issues for shareholders, this paper aims to provide a comprehensive and detailed analysis of the AGM as a platform for shareholder engagement and interaction with company management. As sustainability issues, including those related to climate change, grow in importance and complexity, understanding shareholder perspectives on these issues also becomes increasingly critical. As such, AGMs serve as a unique forum where diverse shareholder views are expressed and represented. Furthermore, considering the recent politicization of ESG topics in the United States (Edmans, 2023b), the US context provides a particularly compelling and relevant setting for examining these increasingly polarizing issues.

In this paper, we analyze three key aspects. The first focuses on shareholders who raise their voices on ESG issues, and their defining characteristics. We examine the types of shareholders engaging in such AGM dialogue, the range of sustainability topics they address (i.e., their “ESG-related communication”), and the extent of this ESG-related communication. In particular, we document how different types of institutional and non-institutional shareholders actively engage on these issues at the AGM. In addition, using data related to the geographical location of the AGM participants, we assess the role of the “political environment” in this context. For the purposes of this study, we define the political environment as the partisan orientation of the US states in which the shareholders reside or are headquartered. We categorize it as Republican-leaning or Democratic-leaning based on voting patterns in presidential elections.

The second aspect focuses on the firms as “targets” of shareholder soft engagement on ESG issues. In particular, we analyze how such engagement relates to the sustainability performance of the firms holding their AGMs. Prior studies have shown that AGMs generate strong attention among shareholders and are particularly contentious events when investors are dissatisfied with the firm’s financial performance (Dimitrov and



Jain, 2011). For example, critical questions about executive compensation are more likely to be raised at shareholder meetings following a poor performance of the share price (Cepuk, 2007). We assess whether a comparable dynamic may be observed for corporate ESG performance. In particular, we assess whether shareholders are more likely to address ESG issues in their AGM statements when a firm's ESG performance is weaker, as measured by its ESG rating. Furthermore, we analyze the tone of shareholder statements, focusing on the negativity of their language, and examine whether such tone also relates to the ESG performance. The underlying intuition is that shareholders may be particularly attentive to sustainability issues if they consider managerial performance in this area to be lacking. In addition, they may also express their discontent at the AGMs by raising concerns with a negative tone.

The third aspect pertains to AGM proposals. Beyond the idea of “one share, one voice”, AGMs play a critical role in enabling shareholders to vote on various agenda items (i.e., “one share, one vote”). These voting items may be initiated by management (management-sponsored proposals) or by shareholders themselves (shareholder-sponsored proposals).<sup>2</sup> We therefore examine the relationship between shareholder soft engagement and voting behavior with respect to both management-sponsored and shareholder-sponsored proposals. The first underlying premise is that shareholder soft engagement at AGMs may serve as a “barometer” of broader shareholder sentiment, reflecting either approval or discontent with management's performance. As a result, there may be a relationship between such sentiment, as reflected in shareholder tone, and voting behavior. The second premise is that AGMs may serve as a platform for specific shareholder groups to mobilize support for their proposals, particularly those related to ESG issues. By vocally expressing their views at AGMs, shareholders may seek to rally their peers and garner support for their cause. We examine both premises.

To address these questions, we study a large sample of 1,813 AGM transcripts from U.S. firms over the time period 2003 to 2022. We explicitly focus on statements made

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<sup>2</sup>Depending on the format of the AGM, shareholders may submit their vote at the meeting in person or online. Many firms also provide shareholders with the possibility to submit their vote in advance of the AGM, e.g., by mail. Shareholders who cannot attend the AGM can appoint a proxy, i.e., a representative or another individual to vote on their behalf.

by shareholders during these meetings. In our analyses, we employ a textual analysis approach to examine the content and tone of shareholder communication (Hillert et al., 2014; Tetlock, 2007; Price et al., 2012). We draw on two established dictionaries: the dictionary of Loughran and McDonald (Loughran and McDonald, 2011) and the Harvard IV-4 psychosocial dictionary (Tetlock, 2007), which are designed to capture negative tone in a financial and sociological context, respectively.<sup>3</sup> In addition, we also add to the literature by developing a dictionary designed to capture the environmental, social and governance words in shareholder communication. Based on this newly created dictionary, we calculate the share of words in shareholder AGM statements that pertain to environmental, social and governance topics. We also classify the shareholder statements according to ten fine-grained categories of institutional and non-institutional shareholders to better capture nuances in shareholder characteristics and preferences. Our classification comprises the following ten categories: individual shareholder, (former) employee, trade union, asset manager, public asset manager, religious asset manager, analyst, NGO, religious organization, proxy.<sup>4</sup>

Our analyses deliver the following sets of results. First, our findings indicate that ESG topics are an integral part of shareholder soft engagement at AGMs, with all categories of shareholders in our sample addressing ESG-related issues. At the same time, we also find that these categories of shareholders attach varying degrees of importance to different ESG issues according to their preferences. For example, religious asset managers<sup>5</sup> and NGOs are among the shareholder types that contribute most to the share of environmental words relative to individual shareholders. This is in line with earlier studies underlying that these shareholder categories were among the first investors to integrate sustainability considerations into their investment process and are nowadays important actors in the field of responsible investments (see e.g., Gillan

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<sup>3</sup>In the following, we refer to these dictionaries as “LMD dictionary” and “Harvard-IV dictionary”.

<sup>4</sup>We provide a detailed description of the various shareholder categories assessed in our study in Section IV.2.2 of this paper. Examples of statements by each shareholder category can be found in Appendix F.

<sup>5</sup>For example, we make a distinction between different types of institutional shareholders, including “religious” asset managers, such as church pension funds and faith-based investment firms, and “public” asset managers, including public sector funds and public pension funds like the Illinois State Board of Investment.

and Starks, 1998; Hong and Kacperczyk, 2009; Louche et al., 2012). Furthermore, we find that trade unions are comparatively more vocal about social issues, in line with the notion that trade unions represent the collective interests of workers and employees, and resort to shareholder engagement to safeguard their interests (see e.g., Marens, 2004; Anderson et al., 2007; Sjöström, 2009).

Considering the distinction between institutional and non-institutional shareholders, we find that institutional shareholders (especially asset managers, religious asset managers, and public-sector investors) are more vocal about ESG issues than small, non-institutional shareholders. Therefore, while AGMs provide a uniquely democratic platform where even the smallest shareholders can participate, our results suggest that non-institutional shareholders do not use this forum as prominently as institutional shareholders to advocate for ESG issues. This relationship is also partly shaped by the political orientation of the US states where shareholders are geographically located. Individual shareholders in Republican-leaning states are even less likely to address ESG issues at AGMs compared to those in Democratic-leaning states. For institutional shareholders, the influence of the political environment is less pronounced, though. Overall, we find that institutional investors actively engage on ESG issues in their AGM statements, and this engagement is not significantly constrained when their headquarters are located in Republican-leaning states.

Second, our analysis reveals a negative relationship between a firm's ESG performance and the prominence of ESG-related words in shareholder communication during AGMs. Specifically, firms with a higher ESG performance, as measured by their industry-adjusted ESG ratings, attract a lower proportion of shareholder statements addressing ESG issues. This relationship is most pronounced when examining the overall ESG ratings but also holds, albeit to a lesser extent, when considering the individual pillar scores. For example, shareholders engage less on social issues at the AGMs of firms with a comparatively higher social performance. Likewise, we find some evidence that firms with stronger governance performance see fewer shareholder statements addressing governance-related concerns. As a next step, we look more closely at the tone of shareholder statements. Similar to the relationship between ESG performance

and ESG-related shareholder communication, we find that stronger overall ESG performance is associated with a less negative tone of shareholder statements, as captured by the LMD and Harvard-IV dictionaries.

Third, we show that shareholders only partly “walk the talk” when it comes to proposals. On the one hand, we find that a more negative tone in their statements is associated with lower approval rates for management-sponsored proposals. Furthermore, we also find that this relationship is particularly strong for management proposals related to director elections or re-elections. This supports the idea that shareholder tone at AGMs serves as a barometer of broader shareholder sentiment. On the other hand, we do not find evidence that a more negative tone and a higher proportion of ESG-related communication during AGMs are associated with an increased support for ESG proposals. Thus, while some shareholders who voice ESG concerns during AGMs may be more likely to vote in favor of such proposals (see e.g., Dikolli et al., 2022), this verbal engagement does not appear to have a strong mobilizing effect and translate into broader support for other shareholder-sponsored proposals as another form of shareholder advocacy.

In sum, our paper is one of the first to comprehensively examine the role of shareholders in shaping the AGM dialogue with respect to sustainability issues. In doing so, we contribute to several research streams. First, we add to the research on direct interaction settings between management and shareholders. Previous studies have focused on settings such as investor conferences (Zhang, 2022), earnings conference calls (Matsumoto et al., 2011; Blau et al., 2015; Dzieliński et al., 2022), and internal investor relations functions (Chapman et al., 2022). Unlike AGMs, these forums typically cater to sophisticated investors (Brochet et al., 2023). In contrast, AGMs, which offer a broader and more democratic platform for interaction, have received comparatively less scholarly attention. Notable exceptions include Brochet et al. (2023) and Gao et al. (2020), who explore the determinants and outcomes of virtual shareholder meetings, and Dimitrov and Jain (2011), who highlight how managers attempt to mitigate shareholder pressure by reporting favorable news ahead of shareholder meetings. The authors conclude that AGMs are an “important corporate governance mechanism, so much so

that managers attempt to influence shareholders” (p. 1198, Dimitrov and Jain 2011). In addition, Lafarre and Van der Elst (2018) document a substantial increase in the share of sustainability-related questions asked by institutional shareholders of Dutch listed companies. Our findings therefore contribute to the limited body of research on AGMs by examining both the tone and ESG-related content of shareholder communication during these meetings.

Second, our study contributes to the growing body of literature on shareholder engagement and sustainability issues. Consistent with Flammer et al. (2021), our findings highlight that shareholders are not a monolithic group, but exhibit heterogeneity in their objectives and preferences. AGMs serve as an important forum where various types of shareholders, each with their own history of ESG engagement, can express their views. For example, endowment funds of religious organizations and political groups were historically among the first to use the shareholder proposal process to address social and environmental concerns (Gillan and Starks, 1998). By the mid-1980s, public pension funds and individual activist shareholders, often referred to as “corporate gadflies”, also became prominent filers of shareholder resolutions at AGMs (Gillan and Starks, 1998; Gantchev and Giannetti, 2020; Wang and Mao, 2015). Furthermore, NGOs began purchasing shares to initiate CSR-focused lobbying campaigns and disrupt shareholder meetings (Subramanian, 2020). More recently, a growing number of more traditional institutional investors have joined initiatives like the Principles for Responsible Investment (PRI) to advocate for the inclusion of social and environmental factors in investment strategies (Flammer et al., 2021). Our study therefore provides valuable insights into the soft engagement pursued by these diverse actors via the AGM dialogue.

In addition, our paper sheds light on the role of shareholders as “norm promoters”, who leverage their position of ownership to drive change — not only in the traditional corporate governance sense, but also increasingly in terms of corporate social responsibility (Sjöström, 2009). This form of “norm entrepreneurship” is increasingly supported by both financial and non-financial motivations (see e.g., Sjöström, 2009; Renneboog et al., 2008; Riedl and Smeets, 2017b). Denes et al. (2015) note that shareholder

activism is motivated by attempts to improve the financial performance of poorly performing firms as reflected in stock returns, return to sales and market to book ratio. More recently, a survey of institutional investors conducted by Krueger et al. (2020) showed that drivers of shareholder engagement on environmental issues are now also linked to factors such as: the need to protect corporate reputation, fulfill legal and fiduciary responsibilities, and adhere to moral or ethical principles. Our study builds on and extends this empirical evidence by exploring the extent to which shareholders act as agents of change, particularly in contexts where managerial performance in ESG areas falls short.

The remainder of this paper proceeds as follows: Section IV.2 describes our sample and the variables construction. Section IV.3 outlines our methodology. Section IV.4 presents and discusses the findings, while Section IV.5 offers concluding remarks and implications.

## IV.2 Data and summary statistics

### IV.2.1 AGM transcripts and shareholder statements

We obtain a total of 3,553 AGM transcripts available for U.S. firms from the Refinitiv database. These firms were listed on the NYSE or NASDAQ at least once between 2003 and 2022.<sup>6</sup> The AGM transcripts are in a text file (“txt”) format and capture the verbatim of speeches and presentations delivered by the board of directors. They also contain the statements made by the shareholders, including those made during the questions-and-answers sessions, and therefore provide a textual record of the interactions between management and shareholders. In addition, the transcripts typically provide a short overview of the participants who spoke during the meetings. This information consists of the names of the directors and the names of the shareholders

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<sup>6</sup>Refinitiv only began collecting AGM transcripts systematically in 2017 (including retroactively), which is why the sample size is smaller for the earlier years in our sample period. In the U.S., AGMs are governed by state law (Brochet et al., 2023). While listed firms are required to hold AGMs, there is no state law that mandates the provision of a written, audio, or video record of these meetings. However, the bylaws or internal policies of individual firms may include specific requirements regarding the recording and distribution of AGM proceedings (Brochet et al., 2023).

who spoke, together with their affiliations. Some shareholders, however, are listed as “unidentified participants”.

Since AGM transcripts are not mandatory, there is also no clear-cut content and format of textual data that we can automatically extract for our empirical analysis. As we are only interested in shareholder communication at AGMs, we manually remove all statements made by company representatives (e.g., board members) and make sure to keep only the questions and comments made by shareholders in the text files. Shareholders can participate in AGMs in various ways, and their interventions are not limited to brief questions; they may also include affirmative statements, such as suggestions, or comments on issues raised by the board of directors (Lafarre and Van der Elst, 2018).

In addition, as shareholders have the opportunity to submit written questions prior to the meetings, it is common practice for board members to respond to these questions by quoting and elaborating on them directly during the AGMs. These questions are also included in our analyses as they may reflect important concerns of shareholders. We assume that board members do not materially change the wording of these questions by repeating them. For example, we classified the following pre-submitted question as shareholder statement, which was read by the director of Investor Relations of PNC Financial Group during an AGM in 2021: “*We received a question asking if we are considering a stock split, why or why not? And if yes, what timing or conditions would you like to see before taking that action?*”. Further examples of shareholder statements are provided in Appendix F. Furthermore, we drop all transcripts that do not comprise any comments, remarks or questions from shareholders. This leaves us with a sample of 1,978 transcripts covering 650 unique firms.<sup>7</sup>

Table IV.1 shows the frequency of transcripts by year. We note that the largest share of transcripts in our sample comes from the year 2020. Specifically, AGM transcripts from 2020 constitute 19.77% of the total sample, representing 858 files, 391 of which include shareholder statements. Interestingly, we also find that more recent transcripts tend to have a lower average word count. This may be related to the COVID-19

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<sup>7</sup>This sample size aligns closely with prior literature. For example, Brochet et al. (2023) analyze a sample of 1,432 virtual or hybrid AGMs held by 426 unique firms between 2000 and February 2020.

Table IV.1: Frequency of AGM transcripts by year.

| Year  | $N$ transcripts | $N$ transcripts with<br>shareholder statements | % of sample | Mean total<br>words |
|-------|-----------------|------------------------------------------------|-------------|---------------------|
| 2003  | 5               | 4                                              | 0.20%       | 1031.000            |
| 2004  | 34              | 29                                             | 1.47%       | 1255.413            |
| 2005  | 46              | 42                                             | 2.12%       | 1153.381            |
| 2006  | 75              | 59                                             | 2.98%       | 1045.016            |
| 2007  | 91              | 67                                             | 3.39%       | 1151.731            |
| 2008  | 98              | 72                                             | 3.64%       | 1127.708            |
| 2009  | 93              | 75                                             | 3.79%       | 1792.053            |
| 2010  | 89              | 68                                             | 3.44%       | 1692.661            |
| 2011  | 76              | 56                                             | 2.83%       | 1777.321            |
| 2012  | 89              | 68                                             | 3.44%       | 1295.676            |
| 2013  | 76              | 53                                             | 2.68%       | 1419.754            |
| 2014  | 70              | 51                                             | 2.58%       | 1440.039            |
| 2015  | 63              | 47                                             | 2.38%       | 1572.319            |
| 2016  | 56              | 39                                             | 1.97%       | 1352.794            |
| 2017  | 217             | 137                                            | 6.93%       | 1094.503            |
| 2018  | 263             | 154                                            | 7.79%       | 946.649             |
| 2019  | 278             | 166                                            | 8.39%       | 970.656             |
| 2020  | 858             | 391                                            | 19.77%      | 356.744             |
| 2021  | 739             | 343                                            | 17.34%      | 421.251             |
| 2022  | 216             | 57                                             | 2.88%       | 377.110             |
| Total | 3,553           | 1,978                                          | 100%        |                     |

*Remark:* This table presents the frequency of AGM transcripts by year and the mean of total words per year in our sample.

pandemic, which prompted many firms to switch to virtual AGM formats and initiated a widespread move towards holding AGMs in virtual or hybrid formats in subsequent years (Brochet et al., 2023). In general, virtual AGMs are substantially shorter than in-person meetings, with business presentations being shorter and more generic (Brochet et al., 2023). However, in the context of our analysis, we did not differentiate between in-person meetings and virtual meetings as both formats represent an opportunity for shareholders to ask questions (Brochet et al., 2023; Gao et al., 2020).

Table IV.2 provides the industry breakdown of the firms in our sample for which we have AGM transcripts, based on their GICS classification. We observe that the Financials sector accounts for the largest share of AGM transcripts (17.95%), followed by the Health Care sector (14.41%), Consumer Discretionary (12.99%), and Industri-



Table IV.2: Frequency of AGM transcripts by sector.

| GICS Sector            | $N$   | %      |
|------------------------|-------|--------|
| Communication services | 108   | 5.46%  |
| Consumer discretionary | 257   | 12.99% |
| Consumer staples       | 200   | 10.11% |
| Energy                 | 66    | 3.34%  |
| Financials             | 355   | 17.95% |
| Health Care            | 285   | 14.41% |
| Industrials            | 239   | 12.08% |
| Information technology | 200   | 10.11% |
| Materials              | 92    | 4.65%  |
| Real estate            | 59    | 2.98%  |
| Utilities              | 117   | 5.92%  |
| Total                  | 1,978 | 100%   |

*Remark:* This table presents the frequency of AGM transcripts to GICS classification sector codes.

als (12.08%).

## IV.2.2 Shareholder types and geographical location

A firm's shareholder base is composed of institutional and non-institutional investors, with considerable differences in terms of their resources, preferences and objectives (Flammer et al., 2021). To account for this heterogeneity in a more granular way, we manually classify each of the shareholder statements in our sample according to a predefined shareholder category. To do so, we employ categories that appear in prior literature on shareholder activism. With respect to institutional investors, Flammer et al. (2021) distinguish between public pension funds, socially responsible investment (SRI) funds, special interest investors, and asset management funds. In the case of non-institutional investors, Flammer et al. (2021) identify individual, union, religious, and other shareholders. In their analysis of shareholder-sponsored proposals, Grewal et al. (2016) use the categories individuals, public pension funds, religious groups, SRI funds, special interest groups, union funds, and coalitions. Benton and You (2018) differentiate between investment funds (e.g., mutual funds), public pensions (e.g., California Public Employees Retirement System), religious and SRI funds, special interest groups, and

union-affiliated pension funds. Giuli et al. (2023) examine union-affiliated sponsors, such as private-sector labor unions and retiree associations, and the role of union-sponsored shareholder proposals. Agrawal (2011) and Grant (2021) study how unions, through their pension funds, use their position as shareholders to influence corporate behavior. Finally, Guay et al. (2004) discuss the role of NGOs as institutional investors and their influence in shaping socially responsible investing.

We extend the literature by introducing additional, fine-grained shareholder categories identified in our sample. Since shareholders typically disclose their identity prior to asking a question or making a comment, we determine the shareholder category based on the affiliation and the content of the statement. Overall, our classification comprises the following ten categories of shareholders: individual shareholder, (former) employee<sup>8</sup>, trade union, asset manager, public asset manager, religious asset manager, analyst, NGO, religious organization, proxy. Appendix F provides an overview and examples for each shareholder type. Furthermore, we also add the category “none” for shareholder statements that cannot be classified due to a lack of information.

Our analysis encompasses a detailed classification of institutional and non-institutional shareholders. Among the institutional shareholders, we classify portfolio managers representing asset management funds, hedge funds, and mutual funds, i.e., entities typically holding large stakes in portfolio companies, as “asset managers”. Large public-sector investors, such as public pension funds (e.g., the Illinois State Board of Investment), are categorized as “public asset managers”, while church pension funds and faith-based investment firms fall under the category of “religious asset managers”. AGM participants from equity research divisions and investment banking institutions fall under the category of “analysts”. AGM participants from trade unions (e.g., AFL-CIO) and union affiliated pension funds (e.g., United Brotherhood of Carpenters Pension Fund) are classified as “trade unions”. In order to account for further types of shareholders, we classify community-based associations, think tanks and foundations as “NGOs”. Furthermore, we dedicate a specific category to “religious organizations” for churches and church representatives. Finally, we categorize shareholder advocacy groups and proxy

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<sup>8</sup>This category includes current and former employees, as well as company retirees

advisory firms as “proxy”.

In addition to institutional shareholders, our analysis considers non-institutional AGM participants. Small retail investors are classified as “individual shareholders”. Since employees may own shares of their employer’s stock and possess both shareholder and employee rights (e.g., retirement savings plan offered by employers), we introduce the category “(former) employees”. The term “former” is included in parentheses to reflect the inclusion of both current employees and former employees, such as retirees, ex-employees, and representatives of retiree associations. Overall, we expect these various categories of institutional and non-institutional shareholders to have contrasted sustainability preferences reflected in their AGM statements.

We categorize each shareholder statement found in an AGM transcript according to the previously outlined shareholder categories. A statement is defined as a segment of text delineated as such within a transcript. To illustrate, let us consider an excerpt from a 2004 AGM transcript of The Walt Disney Company. In this example, the transcript contains a statement by an individual named Portia Spear. The transcript includes her name and designation (i.e., Portia Spear, Shareholder), followed by her statement, which consists of several sentences (e.g., “*Mr. Chairman, members of the Board and stockholders, my name is Portia Spear, and I am here today on behalf of the New York City Pension System to present the fund’s resolution on the implementation of Disney’s human rights labor standards in China. Over the last several years, reports of human rights abuses in the overseas subsidiaries and suppliers of some U.S. corporations have led to increased public awareness of issues such as child labor, sweatshop conditions, and the denial of labor rights in U.S. corporate overseas operations (...).*” The statement concludes when the next speaker begins — in this case, Michael Eisner, Chairman and Chief Executive Officer, who is also identified accordingly in the transcript. In this example, we assign the category “public asset manager” to the statement made by Portia Spear. As can be seen from this example, a statement can consist of several sentences.

In addition to the above, we also manually gather and compile data on the geographical locations of the various shareholders in our sample. Shareholders, particu-

larly non-institutional ones, sometimes disclose their place of residence when introducing themselves at the beginning of a statement. For example: “*Hi, I’m Jill Strew from Bellevue, Kentucky and I want to thank you for the ability to save money on gas. I really like it. And I’m wondering when the Bellevue Market Place Kroger gas pumps will be open. We’ve been looking at empty pumps for about a year. So if anybody could answer that, I’d appreciate it. Thank you.*” When such information is provided, we document the city and state, incorporating it into our categorization of statements. Unless stated otherwise, we assume that the shareholder resides in the U.S. In the example above, the statement is classified under the shareholder category “individual shareholder” and is tagged with the city “Bellevue”, the state “Kentucky” and the country “United States”.

For institutional shareholders, such as asset management firms and their asset managers participating in AGMs, we collect data on the location of their company headquarters, as their representatives on AGMs rarely disclose their personal residence.<sup>9</sup> However, it can generally be assumed that asset managers and analysts spend significant time at their headquarters or work near their firms’ headquarters (Di Giuli and Kostovetsky, 2014). Furthermore, their statements are likely to be aligned with the firms’ internal corporate position, justifying our choice to use these locations.

### IV.2.3 Measures of negative tone and ESG communication

We measure the tone of shareholder communication by applying the “bag of words” method, a widely adopted approach for textual analysis in financial research (Tetlock, 2007; Tetlock et al., 2008; Loughran and McDonald, 2011, 2015; Hillert et al., 2024). The “bag of words” method collects words that express negativity or positivity, respectively, compiles them into a corresponding dictionary and uses this dictionary to systematically measure the tone of a text (Hillert et al., 2024). For our analysis, we focus specifically on the negative tone, as prior research indicates that negative sentiment is easier to isolate and less ambiguous than positive statements (see e.g., Loughran and McDonald, 2015).

In terms of negative word lists, we rely on two widely accepted dictionaries: the

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<sup>9</sup>For consistency, we focus on the location of the asset management firm as the shareholder, rather than the company representative, who may not be a shareholder themselves.

Loughran and McDonald (LMD) negativity dictionary developed by Loughran and McDonald (2011) and the Harvard IV-4 psycho-social dictionary by Tetlock (2007). While the first was developed to capture the sentiment in financial texts or communication, the Harvard IV-4 dictionary was originally designed for psychological and sociological contexts (Yang et al., 2019; Hillert et al., 2024). The use of the Harvard IV-4 dictionary is particularly relevant in our context, as some shareholder groups — such as nongovernmental organizations or religious organizations — are less likely to use financial jargon in their statements compared to asset managers or financial analysts. These shareholders may rely on everyday language rather than technical terminology, making the dictionary by Loughran and McDonald (2011) potentially inadequate or insufficient for fully capturing the tone in their statements.

To refine our analyses, we adopt a term frequency and inverse document frequency adjusted negativity measure, denoted as  $LMD_{tf.idf}^-$  and  $HAR_{tf.idf}^-$ , following the methodology in Loughran and McDonald (2011) and Hillert et al. (2024). This approach assigns higher weights to words that appear frequently within a specific document (term frequency, TF) but are relatively rare across an entire corpus (inverse document frequency, IDF). The TF-IDF statistic therefore enhances the discriminatory power of less common terms and addresses concerns that certain high-frequency words could disproportionately influence our negativity measures (Gorovaia and Makrominas, 2024).<sup>10</sup> Based on the aforementioned dictionaries, the weight of the negative word  $i$  in an AGM transcript  $j$  is defined as:

$$LMD_{tf.idf}^- = \frac{(1 + \log(tf_{i,j}))}{(1 + \log(tf_j))} * \log\left(\frac{N}{df_i}\right) \quad (\text{IV.1})$$

if negative word  $i$  occurs at least once in transcript  $j$  and is zero otherwise.  $tf_{i,j}$  is the term frequency of word  $i$  in transcript  $j$ ,  $tf_j$  is the average word frequency in transcript  $j$ ,  $N$  is the total number of transcripts, and  $df_i$  is the number of transcripts containing negative word  $i$ . While the first term, the term frequency, attenuates the impact of high-

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<sup>10</sup>For example, Hillert et al. (2024) provide the example of the word “volatility”, which is often used in a financial context but does not necessarily carry a negative connotation in the context of mutual fund performance.

frequency words by applying logs, the second term, the inverse document frequency, modifies a word’s weight based on its commonality. The same calculation is used for  $HAR_{tf.idf}^-$ , where the Harvard IV-4 instead of the LMD dictionary is employed. Furthermore, we follow the approach by Hillert et al. (2024) and standardize the negativity measures to mean zero and unit variance.

In addition to the negative tone, we examine the ESG-related content of shareholder communication (“ESG communication”) during AGMs. To do so, we develop a dictionary that allows us to capture the share of environmental, social and governance words in shareholder statements. We isolate these words in a staggered process. First, we extract word lists found in relevant literature on climate change and corporate social responsibility (Sautner et al., 2023; Vaupel et al., 2022; Briscoe-Tran, 2023). Second, we complement these lists by manually collecting relevant keywords from the websites of the Global Reporting Initiative (GRI), the Climate Disclosure Project (CDP), the Task Force on Climate Related Financial Disclosures (TCFD), and the International Labor Organization (ILO). Appendix G provides an overview of the ESG-related word lists used in our analyses.

We then construct several metrics to quantify the ESG communication in shareholder statements. The variable  $ESG\ Share_{j,t}$  represents the share of environmental, social, and governance words in the AGM transcript  $j$  in year  $t$ , serving as a proxy for ESG-related communication from shareholders. In addition, we define separate measures for each of the individual ESG pillars,  $ENV\ Share_{j,t}$ ,  $SOC\ Share_{j,t}$  and  $GOV\ Share_{j,t}$ , which capture the share of environmental (“E”) words, social (“S”) words and governance (“G”) words, respectively. In addition, we account for the frequency of ESG words by adjusting their share, using the term frequency inverse document frequency approach, as outlined in equation IV.1. We label the resulting variables  $ENV\ Share_{tf.idf}$ ,  $SOC\ Share_{tf.idf}$  and  $GOV\ Share_{tf.idf}$ , respectively. We also standardize them to mean zero and unit variance. Unlike our negativity measures, we include in some of our analyses both the unadjusted share of ESG-related words in shareholder communication as well as the corresponding TF-IDF-adjusted statistic. This approach allows us to account for the fact that some ESG terms may frequently

appear across multiple transcripts, without reducing their overall weight.<sup>11</sup>

## IV.2.4 Independent variables

To examine whether the tone of shareholder communication at the AGM is affected by a firm’s sustainability performance, we gather ESG data for the companies in our sample from the MSCI database. Specifically, we collect data on both the industry-adjusted ESG scores and non-adjusted scores for the environmental, social and governance pillars. In addition, we obtain data on the theme scores of the environmental pillar (i.e., environmental opportunities, climate change, waste management and natural resource usage), the social pillar (i.e., human capital, product liability, and social opportunities) and the governance pillar (i.e., corporate governance and business ethics). MSCI evaluates these factors on a scale from 0 to 10, where 10 denotes the highest level of sustainability performance and 0 represents the lowest.

Methodologically, MSCI ESG ratings capture a company’s risk exposure to key ESG issues based on a granular breakdown of company characteristics, including the company’s business risk exposure in terms of revenue (e.g., core products or business segments), assets or operations, as well as its geographical risk exposure based on these same factors. Furthermore, the ratings consider company-level risk exposure elements such as the number of employees, company size, reliance on government contracts, and dependence on outsourced production (MSCI ESG Research LLC, 2024). Finally, they also take into account the extent to which a company has developed robust strategies and demonstrated a strong track record of performance in managing these specific level of risks or opportunities. Ongoing or structural controversies lead to score deductions.

For our analyses, MSCI ESG ratings offer several advantages compared to other data providers. First, they cover a broad range of U.S. firms over an extended period (Grewal et al., 2016). Second, the ESG ratings provide a granular measure of a firm’s environmental, social and governance performance focusing on key issues relevant to

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<sup>11</sup>For example, some shareholder categories may use the word “climate” particularly frequently during multiple AGMs. While we cannot determine if this is the case prior to our analysis, we aim to account for this potential by incorporating both measurements, ensuring a more comprehensive measurement of ESG-related communication.

the industry in question. For example, under the environmental pillar, MSCI tracks performance on carbon emissions, biodiversity & land use and raw material sourcing, among other issues. As such, these ratings capture many aspects that may be of concern to shareholders, making them particularly relevant for understanding soft engagement at AGMs. Finally, MSCI ratings are widely used in academic studies investigating the relationship between ESG and financial performance (see e.g., Pástor et al., 2022; Tsai and Wu, 2022).

In our analyses, we control for confounding factors by including a battery of firm-specific variables using data from Refinitiv. We account for *firm size* by including log-transformed total assets. To account for profitability and growth opportunities, we add the *fixed assets to total assets*, *net income to total assets* and *capital expenditures to total assets*. Lastly, our set of control variables also comprises the *leverage ratio*, measured as long-term debt divided by total assets (Ng and Rezaee, 2015). We winsorize the control variables at the 1<sup>st</sup> and 99<sup>th</sup> percentiles. After dropping all transcripts that do not contain any shareholder statements and merging them with ESG performance data and control variables, our final sample consists of 1,813 AGM transcripts from 2007 to 2022 covering 502 unique firms.

## IV.2.5 Descriptive statistics

Table IV.3 presents the summary statistics of our sample. Panel A shows that the average AGM transcript includes about 60 sentences and an average of 16 words per sentence. As Table IV.1 already shows, the average number of words peaks in 2009 and remains relatively high until 2019. The drops from 2020 to 2022 can be explained by the COVID-19 crisis and the fact that many AGMs took place in a virtual format. In general, virtual AGMs have been found to be substantially shorter than in-person meetings, with business presentations being shorter and more generic (Brochet et al., 2023). However, in the context of our analysis, we did not differentiate between in-person meetings and virtual meetings as both formats still represent an opportunity for shareholders to ask questions and make comments (Brochet et al., 2023; Gao et al., 2020).



Table IV.3: Descriptive statistics.

|                                                                 | <i>N</i> | Mean   | Median | Std. dev. | Min.   | Max.   |
|-----------------------------------------------------------------|----------|--------|--------|-----------|--------|--------|
| <i>Panel A: Shareholder tone and ESG communication measures</i> |          |        |        |           |        |        |
| Words per sentence                                              | 1,813    | 16.099 | 15.583 | 5.012     | 5.166  | 86.000 |
| Number of sentence                                              | 1,813    | 59.557 | 25.000 | 103.350   | 3.000  | 1,133  |
| $HAR_{tf.idf}^-$                                                | 1,760    | 0.023  | -0.379 | 1.128     | -0.568 | 8.576  |
| $LMD_{tf.idf}^-$                                                | 1,722    | 0.044  | -0.375 | 1.104     | -0.695 | 8.336  |
| ENV Share                                                       | 1,813    | 0.017  | 0.011  | 0.019     | 0.000  | 0.143  |
| SOC Share                                                       | 1,813    | 0.025  | 0.0212 | 0.020     | 0.000  | 0.136  |
| GOV Share                                                       | 1,813    | 0.073  | 0.060  | 0.051     | 0.000  | 0.305  |
| ENV Share $_{tf.idf}$                                           | 1,783    | 0.026  | -0.379 | 1.073     | 0.055  | 8.631  |
| SOC Share $_{tf.idf}$                                           | 1,783    | 0.051  | -0.608 | 1.027     | 0.407  | 5.547  |
| GOV Share $_{tf.idf}$                                           | 1,783    | 0.091  | -0.261 | 1.086     | 0.456  | 5.747  |
| <i>Panel B: Sustainability performance variables</i>            |          |        |        |           |        |        |
| ESG Score                                                       | 1,813    | 5.077  | 5.100  | 2.211     | 0.000  | 10.000 |
| Environmental Score                                             | 1,813    | 5.912  | 5.800  | 2.351     | 0.000  | 10.000 |
| Social Score                                                    | 1,813    | 4.465  | 4.400  | 1.523     | 0.000  | 9.800  |
| Governance Score                                                | 1,813    | 5.344  | 5.300  | 1.617     | 0.000  | 10.000 |
| Environmental Opportunities Score                               | 429      | 4.734  | 4.500  | 1.634     | 1.700  | 9.000  |
| Waste Management Score                                          | 590      | 6.070  | 6.000  | 2.502     | 0.000  | 10.000 |
| Climate Change Theme Score                                      | 1,478    | 7.331  | 8.000  | 2.631     | 0.000  | 10.000 |
| Natural Resource Usage Score                                    | 1,244    | 6.693  | 6.400  | 2.484     | 0.000  | 10.000 |
| Log(Scope 1)                                                    | 1,734    | 10.996 | 10.592 | 2.9701    | 0.000  | 18.814 |
| Product Safety Score                                            | 1,065    | 4.216  | 4.000  | 1.997     | 0.000  | 10.000 |
| Human Capital Score                                             | 1,473    | 4.526  | 4.400  | 1.930     | 0.000  | 10.000 |
| Social Opportunities Score                                      | 427      | 4.437  | 4.500  | 1.551     | 0.700  | 7.9000 |
| Corporate Gov. Score                                            | 1,479    | 5.903  | 6.000  | 1.529     | 0.000  | 10.000 |
| Business Ethics Score                                           | 1,101    | 5.264  | 5.600  | 1.926     | 0.000  | 10.000 |
| <i>Panel C: Control variables</i>                               |          |        |        |           |        |        |
| Ln(Total assets)                                                | 1,760    | 10.405 | 10.323 | 1.813     | 6.273  | 14.674 |
| Leverage                                                        | 1,740    | 0.285  | 0.268  | 0.198     | 0.000  | 2.780  |
| Return on Assets                                                | 1,466    | 0.090  | 0.079  | 0.086     | -0.399 | 0.538  |
| Capex to Total Assets                                           | 1,462    | 0.031  | 0.023  | 0.028     | 0.000  | 0.181  |
| Fixed Assets to Total Assets                                    | 1,658    | 0.212  | 0.116  | 0.233     | 0.000  | 0.927  |

*Remark:* This table presents the descriptive statistics of our sample. *Panel A* provides descriptive statistics for the tone and shareholders' communication measures. *Panel B* for the sustainability performance variables and *Panel C* for the control variables.

Panel A in Table IV.3 shows that the TF-IDF adjusted mean percentage of negative words in a given AGM transcript amounts to 2.3% when measured using the Harvard-IV dictionary and to 4.4% using the LMD dictionary. This is in line with an average negativity of 1.57% for 10-K filings found in Loughran and McDonald (2011) as well as the mean percentage of negative words of 2.08% (according to LMD) found for shareholder letters in Hillert et al. (2024). In a given AGM transcript, the TF-IDF adjusted mean percentage of environmental words is 2.6%, of social words 5.1% and of governance-related words 9.1%. A similar pattern emerges when examining the non-adjusted shares of these words, where governance-related terms are most prevalent, followed by social and environmental words. The higher percentage of governance words can be attributed to the fact that governance topics, such as board compensation, are mandatory agenda items at shareholder meetings and are central to these events.

Furthermore, Panel B reports the descriptive statistics for the sustainability performance variables. The average company in our sample has an ESG score of 5.08, suggesting a moderate level of overall sustainability performance within the sample. Breaking this down by individual pillar, the average environmental score is slightly higher at 5.91, suggesting a stronger track record on environmental factors. The average company has an average governance score of 5.34 and a comparatively lower social score of 4.46. Panel C provides the descriptive statistics for the control variables used in the analysis. Size is calculated as the natural logarithm of total assets and averages 10.41, indicating a wide range of firm sizes. Average financial ratios, such as leverage (28.5%), return on assets (9%), and capital expenditure to total assets (3.1%) are consistent with sample data in previous related studies (see e.g., Cuñat et al., 2015; Grewal et al., 2016; Brochet et al., 2023).

## IV.3 Empirical methodology

### IV.3.1 Shareholder soft engagement and shareholder characteristics

We first analyze whether specific shareholder characteristics influence shareholder soft ESG engagement at AGMs. Given that a firm’s investor base comprises a diverse range of shareholder types, we include fine-grained categories to capture potential variation in their sustainability preferences and objectives. Drawing on Grewal et al. (2016), Flammer et al. (2021) and Benton and You (2018), we identify ten distinct shareholder categories: individual shareholders, (former) employees, trade unions, asset managers, public asset managers, religious asset managers, analysts, NGOs, religious organizations, and proxies. These categories differ in their level of sophistication as well as engagement approaches (see e.g., Brochet et al., 2023; Barko et al., 2021; Flammer et al., 2021).

We expect these different types of shareholders to prioritize sustainability dimensions to varying degrees. Thus, for this subsection, we transform our panel dataset from the AGM level (i.e., one AGM is one observation) to a panel dataset structured at the individual shareholder statement level (i.e., one statement represents one observation). This approach enables a more granular analysis of the heterogeneity in tone and content of shareholder communication. In a first step, we test our hypothesis by regressing the share of environmental, social and governance words in each shareholder statement across all AGMs in our sample against the type of shareholder that made the respective statement:

$$ESG\ Share_{i,j,t} = \beta_1 * Shareholder\ Type_{i,j,t} + \gamma * Controls_{i,t} + \alpha_i + \alpha_t \quad (IV.2)$$

where  $ESG\ Share_{i,j,t}$  denotes the share of either environmental, social or governance words in shareholder statement  $j$  made during the AGM of company  $i$  in year  $t$ . The shares are calculated by dividing the number of environmental, social and governance words by the number of total words in a statement.  $Shareholder\ Type_{i,j,t}$  is a vector of

dummy variables for each shareholder type, with the individual shareholder representing our baseline category.  $Controls_{i,t}$  describes a vector of control variables. It includes the logarithm of a firm's total assets, the leverage ratio measured by total debts to total assets, return on assets, its fixed assets to total assets ratio and its capital expenditures to total assets ratio.  $\alpha_t$  and  $\alpha_i$  denote year fixed effects and industry fixed effects, respectively. We further cluster the standard errors at the firm level.

Starting with the environmental pillar, we expect certain shareholder groups, such as NGOs, religious organizations and asset managers, to be more vocal about environmental issues than the average individual investor. NGOs have social and/or environmental agendas and participate in AGMs to draw attention to corresponding issues (Subramanian, 2020). Similarly, religious organizations, particularly religious asset managers, play a very active and sometimes overlooked role as investors Louche et al. (2012). This category of investors pioneered socially responsible investing and were among the first to integrate both environmental and social considerations into their investment strategies (Hong and Kacperczyk, 2009). Consequently, we expect religiously motivated investors in our sample to be particularly vocal about both environmental and social issues. In addition, studies by Krueger et al. (2020) and Hoepner et al. (2023) show that institutional investors tend to actively engage on environmental issues, especially those related to climate, given their potential financial implications (Flammer et al., 2021; Sautner et al., 2023). As a result, we expect asset managers in our sample to also be vocal about environmental issues. Turning to the social pillar, we expect shareholders that are or were directly involved with the firm, such as current and former employees as well as trade unions, to be particularly vocal about social matters since they encompass topics related to their work environment and human capital management. With regard to governance aspects, we expect all categories of shareholders to address these topics, as they are generally standard agenda items at general meetings (Ertimur et al., 2010a).

In addition to these distinct shareholder categories and their respective objectives, it is also well established that shareholders hold diverse political views (see e.g., DesJardine et al., 2024). Consequently, both their identity as shareholders and their political

orientation may affect their investment priorities and thus their engagement strategies. Specifically, several studies highlight the role of political preferences in the context of shareholder activism and corporate social responsibility (see e.g., Min and You, 2019; Duan et al., 2021; Hoepner and Lin, 2022; Giuli et al., 2023). Most of these studies focus on institutional shareholders and their political orientation. For example, Duan et al. (2021) show that public pension funds support shareholder (management) proposals more (less) when Democrats gain more power in the funds' home states. Kim et al. (2020) report that institutional shareholders with a Republican orientation are negatively associated with their investee firms' environmental performance. Furthermore, the authors find that firms with Republican-oriented institutional shareholders are less likely to issue environmental reports. Overall, Republican shareholders are generally found to be more business-friendly and support corporate policies that prioritize business interests over concerns related environmental issues and labor rights (Duan et al., 2021). At a more individual level, Smith et al. (2024) report that Republicans are less likely to be concerned about the environment and climate change, or to support environmental policies.

The political environment, i.e., the political orientation of US states, may also play a critical role in shaping the extent of shareholder engagement strategies. This is illustrated by recent initiatives launched by Republican-led states opposing ESG-focused investment practices by institutional investors. For example, in late 2022 and early 2023, the Tennessee attorney general and other Republican officials accused several asset management firms of breaching fiduciary duties through their environmental and social investing practices (Reuters, 2023b). In a related development, Larry Fink, Chairman and CEO of BlackRock, announced that he would cease using the term ESG due to its politicization and the growing scrutiny and boycotts initiated by Republican-controlled states (Reuters, 2023a; Financial Times, 2022). These developments highlight how the political environment not only shapes shareholder priorities, but also influences the discourse and issues addressed (or deliberately avoided) during AGMs.

We add to this literature by examining the role of the political environment for soft ESG engagement at AGMs. To examine how shareholders' political environment may

influence their soft engagement, we focus on the political orientation of the US states in which they reside. Specifically, we map the results of U.S. presidential elections to the geographical location of the shareholders. To this end, we collect data from the presidential elections between 2000 and 2022.<sup>12</sup> In our panel data, we assume that in non-election years, the results of the most recent election continue to represent the political landscape of each state. We classify US states that consistently voted Republican across these elections as “Republican states” and those that consistently voted Democratic as “Democratic states”. We also exploit data on the shareholders’ geographical location as outlined in Section IV.2.2. We then analyze whether shareholders from Republican or Democratic states differ in their ESG communication by estimating the following regression:

$$ESG\ Share_{i,j,t} = \beta_1 * Individual\ Shareholder_{i,j,t} \times REP + \gamma * Controls_{i,t} + \alpha_i + \alpha_t \quad (IV.3)$$

where  $ESG\ Share_{i,j,t}$  denotes the share of either environmental, social or governance words in shareholder statement  $j$  made during the AGM of company  $i$  in year  $t$ .  $Individual\ Shareholder_{i,j,t}$  is a dummy variable that equals one if the statement  $j$  during AGM  $i$  in year  $t$  was made by an individual shareholder and zero otherwise.  $REP$  is a dummy variable that equals one if the shareholder resides in a U.S. state that voted Republican in a previous presidential election, and zero otherwise.  $Controls_{i,t}$  describes the same vector of control variables as in equation IV.2.  $\alpha_t$  and  $\alpha_i$  denote year fixed effects and industry fixed effects, respectively. We cluster the standard errors at the firm level.

### IV.3.2 Shareholder soft engagement, tone and firm sustainability performance

Next, we examine whether a firm’s sustainability track record affects shareholder soft engagement on ESG issues at AGMs. A large strand of literature shows that targets

<sup>12</sup>We therefore focus on the election years 2000, 2004, 2008, 2012, 2016, 2020.

of shareholder activism display certain characteristics. For example, Gillan and Starks (1998) and Huson (1997) report that the targets of large public institutional investors are characterized by poor governance structures. Empirical evidence also indicates that firms with abnormal CEO compensation and limited shareholder voting rights are more likely to be the target of shareholder resolutions (Ertimur et al., 2010a; Renneboog and Szilagyi, 2011). Johnson and Shackell (1997) examine executive compensation proposals and find that the probability of filing such a proposal is higher for firms that face negative financial press coverage. Finally, Denes et al. (2015) find that firms targeted by shareholder activism tend to be poor performers, as measured by prior stock returns, sales growth or return to sales.

We focus on firm sustainability performance as a potential driver of shareholder soft engagement. To do so, we employ both the overall ESG score, which reflects a firm's overall sustainability performance, and the individual pillar scores as well as their theme scores, which capture a more granular view of environmental, social and governance performance. We expect shareholders to engage more strongly with respect to sustainability issues at AGMs of companies that perform relatively poorly in these areas. For example, if a company has a particularly poor track record on environmental issues, as measured by its environmental score, we expect the number of questions and comments in this area to be higher. However, if a company is an environmental leader, shareholders may have little reason to ask a particularly large number of questions or make critical statements about these issues. These assumptions are corroborated by empirical evidence showing that firms targeted by shareholder activism tend to be poor performers in specific areas (see e.g., Denes et al., 2015; Gillan and Starks, 1998). To estimate the effect of ESG performance on the share of sustainability-related communication by shareholders during an AGM, we conduct regressions in the form of the following equation:

$$ESG\ Share_{i,t} = \beta_1 * ESG\ Score_{i,t} + \gamma * Controls_{i,t} + \alpha_i + \alpha_t \quad (IV.4)$$

where  $ESG\ Share_{i,t}$  measures the relative share of either environmental, social or

governance words from shareholders during the AGM of company  $i$  in year  $t$ . As some of the ESG words in our dictionary might be used in an inflationary manner, we adjust the share by re-weighting it based on the term frequency and the inverse document frequency of the words as in Loughran and McDonald (2011).  $ESG\ Score_{i,t}$  is the ESG score for company  $i$  in year  $t$ . We also use individual pillar scores and theme scores.  $Controls_{i,t}$  describes the same vector of control variables as in equation IV.2. We include industry and time fixed effects and cluster the standard errors at the firm level. We, again, re-estimate equation IV.4 by including the ESG pillar scores and the sub-scores as the independent variables.

If shareholders particularly care about certain sustainability issues and feel that a firm in question is not doing enough to address such issues, we hypothesize that shareholders may engage with a negative tone at the AGM. Given that poor sustainability performance may lead to immediate or long-term reputational and financial risks, we expect lower ESG performance to be associated with a more negative tone of shareholder statements. Formally, we test this by estimating an OLS panel regression in the following way:

$$Tone_{i,t} = \beta_1 * ESG\ Score_{i,t} + \gamma * Controls_{i,t} + \alpha_i + \alpha_t \quad (IV.5)$$

where we regress shareholder tone,  $Tone_{i,t}$ , on a company's ESG score,  $ESG\ Score_{i,t}$ , controlling for the same firm controls as in equation IV.2. We include industry and time fixed effects and cluster the standard errors at the firm level. The tone is measured by the adjusted negativity measures based on the LMD and the Harvard IV-4 dictionary,  $LMD_{tf.idf}^-$  and  $HAR_{tf.idf}^-$ . We re-estimate equation IV.5 by including the ESG pillar scores and the theme scores as the independent variables to gain a deeper understanding of the relationship between shareholder tone and ESG performance, expecting to find negative coefficients for ESG measures.



### IV.3.3 Shareholder tone and further engagement activities

In the last part of our analysis, we focus on the relationship between shareholder tone at the AGM and voting outcomes on submitted proposals. During AGMs, shareholders have the opportunity not only to engage with management by asking questions or making comments, but they can also vote actively on a range of agenda items presented as proposals (Van der Elst, 2011). Typically, shareholders are asked to vote on issues such as director and committee member elections, say-on-pay policies, auditor appointment and ratifications, and the approval of financial statements and statutory reports (Cuñat et al., 2015; Babenko et al., 2018). Shareholders may approve such proposals, reject or withhold a vote (Van der Elst, 2011). In addition, shareholders may also submit their own “shareholder-sponsored” proposals for consideration.

To support our analyses, we gather data from the Institutional Shareholder Services (ISS) Voting Analytics database. For each proposal, the database provides several attributes, including a description of the proposal, the date of the AGM, the sponsor and the voting requirement. As a first step, we focus on proposals classified as “management-sponsored” by ISS. We examine whether a negative tone from shareholders is associated with reduced support for these proposals. In addition, prior research (see e.g., Cai et al., 2009; Yermack, 2010; Aggarwal et al., 2023) highlights that director elections provide shareholders with another important avenue to express their discontent, especially when management falls short of their expectations. Directors of firms that performed well typically receive more “yes” votes, while directors of badly governed companies receive more opposition (Van der Elst, 2011). Furthermore, directors play a crucial role in representing shareholders and their interests (Cai et al., 2009; Ertimur et al., 2010b). We therefore place particular focus on proposals related to director elections or re-elections, and treat such proposals as proxies for gauging overall support for management.

As shareholder dissatisfaction is likely to be reflected in lower approval rates (i.e., more votes against) for management-sponsored proposals, including proposals related to director elections, we expect voting outcomes to be less favorable when shareholder

sentiment, as expressed at AGMs, is more negative. We test this hypothesis as follows:

$$Votes_{i,t} = \beta_1 * Tone_{i,t} + \gamma * Controls_{i,t} + \alpha_i + \alpha_t \quad (IV.6)$$

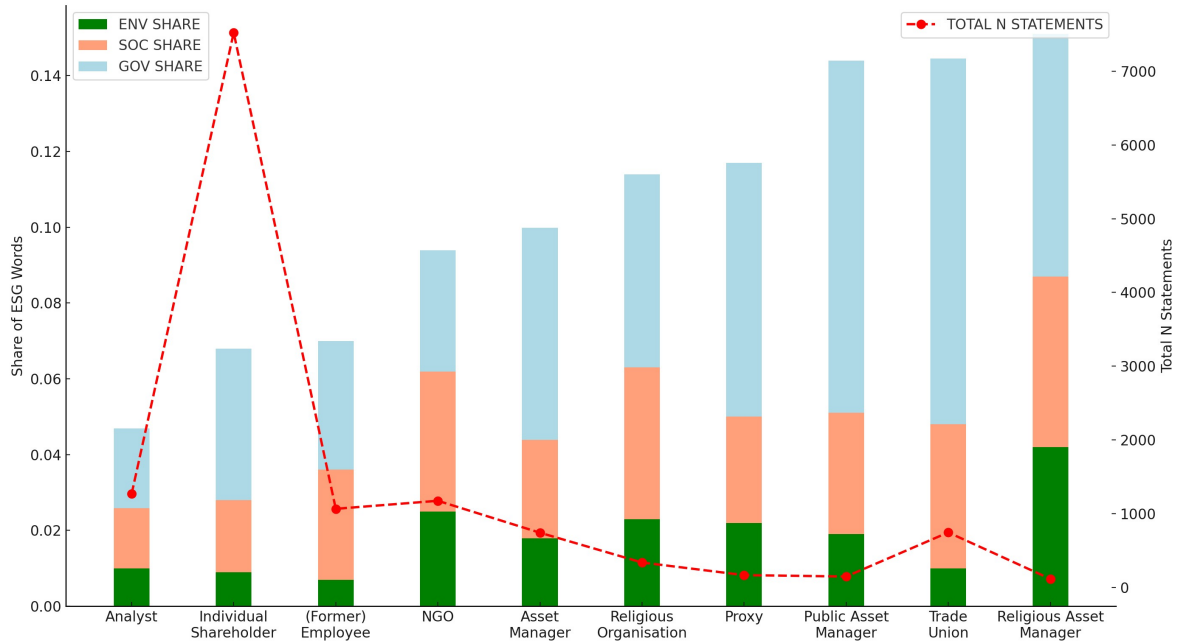
where  $Votes_{i,t}$  describes the mean or median percentage of votes against management-sponsored proposals or director-related proposals for the AGM of company  $i$  in year  $t$ . We include a median value to account for potential outliers.  $Tone_{i,t}$  describes the negativity of shareholder communication for the AGM of company  $i$  in year  $t$ , measured by the adjusted negativity measures  $LMD_{tf.idf}^-$  and  $HAR_{tf.idf}^-$ .  $\alpha_t$  and  $\alpha_i$  denote year fixed effects and industry fixed effects, respectively.

Finally, we examine the relationship between shareholder sentiment expressed at the AGM, ESG communication and the voting outcomes on ESG proposals. We use the classification provided by ISS of SRI proposals and include shareholder governance-related proposals on issues such as shareholder rights, political donations and transparency, following Dikolli et al. (2022). Our analysis examines whether the tone of shareholder statements at AGMs is linked to the approval rates of shareholder-sponsored ESG proposals. For example, it may be anticipated that when significant ESG concerns are raised during the AGM, shareholders may also be more likely to vote in favor of ESG proposals. In addition, shareholders might express dissatisfaction with the management's handling of key ESG issues by more strongly endorsing shareholder-sponsored proposals. To examine this, we apply the following regression analysis:

$$Votes_{i,t} = \beta_1 * Tone_{i,t} * \beta_2 * ESG\_Score_{i,t} + \gamma * Controls_{i,t} + \alpha_i + \alpha_t \quad (IV.7)$$

where  $Votes_{i,t}$  describes the mean or median of votes for shareholder-sponsored ESG proposals for the AGM of company  $i$  in year  $t$ .  $Tone_{i,t}$  describes the negativity of shareholder communication for the AGM of company  $i$  in year  $t$ , measured by the adjusted negativity measures  $LMD_{tf.idf}^-$  and  $HAR_{tf.idf}^-$ .  $ESG_{i,t}$  denotes the tf-idf adjusted share of either environmental, social or governance communication by shareholders.

Figure IV.1: Share of ESG words and total number of AGM statements by shareholder type.



*Remark:* The figure displays the total number of statements made by each shareholder type on the right axis, while the left axis represents the share of environmental, social, and governance terms within these statements.

## IV.4 Results

### IV.4.1 To what extent do shareholders engage on ESG issues at AGMs?

We begin by conducting an exploratory analysis of shareholder statements at AGMs. Figure IV.1 presents the total number of statements by each shareholder type on the right axis, while the left axis depicts the share of environmental, social, and governance words used in these statements. Individual shareholders contribute the highest number of statements at AGMs, followed by analysts, NGOs and (former) employees. Figure IV.1 also highlights that the proportion of environmental, social and governance words varies considerably across shareholder types. Although religious asset managers engage less at AGMs compared to other groups, their statements display a large share of words related to environmental and social themes. Historically, religious asset managers

were the first investors to integrate sustainability considerations into their investment process (Gillan and Starks, 1998). Hong and Kacperczyk (2009) find that religious investors are less likely to hold sin stocks, while Louche et al. (2012) show that they are important actors in the field of responsible investment and impact investing. Thus, the high proportion of environmental and social words observed for this category appears plausible. In contrast, while analysts and individual shareholders make a substantial number of statements at AGMs, their focus on environmental and social themes is considerably more limited. Furthermore, we observe that governance words are consistently present across all shareholder types, in line with our expectation that governance issues are standard agenda items at general meetings and a central concern for shareholders engaging in the AGM dialogue. Overall, the analysis shows that ESG topics are an integral part of shareholder soft engagement at AGMs.

Next, we examine the environmental, social and governance words most frequently used by the different types of shareholders to identify potential nuances in their sustainability-related priorities. Table IV.4 presents an overview of the 30 most frequently used environmental words for each shareholder category. We observe that words such as “climate”, “change”, and “disclosure” are commonly employed by institutional investors, particularly asset managers. This is in line with earlier studies that highlight the growing importance of engagement on climate risks for institutional investors (Krueger et al., 2020; Ilhan et al., 2023; Hoepner et al., 2023). For example, Krueger et al. (2020) document that investors believe that climate change has financial implications for portfolio companies, necessitating the integration of climate-related risk considerations into the investment decision-making process. Ilhan et al. (2023) find that institutional investors value climate-related disclosures and see them as complementary to traditional financial reporting. Furthermore, Sautner et al. (2023) document a significant increase in climate-related discussions during earnings conference calls in recent years. A comparison of word frequencies further shows that the term “climate” is also frequently mentioned by NGOs, religious organizations and individual shareholders. Moreover, NGOs and religious organizations are particularly vocal about issues related to biodiversity and pollution, often using words such as “energy”, “water”, “animals”, “coal” and

“land”. Lastly, we find that trade unions and (former) employees frequently reference terms like “future” and “protect”, along with words such as “refinery” and “oil”. In line with previous research (see e.g., Grant, 2021), unions therefore also actively engage as shareholders at AGMs, although they typically do not prioritize environmental projects (see e.g., Ertugrul and Marciukaityte, 2021).

Table IV.4: Top 30 environment words by frequency.

| Analyst       | Freq. | Asset Manager  | Freq. | Pub. Asset Mg. | Freq. | Rel. Asset Mg. | Freq. | Rel. Org.      | Freq. | NGO            | Freq. | Trade Union    | Freq. | Proxy         | Freq. | Indiv. Sh.    | Freq. | (Form.) Emp.  | Freq. |
|---------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|---------------|-------|---------------|-------|---------------|-------|
| change        | 59    | climate        | 227   | disclosure     | 94    | climate        | 55    | climate        | 135   | climate        | 214   | disclosure     | 123   | plastic       | 50    | energy        | 333   | electric      | 39    |
| impact        | 47    | disclosure     | 153   | climate        | 67    | energy         | 48    | land           | 93    | energy         | 188   | impact         | 44    | packaging     | 28    | power         | 323   | change        | 34    |
| target        | 40    | change         | 112   | energy         | 55    | future         | 40    | disclosure     | 88    | water          | 150   | change         | 43    | climate       | 21    | change        | 268   | future        | 28    |
| targets       | 29    | global         | 91    | change         | 39    | disclosure     | 38    | change         | 68    | animal         | 147   | future         | 42    | change        | 21    | future        | 266   | global        | 24    |
| climate       | 29    | commitment     | 76    | goals          | 19    | change         | 36    | impact         | 55    | environmental  | 122   | alternative    | 36    | animal        | 19    | coal          | 216   | refinery      | 24    |
| energy        | 28    | impact         | 76    | resources      | 18    | coal           | 35    | gas            | 53    | coal           | 122   | protect        | 34    | water         | 18    | climate       | 213   | power         | 22    |
| future        | 27    | carbon         | 57    | gas            | 13    | gas            | 32    | water          | 50    | animals        | 122   | building       | 34    | gas           | 17    | global        | 177   | building      | 20    |
| global        | 23    | oil            | 57    | commitment     | 12    | responsible    | 29    | environmental  | 49    | change         | 114   | commitment     | 34    | environmental | 17    | water         | 174   | refineries    | 20    |
| environment   | 20    | future         | 54    | reduce         | 12    | carbon         | 28    | goals          | 47    | commitment     | 101   | climate        | 27    | disclosure    | 17    | gas           | 150   | commitment    | 19    |
| positive      | 20    | energy         | 53    | carbon         | 12    | environmental  | 27    | commitment     | 45    | carbon         | 91    | positive       | 26    | energy        | 15    | impact        | 138   | aware         | 18    |
| oil           | 19    | gas            | 50    | greenhouse     | 12    | oil            | 27    | energy         | 45    | power          | 84    | global         | 24    | responsible   | 15    | oil           | 112   | oil           | 18    |
| environmental | 19    | reduce         | 48    | global         | 11    | impact         | 24    | global         | 43    | responsible    | 82    | power          | 23    | global        | 14    | technology    | 110   | energy        | 16    |
| gas           | 18    | environmental  | 47    | efficient      | 11    | emissions      | 23    | reduce         | 43    | fossil         | 82    | oil            | 22    | coal          | 12    | disclosure    | 109   | impact        | 15    |
| water         | 18    | responsible    | 44    | impact         | 11    | greenhouse     | 22    | greenhouse     | 39    | impact         | 80    | negative       | 21    | commitment    | 12    | electric      | 104   | protect       | 13    |
| below         | 17    | protect        | 39    | transition     | 11    | reduce         | 20    | responsible    | 37    | disclosure     | 76    | resources      | 18    | recycling     | 12    | commitment    | 98    | responsible   | 13    |
| net           | 17    | emissions      | 38    | protection     | 11    | sustainability | 20    | emissions      | 36    | oil            | 75    | responsible    | 18    | waste         | 12    | nuclear       | 96    | positive      | 12    |
| production    | 16    | power          | 33    | paris          | 11    | power          | 18    | future         | 32    | gas            | 70    | protecting     | 17    | future        | 10    | solar         | 96    | car           | 12    |
| disclosure    | 14    | sustainability | 32    | emissions      | 10    | water          | 18    | oil            | 32    | reduce         | 69    | align          | 15    | impact        | 10    | negative      | 93    | reduce        | 11    |
| fuel          | 13    | goals          | 32    | future         | 9     | goals          | 18    | power          | 23    | arctic         | 66    | aware          | 15    | goal          | 9     | carbon        | 92    | chemical      | 10    |
| negative      | 11    | greenhouse     | 30    | oil            | 9     | nuclear        | 17    | carbon         | 23    | protect        | 63    | protection     | 15    | welfare       | 9     | reduce        | 88    | below         | 9     |
| chain         | 11    | impacts        | 30    | power          | 9     | impacts        | 15    | sustainable    | 23    | future         | 56    | chain          | 14    | impacts       | 8     | renewable     | 87    | solar         | 9     |
| power         | 11    | sustainable    | 26    | sustainability | 8     | warming        | 14    | protect        | 22    | sustainability | 50    | goals          | 14    | reduce        | 8     | protect       | 87    | resources     | 8     |
| emissions     | 10    | water          | 25    | sustainable    | 8     | targets        | 13    | sustainability | 21    | renewable      | 49    | sustainability | 14    | animals       | 8     | responsible   | 84    | water         | 8     |
| technology    | 10    | positive       | 24    | ghg            | 7     | waste          | 12    | coal           | 20    | environment    | 45    | sustainable    | 14    | oil           | 7     | clean         | 83    | plants        | 8     |
| carbon        | 10    | environment    | 23    | protect        | 7     | commitment     | 12    | reduction      | 20    | clean          | 43    | environmental  | 14    | greenhouse    | 7     | environmental | 81    | goals         | 8     |
| reduction     | 9     | technology     | 22    | responsible    | 7     | wetlands       | 11    | chain          | 20    | positive       | 43    | water          | 13    | ocean         | 7     | air           | 77    | negative      | 7     |
| reduce        | 9     | fossil         | 22    | reduction      | 6     | reduction      | 11    | targets        | 19    | goals          | 40    | energy         | 13    | pollution     | 7     | aware         | 76    | resource      | 7     |
| air           | 9     | resources      | 21    | electric       | 5     | hydraulic      | 10    | impacts        | 19    | technology     | 39    | refineries     | 13    | sustainable   | 7     | building      | 73    | fire          | 7     |
| building      | 9     | aware          | 21    | technology     | 5     | paris          | 10    | mitigate       | 18    | fuel           | 39    | impacts        | 12    | emissions     | 7     | car           | 71    | coal          | 7     |
| reducing      | 8     | goal           | 18    | target         | 5     | air            | 9     | pollution      | 16    | emissions      | 37    | transition     | 11    | zero          | 7     | net           | 69    | environmental | 7     |

*Remark:* This table reports the 30 most frequent environment-related words used by each shareholder type.

Table IV.5 gives an overview of the 30 most common social words used by the shareholders in our sample. Overall, the terms “people”, “employees”, “pension” and “workers” are among the most frequently used. Trade unions, for instance, prominently use words such as “pension”, “workers”, “employees” and “safety”, reflecting their strong focus on labor rights, employee welfare, and retirement benefits. This is consistent with the role of trade unions in advocating for the protection of workers and ensuring fair treatment in areas such as wages, working conditions and pension plans (Sjöström, 2009). It also supports the idea that trade unions represent the collective interests of workers and resort to shareholder activism to safeguard such interests (Marens, 2004; Anderson et al., 2007). Employees and former employees, who engage in the AGM dialogue, display a similar pattern, frequently using words like “employee”, “retirees” and “right”, which suggests that their concerns align closely with those of trade unions, particularly on issues related to labor conditions and employee benefits. NGOs, on the other hand, frequently refer to “people”, “public”, “community” and “health”, but also “hispanic”, “children” and “latino”, indicating their broader concern for social welfare, public health and the well-being of communities. This also suggests that NGOs approach shareholder engagement with a focus on societal impacts of corporate actions, advocating for issues that affect broader populations and marginalized groups. Finally, institutional investors, particularly asset managers, show a slightly different set of priorities in their choice of words. They frequently highlight issues associated with words such “employees”, “public”, “women”, “gender” and “gap”. This suggests a focus on diversity and inclusion. Such issues have notably become important criteria for share ownership by socially responsible investment funds (von Meyerinck et al., 2018). In addition, the presence of words such as “gender” and “gap” also suggests that institutional investors are increasingly paying attention to gender-related issues, such as those related to pay gaps and representation, which is in line with von Meyerinck et al. (2018); Billings et al. (2022); Haan (2022). Finally, the words “public” and “pension” frequently appear in the statements by public asset managers, which is in line with Duan et al. (2021), who show that this category of shareholders is often influenced by organized labor and prioritizes labor-related objectives.

Table IV.5: Top 30 social words by frequency.

| Analyst       | Freq. | Asset Manager  | Freq. | Pub. Asset Mg. | Freq. | Rel. Asset Mg. | Freq. | Rel. Org.      | Freq. | NGO            | Freq. | Trade Union    | Freq. | Proxy          | Freq. | Indiv. Sh.  | Freq. | (Form.) Emp. | Freq. |
|---------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|-------------|-------|--------------|-------|
| right         | 126   | employees      | 177   | public         | 80    | public         | 53    | people         | 174   | people         | 543   | pension        | 377   | access         | 38    | people      | 1456  | people       | 352   |
| data          | 73    | public         | 161   | pension        | 66    | rights         | 47    | rights         | 146   | public         | 366   | union          | 269   | human          | 35    | right       | 963   | employee     | 243   |
| people        | 68    | women          | 153   | accountability | 43    | trade          | 37    | human          | 137   | community      | 270   | workers        | 228   | people         | 35    | employees   | 380   | employees    | 243   |
| opportunities | 53    | trade          | 141   | trade          | 43    | people         | 36    | workers        | 113   | health         | 218   | employees      | 202   | public         | 31    | access      | 379   | retirees     | 215   |
| equity        | 35    | gender         | 126   | access         | 42    | indigenous     | 36    | health         | 109   | right          | 207   | public         | 128   | diversity      | 31    | public      | 344   | right        | 140   |
| public        | 34    | rights         | 118   | employees      | 40    | diversity      | 35    | public         | 80    | rights         | 192   | rights         | 115   | rights         | 24    | job         | 275   | retiree      | 120   |
| working       | 28    | gap            | 115   | transparency   | 37    | social         | 33    | right          | 76    | human          | 177   | labor          | 111   | health         | 23    | family      | 263   | workers      | 120   |
| respect       | 25    | people         | 102   | gender         | 29    | human          | 32    | labor          | 66    | communities    | 149   | right          | 111   | data           | 23    | community   | 247   | union        | 117   |
| trade         | 25    | social         | 101   | data           | 28    | health         | 29    | employment     | 63    | working        | 148   | equity         | 108   | equity         | 23    | health      | 222   | job          | 113   |
| income        | 24    | equal          | 100   | discrimination | 25    | transparency   | 22    | fair           | 62    | hispanic       | 143   | trade          | 104   | labor          | 20    | care        | 181   | health       | 86    |
| fair          | 24    | equity         | 94    | sexual         | 24    | right          | 21    | communities    | 58    | diversity      | 136   | health         | 101   | pension        | 17    | rights      | 176   | care         | 86    |
| employees     | 22    | diversity      | 89    | rights         | 21    | data           | 21    | trade          | 56    | employees      | 133   | safety         | 100   | employee       | 16    | working     | 174   | working      | 85    |
| life          | 20    | right          | 87    | diversity      | 21    | access         | 21    | community      | 56    | trade          | 118   | accountability | 88    | racial         | 16    | life        | 150   | safety       | 65    |
| diversity     | 20    | data           | 80    | human          | 20    | healthcare     | 20    | transparency   | 52    | workers        | 115   | people         | 79    | right          | 16    | employee    | 135   | family       | 62    |
| human         | 19    | accountability | 75    | orientation    | 18    | pension        | 15    | discrimination | 48    | children       | 114   | collective     | 78    | employees      | 15    | children    | 125   | pension      | 53    |
| rights        | 19    | human          | 65    | people         | 17    | respect        | 14    | diversity      | 48    | accountability | 100   | working        | 69    | transparency   | 14    | income      | 121   | healthcare   | 47    |
| restructuring | 17    | labor          | 59    | employee       | 17    | nations        | 13    | employees      | 48    | latino         | 100   | human          | 67    | workforce      | 12    | social      | 107   | life         | 45    |
| care          | 17    | transparency   | 59    | right          | 16    | community      | 12    | working        | 46    | care           | 89    | employee       | 65    | social         | 12    | young       | 106   | jobs         | 45    |
| contract      | 17    | health         | 58    | equity         | 16    | opportunities  | 11    | data           | 46    | population     | 85    | pandemic       | 55    | welfare        | 12    | fair        | 105   | public       | 43    |
| access        | 17    | workers        | 56    | job            | 13    | care           | 10    | social         | 44    | social         | 81    | transparency   | 53    | gender         | 11    | human       | 101   | women        | 40    |
| transparency  | 17    | indigenous     | 53    | community      | 13    | socially       | 10    | equal          | 39    | family         | 79    | local          | 53    | gap            | 11    | equal       | 98    | hours        | 40    |
| women         | 15    | jobs           | 51    | protection     | 12    | communities    | 10    | accountability | 34    | labor          | 77    | care           | 47    | communities    | 10    | safety      | 98    | contract     | 40    |
| equal         | 13    | racial         | 51    | health         | 9     | accountability | 9     | indigenous     | 34    | religious      | 77    | job            | 44    | equal          | 10    | security    | 95    | fair         | 38    |
| job           | 12    | working        | 49    | fundamental    | 8     | pandemic       | 9     | children       | 32    | refuge         | 75    | worker         | 34    | workers        | 10    | jobs        | 95    | human        | 34    |
| safety        | 12    | employee       | 44    | social         | 8     | employees      | 9     | moral          | 32    | women          | 75    | community      | 33    | accountability | 9     | women       | 93    | community    | 29    |
| health        | 11    | pension        | 42    | employment     | 8     | drug           | 8     | access         | 30    | fair           | 73    | contract       | 31    | inclusion      | 9     | poor        | 92    | wage         | 29    |
| gender        | 11    | communities    | 41    | workforce      | 8     | workers        | 8     | families       | 29    | families       | 73    | integrity      | 30    | black          | 9     | communities | 92    | local        | 29    |
| labor         | 10    | job            | 41    | labor          | 8     | women          | 8     | religious      | 29    | drug           | 71    | bargaining     | 30    | job            | 8     | local       | 91    | children     | 28    |
| community     | 9     | respect        | 31    | gap            | 7     | safety         | 8     | drug           | 28    | life           | 68    | communities    | 30    | workplace      | 8     | respect     | 91    | labor        | 28    |
| drug          | 9     | safety         | 29    | respect        | 7     | aids           | 8     | healthcare     | 28    | jobs           | 68    | security       | 29    | indigenous     | 8     | quality     | 90    | rights       | 28    |

*Remark:* This table reports the 30 most frequent social-related words used by each shareholder type.



Table IV.6 provides an overview of the 30 most frequently used governance words. Overall, across all shareholder categories, the words “board”, “shareholders”, “proposal” and “management” dominate, underscoring the importance of shareholder rights, board accountability and company management. This finding reflects the central role of governance issues in the AGM context. Notably, all shareholder groups appear to engage on governance-related topics, which contrasts with the environmental and social dimensions, where priorities vary more strongly across different shareholder types.

Table IV.6: Top 30 governance words by frequency.

| Analyst      | Freq. | Asset Manager  | Freq. | Pub. Asset Mg. | Freq. | Rel. Asset Mg. | Freq. | Rel. Org.      | Freq. | NGO            | Freq. | Trade Union    | Freq. | Proxy          | Freq. | Indiv. Sh.   | Freq. | (Form.) Emp. | Freq. |
|--------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|--------------|-------|--------------|-------|
| management   | 107   | board          | 588   | board          | 235   | shareholders   | 161   | shareholders   | 347   | shareholders   | 453   | board          | 794   | proposal       | 157   | shareholder  | 2450  | board        | 284   |
| board        | 104   | shareholders   | 557   | shareholders   | 206   | board          | 131   | board          | 306   | board          | 414   | shareholders   | 510   | shareholders   | 150   | shareholders | 2414  | shareholder  | 190   |
| shareholders | 76    | pay            | 439   | proposal       | 180   | proposal       | 96    | proposal       | 264   | proposal       | 343   | chairman       | 482   | board          | 142   | board        | 1957  | directors    | 163   |
| ceo          | 60    | proposal       | 408   | disclosure     | 105   | investors      | 95    | principles     | 157   | policy         | 282   | compensation   | 467   | vote           | 94    | proposal     | 1499  | shareholders | 137   |
| investors    | 59    | management     | 376   | directors      | 102   | report         | 75    | shareholder    | 153   | shareholder    | 265   | proposal       | 442   | shareholder    | 92    | directors    | 1365  | proposal     | 116   |
| proposal     | 59    | shareholder    | 321   | proxy          | 95    | lobbying       | 67    | report         | 150   | report         | 177   | vote           | 331   | proxy          | 90    | management   | 960   | management   | 106   |
| pay          | 55    | investors      | 298   | retirement     | 87    | management     | 63    | investors      | 139   | vote           | 142   | shares         | 295   | directors      | 68    | chairman     | 923   | compensation | 97    |
| revenue      | 54    | vote           | 256   | management     | 76    | shareholder    | 63    | responsibility | 127   | chairman       | 141   | committee      | 241   | management     | 65    | vote         | 914   | pay          | 92    |
| shares       | 51    | lobbying       | 255   | chairman       | 68    | disclosure     | 48    | policy         | 114   | directors      | 133   | shareholder    | 234   | pay            | 41    | shares       | 877   | statement    | 78    |
| chairman     | 47    | chairman       | 193   | report         | 68    | policy         | 44    | disclosure     | 111   | investors      | 132   | pay            | 221   | ceo            | 36    | proxy        | 605   | chairman     | 75    |
| report       | 46    | disclosure     | 192   | shares         | 65    | proxy          | 42    | management     | 95    | ceo            | 122   | director       | 220   | chairman       | 35    | pay          | 534   | cast         | 61    |
| performance  | 39    | report         | 176   | policy         | 64    | vote           | 40    | lobbying       | 86    | management     | 122   | directors      | 207   | director       | 34    | director     | 469   | report       | 56    |
| shareholder  | 39    | policy         | 155   | lobbying       | 63    | chairman       | 36    | proxy          | 79    | power          | 112   | performance    | 205   | statement      | 31    | ceo          | 443   | performance  | 56    |
| tax          | 39    | compensation   | 153   | performance    | 60    | directors      | 35    | chairman       | 76    | leadership     | 105   | lobbying       | 200   | report         | 28    | independent  | 426   | proxy        | 54    |
| compensation | 39    | governance     | 148   | shareholder    | 56    | leadership     | 31    | vote           | 73    | accountability | 100   | ceo            | 185   | policy         | 28    | power        | 407   | shares       | 50    |
| equity       | 35    | shares         | 140   | spending       | 56    | responsibility | 26    | directors      | 57    | responsibility | 99    | independent    | 181   | shares         | 28    | voting       | 350   | vote         | 48    |
| lobbying     | 33    | proxy          | 134   | vote           | 55    | statement      | 26    | statement      | 55    | statement      | 95    | investors      | 171   | investors      | 27    | report       | 331   | ceo          | 45    |
| investor     | 28    | directors      | 126   | investors      | 49    | spending       | 23    | pay            | 53    | pay            | 95    | policy         | 161   | governance     | 26    | policy       | 326   | committee    | 45    |
| presentation | 26    | voting         | 109   | ceo            | 48    | transparency   | 22    | transparency   | 52    | disclosure     | 94    | ownership      | 151   | disclosure     | 24    | dividend     | 312   | conduct      | 43    |
| policy       | 25    | contributions  | 108   | director       | 47    | power          | 22    | compensation   | 51    | control        | 93    | governance     | 147   | equity         | 23    | compensation | 307   | leadership   | 38    |
| spending     | 22    | leadership     | 104   | independent    | 46    | shares         | 19    | independent    | 49    | lobbying       | 89    | management     | 143   | committee      | 23    | statement    | 305   | retirement   | 35    |
| proxy        | 22    | ceo            | 99    | compensation   | 45    | director       | 16    | leadership     | 42    | tax            | 84    | disclosure     | 138   | independent    | 21    | governance   | 299   | dividend     | 31    |
| dividend     | 21    | spending       | 98    | accountability | 43    | reporting      | 15    | oversight      | 41    | director       | 83    | proxy          | 110   | lobbying       | 20    | votes        | 292   | policy       | 29    |
| directors    | 21    | equity         | 94    | pay            | 43    | contributions  | 15    | review         | 37    | proxy          | 76    | voting         | 108   | performance    | 19    | committee    | 247   | power        | 28    |
| vote         | 19    | performance    | 92    | governance     | 42    | compensation   | 15    | governance     | 36    | compensation   | 69    | equity         | 108   | audit          | 19    | performance  | 229   | security     | 25    |
| leadership   | 18    | committee      | 91    | transparency   | 37    | regulatory     | 13    | ceo            | 36    | committee      | 64    | audit          | 108   | responsibility | 18    | dividends    | 197   | dividends    | 25    |
| statement    | 18    | independent    | 85    | disclose       | 35    | principles     | 13    | spending       | 35    | transparency   | 64    | stakeholder    | 104   | votes          | 17    | investors    | 183   | director     | 25    |
| regulatory   | 17    | statement      | 78    | contributions  | 32    | governance     | 12    | accountability | 34    | independent    | 55    | election       | 103   | leadership     | 15    | investor     | 181   | bonus        | 24    |
| transparency | 17    | accountability | 75    | committee      | 31    | pay            | 12    | reporting      | 31    | contributions  | 54    | report         | 101   | election       | 14    | leadership   | 178   | independent  | 24    |
| voting       | 16    | disclose       | 70    | oversight      | 25    | independent    | 12    | committee      | 31    | reports        | 51    | accountability | 88    | transparency   | 14    | election     | 161   | paying       | 23    |

*Remark:* This table reports the 30 most frequent governance-related words used by each shareholder type.

In a next step, we extend our exploratory analysis by examining how different types of shareholders contribute to the proportion of environmental, social or governance words used during the AGM dialogue. In Table IV.7, we report the results from estimating equation IV.2 where we regress the share of environmental, social and governance words in shareholder statements on dummy variables representing shareholder types. Since analyzing thousands of individual shareholder statements is more challenging with tf-idf adjustments due to the fragmented, highly variable, and often unstructured nature of these statements, we use the unadjusted share values as our dependent variables. This variability can make it harder to establish meaningful term weights because the context is less consistent, resulting in challenges such as noise dominating the analysis. The baseline used for comparison is the category of individual shareholders.

Column (1) presents the results for the share of environmental words in shareholder statements as our main variable of interest. Several shareholder types positively contribute to the share of environmental words compared to individual shareholders. Notably, the coefficients on *religious asset manager*, *religious organization*, *proxy*, *NGO*, *asset manager*, and *public asset manager* are positive and statistically significant at the 1% and 5% levels, indicating a stronger emphasis on environmental issues in AGM statements compared to individual shareholders. In contrast, the coefficient on *(former) employee* is negative and significant at the 1% level, suggesting that they downplay environmental issues compared to individual shareholders. The coefficient on *analyst* is also negative, but statistically insignificant, indicating that this shareholder category does not significantly differ from individual shareholders in this area. Similarly, the coefficient on *trade union* is comparatively small and statistically insignificant, suggesting no notable contribution to the share of environmental words in the AGM dialogue compared to individual shareholders.

Column (2) presents the results for the share of social words in shareholder statements as our main variable of interest. Most shareholder categories contribute positively to the share of social words relative to individual shareholders. Public asset managers, trade unions, and NGOs stand out as the largest contributors, with coefficients that are statistically significant at the 1% level, suggesting that these groups place a stronger

Table IV.7: Heterogeneity of shareholders' ESG communication.

|                            | ENV Share<br>(1)     | SOC Share<br>(2)    | GOV Share<br>(3)    |
|----------------------------|----------------------|---------------------|---------------------|
| (Former) Employee          | -0.160***<br>(0.055) | 0.082*<br>(0.046)   | -0.030<br>(0.069)   |
| Analyst                    | -0.018<br>(0.082)    | -0.025<br>(0.094)   | -0.213*<br>(0.128)  |
| Asset Manager              | 0.618***<br>(0.112)  | 0.559***<br>(0.106) | 0.964**<br>(0.145)  |
| NGO                        | 0.778***<br>(0.093)  | 0.659***<br>(0.107) | 0.289***<br>(0.055) |
| Proxy                      | 0.794***<br>(3.59)   | 0.442**<br>(1.97)   | 0.559***<br>(2.43)  |
| Public Asset Manager       | 0.350**<br>(0.145)   | 1.254***<br>(0.254) | 1.690***<br>(0.181) |
| Religious Asset Manager    | 1.148***<br>(0.274)  | 0.357***<br>(0.166) | 0.771***<br>(0.257) |
| Religious Organization     | 0.801***<br>(0.167)  | 0.551***<br>(0.115) | 0.867***<br>(0.122) |
| Trade Union                | 0.018<br>(0.051)     | 0.675***<br>(0.102) | 0.896***<br>(0.092) |
| Controls                   | Yes                  | Yes                 | Yes                 |
| Industry FE                | Yes                  | Yes                 | Yes                 |
| Year FE                    | Yes                  | Yes                 | Yes                 |
| Observations               | 5,940                | 5,940               | 5,940               |
| Adjusted <i>R</i> -squared | 0.226                | 0.118               | 0.258               |

*Remark:* This table reports the coefficients from OLS regressions of the share of ESG communication on dummy variables that proxy the shareholder types. ENV Share, SOC Share and GOV Share denote the share of environmental, social and governance words in shareholder communication, respectively, and are calculated by dividing the number of environmental, social and governance words by the total word count in a statement. The variables *Analyst*, *(Former) Employee*, *Trade Union*, *Religious Organization*, *Religious Asset Manager*, *Public Asset Manager*, *NGOs* and *Proxy* are dummy variables which equal one if the statement was made by a shareholder from the respective category. The baseline group is *Individual Shareholder*. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

emphasis on social issues in their communication compared to individual shareholders. (Former) employees also contribute positively to the share of social words, but their contribution is more marginal, with a coefficient of 0.082 that is significant at the 10% level. In contrast, the coefficient on *analyst* is once again negative and statistically insignificant, suggesting that although analysts are rather vocal during AGMs (see Figure IV.1), their soft engagement is not strongly targeted at social issues.

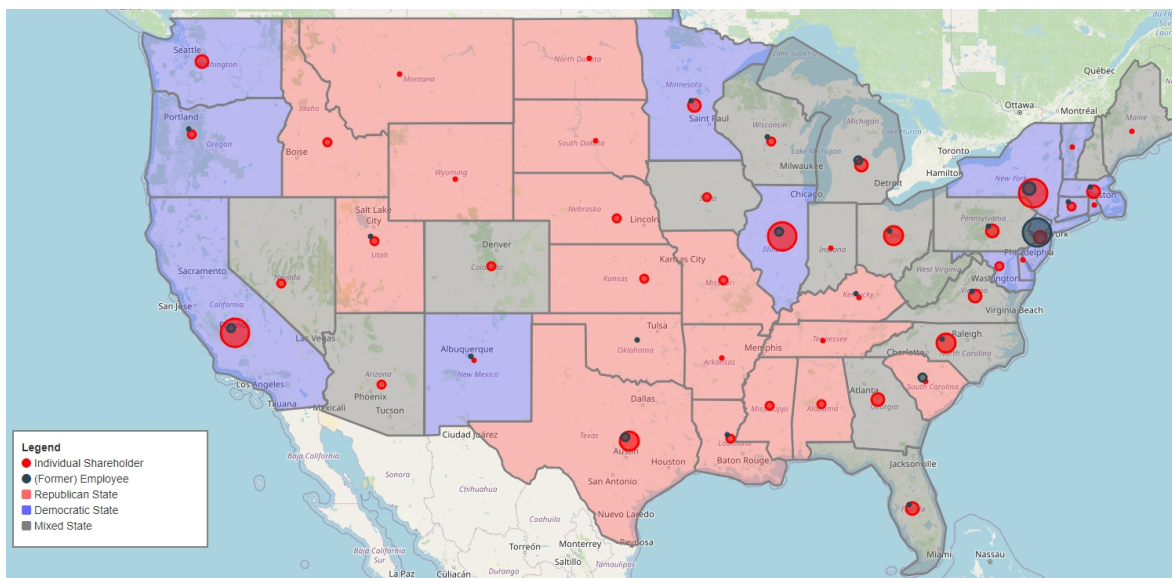
The comparatively large coefficients in column (3) are consistent with our previous observations and in line with the notion that governance topics are a central aspect of AGMs. We find that the public asset managers, asset managers and trade unions contribute particularly strongly to the share of governance words compared to individual shareholders. This is shown by the large coefficients on *public asset manager*, *asset manager*, and *trade union*, which are all significant at least at the 5% level. In contrast, the coefficient on *analyst* is negative and statistically significant at the 10% level, indicating a weaker emphasis on governance issues in their statements. The coefficient on *(former) employee* is negative but statistically insignificant.

Overall, the analysis shows important differences in the extent to which different shareholder types engage on ESG issues at the AGM. Asset managers, public asset managers and religious asset managers consistently engage on all three ESG dimensions. NGOs also show strong contributions across all dimensions, with a particularly notable focus on environmental and social issues. Trade unions display significant engagement with social and governance matters. These findings indicate that institutional investors, with the exception of analysts, are particularly active in terms of soft engagement related to ESG issues during AGMs, and more strongly so than individual shareholders.

#### **IV.4.2 What is the role of the political environment for shareholder soft engagement on ESG issues?**

In a next step, we examine the role of the political environment for shareholder soft ESG engagement. As outlined in Section IV.3, we exploit data on the geographical location of the shareholders in our sample. For individual shareholders who speak at the AGM

Figure IV.2: Geographical distribution of individual shareholders and (former) employees across continental US.



*Remark:* This figure shows the geographical location of individual shareholders and (former) employees as measured by number of statements per shareholder category per US state.

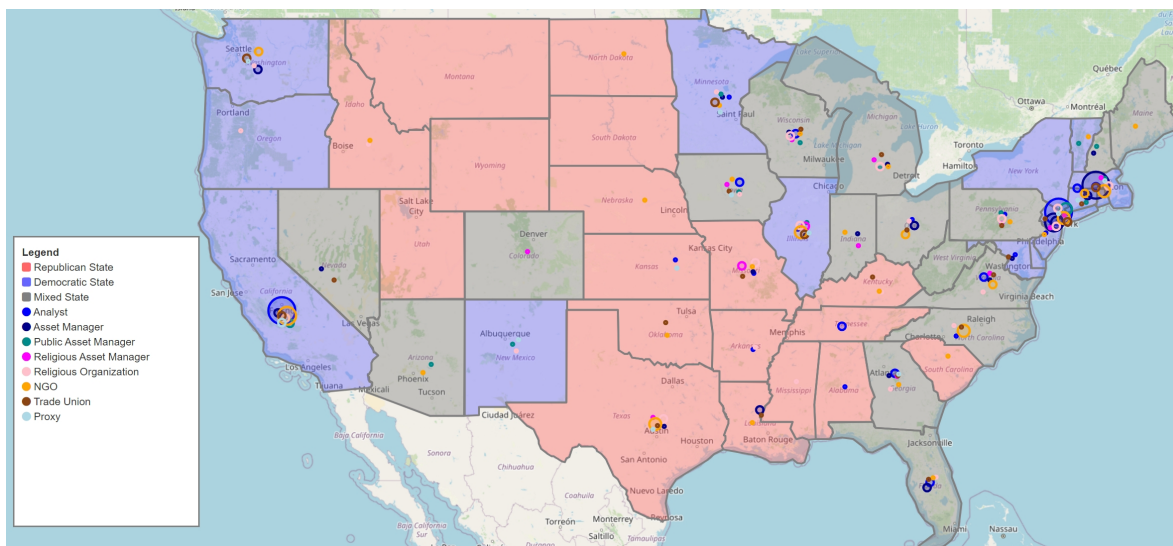
on their own behalf, these locations are directly inferred from their AGM statements and typically correspond to their places of residence. For institutional shareholders, locations are assigned based on their company headquarters. In line with Di Giuli and Kostovetsky (2014), we assume that asset managers and other institutional shareholders spend significant time at their headquarters and are likely to make statements aligned with corporate policies, justifying our choice to use these locations.

Figure IV.2 presents a map of the continental U.S., illustrating the geographical distribution of individual shareholders and (former) employees by state, based on their statements.<sup>13</sup> Red dots represent statements made by individual shareholders from that particular geographic location, while dark blue dots represent statements from (former) employees. Given the larger number of statements made by individual shareholder in our sample, the red dots stand out more on the map. The map shows that individual shareholders are widely distributed across the country and are represented in democratic (blue), republican (red) and swing (grey) states.<sup>14</sup> In contrast, Figure IV.3 presents a

<sup>13</sup>The map does not include Alaska and Hawaii.

<sup>14</sup>States that alternated at least once between voting Democratic and Republican are categorized as “mixed states” because we consider the entire sample period in this map rather than a single year. We

Figure IV.3: Geographical distribution of institutional shareholders across continental US.



*Remark:* This figure shows the geographical location of institutional shareholders as measured by number of statements per shareholder category per US state.

similar map, this time illustrating the geographical distribution of institutional shareholders, based on their statements. The results indicate that institutional shareholders, especially asset managers, are more concentrated in democratic (blue) states, largely due to the clustering of financial firms and company headquarters on the East Coast and in the state of California.

Given the marked differences in the geographical distribution of shareholders, we examine whether their political environment, as measured by the political orientation of their state of establishment, affects their soft engagement on ESG issues at AGMs. To do so, we estimate equation IV.3 and report the results in Table IV.8. In Panel A, we focus on individual shareholders and use a dummy variable, which is equal to one if a statement was made by an individual shareholder and zero otherwise. In Panel B, we perform the same analysis, this time with a focus on institutional shareholders. Columns (1-3) display the results for the tf-idf adjusted shares of ESG communication, while columns (4-6) present the results for the non-adjusted shares as our main variables of interest.

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refer to these swing states as “mixed states” on purpose to highlight that their political orientation is mixed and varies between a Democratic and a Republican orientation.

Table IV.8: Relationship between political environment and ESG communication.

| <b>Panel A: Individual Shareholders</b>    |                                    |                                    |                                    |                      |                     |                      |
|--------------------------------------------|------------------------------------|------------------------------------|------------------------------------|----------------------|---------------------|----------------------|
|                                            | ENV Share <sub>tf.idf</sub><br>(1) | SOC Share <sub>tf.idf</sub><br>(2) | GOV Share <sub>tf.idf</sub><br>(3) | ENV Share<br>(4)     | SOC Share<br>(5)    | GOV Share<br>(6)     |
| REP × individual shareholder               | -0.072<br>(0.204)                  | 0.043<br>(0.149)                   | -0.519***<br>(0.178)               | 0.003<br>(0.004)     | -0.011**<br>(0.005) | -0.025***<br>(0.008) |
| Individual shareholder                     | -0.441***<br>(0.078)               | -0.502***<br>(0.089)               | -0.262***<br>(0.099)               | -0.006***<br>(0.001) | -0.008**<br>(0.004) | 0.014***<br>(0.005)  |
| REP                                        | -0.019<br>(0.157)                  | -0.089<br>(0.150)                  | -0.026<br>(0.134)                  | -0.004<br>(0.003)    | 0.011**<br>(0.005)  | -0.004<br>(0.004)    |
| Controls                                   | Yes                                | Yes                                | Yes                                | Yes                  | Yes                 | Yes                  |
| Industry FE                                | Yes                                | Yes                                | Yes                                | Yes                  | Yes                 | Yes                  |
| Year FE                                    | Yes                                | Yes                                | Yes                                | Yes                  | Yes                 | Yes                  |
| Observations                               | 2,876                              | 2,876                              | 2,876                              | 4,321                | 4,321               | 4,321                |
| Adjusted <i>R</i> -squared                 | 0.171                              | 0.085                              | 0.200                              | 0.134                | 0.021               | 0.118                |
| <b>Panel B: Institutional Shareholders</b> |                                    |                                    |                                    |                      |                     |                      |
|                                            | ENV Share <sub>tf.idf</sub><br>(1) | SOC Share <sub>tf.idf</sub><br>(2) | GOV Share <sub>tf.idf</sub><br>(3) | ENV Share<br>(4)     | SOC Share<br>(5)    | GOV Share<br>(6)     |
| REP × institutional shareholder            | 0.086<br>(0.204)                   | 0.020<br>(0.146)                   | 0.550***<br>(0.156)                | -0.001<br>(0.004)    | 0.015***<br>(0.006) | 0.028***<br>(0.008)  |
| Institutional shareholder                  | 0.510***<br>(0.088)                | 0.533***<br>(0.092)                | 0.307***<br>(0.102)                | 0.008***<br>(0.002)  | 0.007**<br>(0.003)  | -0.010**<br>(0.005)  |
| REP                                        | -0.081<br>(0.093)                  | -0.069<br>(0.073)                  | -0.523***<br>(0.090)               | -0.001<br>(0.003)    | -0.001<br>(0.003)   | -0.028***<br>(0.007) |
| Controls                                   | Yes                                | Yes                                | Yes                                | Yes                  | Yes                 | Yes                  |
| Industry FE                                | Yes                                | Yes                                | Yes                                | Yes                  | Yes                 | Yes                  |
| Year FE                                    | Yes                                | Yes                                | Yes                                | Yes                  | Yes                 | Yes                  |
| Observations                               | 2,876                              | 2,876                              | 2,876                              | 4,321                | 4,321               | 4,321                |
| Adjusted <i>R</i> -squared                 | 0.177                              | 0.090                              | 0.205                              | 0.137                | 0.021               | 0.117                |

*Remark:* This table reports coefficients from OLS regressions of different measures of the share of ESG communication by shareholders on the political environment and company characteristics. Panel A focuses on statements made by individual shareholders, while Panel B examines statements made by institutional shareholders. *Individual Shareholder* is a dummy that equals one if the statement was made by an individual shareholder and *REP* is a dummy variable that equals one if the individual shareholder lives in a U.S. state that voted Republican in the last presidential election. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.



The results corroborate our previous findings from the exploratory analysis in Section IV.4.1 and suggest that individual shareholders are less vocal about ESG issues in their AGM statements compared to institutional shareholders, potentially prioritizing issues more directly tied to their own financial returns. In all specifications, except for column (6), the coefficient on *individual shareholder* is negative and significant at least at the 5% level. While this is particularly pronounced for the adjusted shares of environmental and social words, as shown by columns (1) and (2), a similar pattern can be observed for non-adjusted shares in columns (4) and (5), reinforcing the notion that individual shareholders emphasize environmental and social issues less strongly in their AGM statements compared to institutional shareholders. Overall, this is in line with prior research that highlights the important role played by institutional investors in promoting ESG considerations, and it aligns with the notion that both social and environmental issues have become important criteria for share ownership (see e.g., Guay et al., 2004; Krueger et al., 2020; von Meyerinck et al., 2018; Flammer et al., 2021; Hoepner et al., 2023).

Next, we analyze the political environment as a potential mediator for the relationship between shareholder category and share of ESG communication. The coefficients on *REP* are negative across all specifications (except for column (5)), as expected, but are statistically insignificant. Turning to the interaction term in Panel A, we obtain a negative and statistically significant coefficient at the 1% level in columns (3) and (6), indicating that individual shareholders are even less vocal about governance topics when they reside in Republican states. A similar pattern can be observed in column (5), where the coefficient on the interaction term is negative and statistically significant at the 5% level, suggesting that individual shareholders are also even less vocal about social issues when they are located in Republican states compared to individual shareholders who live in Democratic states. In terms of environmental share, we obtain in both column (1) and (4) an insignificant coefficient for the interaction term. Thus, we conclude that individual shareholders' engagement on environmental issues, as measured by the share of related words, does not depend on whether they reside in a Republican state. While their overall engagement on environmental issues

is lower than that of institutional shareholders, this difference does not appear to be significantly influenced by their political environment.

Further, Panel B shows that institutional investors actively engage on ESG issues in their AGM statements, and that this engagement is not significantly constrained when their headquarters are located in Republican-leaning states. Focusing on the interaction term, we obtain an insignificant coefficient in columns (1), (2) and (4). At the same time, the coefficients in columns (3), (5) and (6) are positive and significant at the 1% level, suggesting that institutional shareholders are even more vocal on governance and social issues when they are located in Republican-leaning states compared to institutional investors who are headquartered in Democratic states. In sum, while the political environment has some influence, it does not appear to be a decisive factor in limiting the ESG communication of institutional shareholders. Nevertheless, it is also worth noting that while some states such as Texas began directing their agencies to divest from investment firms perceived as hostile to fossil fuels as early as 2021, publishing a list of specific list of banned funds (Rajgopal et al., 2023), the broader wave of “ESG backlash” in Republican states occurred later on, i.e., in 2022–2023. Consequently, its effects may not be fully captured within the timeframe considered in this study.

#### **IV.4.3 Which firms are targeted by shareholder soft engagement on ESG issues?**

In a next step, we turn to the firms in our sample and examine whether their ESG performance influences shareholder soft engagement at AGMs. As discussed in Section IV.1, AGMs provide shareholders with a platform to interact with management, raise concerns, and discuss corporate policies and strategies. Shareholders may be especially inclined to engage with firms that exhibit weaker performance, including in ESG areas. For example, prior research shows that soft engagement at AGMs may be triggered by shareholder discontent with the firm’s financial performance (Dimitrov and Jain, 2011). Thus, soft engagement appears to be particularly directed toward firms for which shareholders perceive a greater need to address deficiencies and push

for improvements.

Building on this, we examine whether ESG performance influences shareholder soft engagement. To do so, we estimate equation (IV.4), where we regress the proportion of environmental, social and governance words in shareholder communication at AGMs on the firms' overall ESG scores and their individual pillar scores. The results of this analysis are presented in Table IV.9.

Table IV.9: Relationship between sustainability performance and ESG communication (industry-adjusted ESG score and pillar scores).

|                                  | ENV $Share_{tf.idf}$<br>(1) | SOC $Share_{tf.idf}$<br>(2) | GOV $Share_{tf.idf}$<br>(3) | ENV $Share_{tf.idf}$<br>(4) | SOC $Share_{tf.idf}$<br>(5) | GOV $Share_{tf.idf}$<br>(6) |
|----------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| ESG score <sub>t</sub>           | -0.058***<br>(0.021)        | -0.045***<br>(0.016)        | -0.043**<br>(0.018)         |                             |                             |                             |
| Environmental score <sub>t</sub> |                             |                             |                             | -0.023<br>(0.019)           |                             |                             |
| Social score <sub>t</sub>        |                             |                             |                             |                             | -0.064**<br>(0.021)         |                             |
| Governance score <sub>t</sub>    |                             |                             |                             |                             |                             | -0.047*<br>(0.026)          |
| Controls                         | Yes                         | Yes                         | Yes                         | Yes                         | Yes                         | Yes                         |
| Industry FE                      | Yes                         | Yes                         | Yes                         | Yes                         | Yes                         | Yes                         |
| Year FE                          | Yes                         | Yes                         | Yes                         | Yes                         | Yes                         | Yes                         |
| Observations                     | 1,419                       | 1,419                       | 1,419                       | 1,419                       | 1,419                       | 1,419                       |
| Adjusted <i>R</i> -squared       | 0.471                       | 0.331                       | 0.428                       | 0.462                       | 0.330                       | 0.426                       |

*Remark:* This table reports coefficients from OLS regressions of different measures of the share of ESG communication by shareholders on ESG scores and company characteristics.  $ENV Share_{tf.idf}$ ,  $SOC Share_{tf.idf}$  and  $GOV Share_{tf.idf}$  denote the share of E, S and G words in shareholder communication, respectively. All three measures are adjusted by their term frequency and their inverse document frequency. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

In line with our expectations, we find a negative relationship between a firm's ESG performance and the prominence of ESG-related words in shareholder communication during AGMs. Columns (1)–(3) focus on the overall ESG scores as independent variable, while columns (4)–(6) provide a more detailed examination of the individual pillar scores. The coefficients on *ESG score* in columns (1)–(3) are all negative and statistically significant at the 1% or 5% level. Overall, we find that the better a firm's sustainability performance, as measured by its ESG rating, the lower the level of shareholder engagement on ESG issues at AGMs, based on the proportion of environmental, social and governance words. One plausible explanation for these findings is that shareholders are less likely to raise questions or make comments about ESG issues when they perceive the firm to be performing well in these dimensions. Conversely, shareholders are more likely to engage and voice concerns when they perceive a misalignment between the firm's ESG practices and their expectations or interests.

Looking at individual ESG pillar scores, we continue to observe a negative relationship with the proportion of environmental, social and governance terms in shareholder communication, although the effect is statistically weaker. The coefficient on *social score* is negative and statistically significant at the 5% level. In the same vein, the coefficient on *governance score* is negative and statistically significant at the 10% level. At the same time, we obtain a statistically insignificant coefficient on *environmental score*. Overall, while a higher social and governance performance thus tend to go along with a reduction in the use of related language, the relationship is not systematic and perfectly aligned. Specifically, although firms may exhibit high environmental performance, this does not appear to translate into a corresponding decrease in the use of environmental language employed by shareholders. There may be several reasons for this. First, the overall ESG performance may be particularly relevant to shareholders, and their perception of the underlying issues at hand may vary, leading to different levels of engagement with respect to environmental, social and governance issues at AGMs. Second, it is important to recall that the overall ESG scores in our analyses are an industry-adjusted measures, while the individual pillar scores are not. As a result, the ESG scores may better capture how firms fare compared to their peers,

which may also matter to shareholders. Furthermore, Figure IV.1 already highlighted the importance of the social and governance dimensions for shareholders in their AGM statements, and our results further align with our initial observations.

Next, we break down the analysis further by regressing the share of shareholder ESG communication against the ESG sub-scores (or “theme” scores) that belong to the individual environmental, social and governance pillars. This analysis allows us to examine whether specific themes emerge as particularly important and relevant for shareholder soft engagement on ESG issues. The results are reported in Table IV.10.

Table IV.10: Relationship between sustainability performance and ESG communication (theme scores).

|                                                | ENV Share <sub>tf.idf</sub><br>(1) | ENV Share <sub>tf.idf</sub><br>(2) | ENV Share <sub>tf.idf</sub><br>(3) | ENV Share <sub>tf.idf</sub><br>(4) | ENV Share <sub>tf.idf</sub><br>(5) | SOC Share <sub>tf.idf</sub><br>(6) | SOC Share <sub>tf.idf</sub><br>(7) | SOC Share <sub>tf.idf</sub><br>(8) | GOV Share <sub>tf.idf</sub><br>(9) | GOV Share <sub>tf.idf</sub><br>(10) |
|------------------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-------------------------------------|
| Environmental opportunities score <sub>t</sub> | -0.061<br>(0.092)                  |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                     |
| Waste management score <sub>t</sub>            |                                    | -0.138***<br>(0.050)               |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                     |
| Natural resources usage score <sub>t</sub>     |                                    |                                    | -0.102***<br>(0.037)               |                                    |                                    |                                    |                                    |                                    |                                    |                                     |
| Log(scope 1) <sub>t</sub>                      |                                    |                                    |                                    | 0.039*<br>(0.022)                  |                                    |                                    |                                    |                                    |                                    |                                     |
| Climate change score <sub>t</sub>              |                                    |                                    |                                    |                                    | 0.010<br>(0.019)                   |                                    |                                    |                                    |                                    |                                     |
| Product safety score <sub>t</sub>              |                                    |                                    |                                    |                                    |                                    | -0.033<br>(0.023)                  |                                    |                                    |                                    |                                     |
| Human capital score <sub>t</sub>               |                                    |                                    |                                    |                                    |                                    |                                    | -0.033*<br>(0.019)                 |                                    |                                    |                                     |
| Social opportunities score <sub>t</sub>        |                                    |                                    |                                    |                                    |                                    |                                    |                                    | -0.042<br>(0.047)                  |                                    |                                     |
| Corporate gov. score <sub>t</sub>              |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    | -0.014<br>(0.021)                  |                                     |
| Business ethics score <sub>t</sub>             |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    | -0.063*<br>(0.037)                  |
| Controls                                       | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                 |
| Industry FE                                    | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                 |
| Year FE                                        | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                | Yes                                 |
| Observations                                   | 362                                | 528                                | 1,008                              | 1,363                              | 1,366                              | 825                                | 1,151                              | 294                                | 1,157                              | 824                                 |
| Adjusted R-squared                             | 0.267                              | 0.324                              | 0.394                              | 0.582                              | 0.582                              | 0.259                              | 0.261                              | 0.253                              | 0.377                              | 0.347                               |

*Remark:* This table reports coefficients from OLS regressions of different measures of the share of ESG communication by shareholders on ESG scores and company characteristics.  $ENV Share_{tf.idf}$ ,  $SOC Share_{tf.idf}$  and  $GOV Share_{tf.idf}$  denote the share of E, S and G words in shareholder communication, respectively. All three measures are adjusted by their term frequency and their inverse document frequency. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

In columns (1)–(5), we examine the adjusted share of environmental words as our main variable of interest, followed by the adjusted share of social words in columns (6)–(8) and the adjusted share of governance words in columns (9)–(10). We obtain a negative and significant coefficient at the 1% level on both *waste management score* and *natural resources usage score*. The results indicate that a stronger environmental performance, particularly in these areas, is associated with a lower proportion of environmental terms in shareholder statements during AGMs (columns (2) and (3)). In contrast, higher levels of scope 1 greenhouse gas emissions are linked to a marginally significant increase in the share of environmental language, as shown by the positive and significant coefficient on  $\log(\text{scope } 1)$  in column (4). While this effect is weaker both in terms of size and statistical significance (10% level) than the ones in columns (2) and (3), it suggests that shareholders are more likely to engage on this issue when a firm’s direct emissions are higher (column (4)). These findings are consistent with prior studies that emphasize the attention paid to greenhouse gas emissions, particularly by institutional investors (Bolton and Kacperczyk, 2021, 2023). However, we obtain no statistically significant coefficient for the climate change theme score (Column 5), which may be due to the score’s dual focus on both a firm’s exposure to climate change and its efforts to manage that exposure.<sup>15</sup>

In the social dimension, we find in column (7) a negative and significant coefficient at the 10% level on *human capital score*, underscoring the relationship between shareholder engagement on social issues, as measured by the proportion of social words, and human capital. This is consistent with the notion that issues such as employee well-being, but also the ability of firms to attract, retain and develop a highly skilled workforce, are of concern to shareholders. This relationship may also be partly explained by the presence of employees and trade unions among the shareholders in the sample. Finally, business ethics emerges as a relevant factor for governance-related shareholder engagement, with a negative and significant coefficient observed on *business ethics score*

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<sup>15</sup>For example, the theme score incorporates factors such as a firm’s vulnerability to climate change, as well as its exposure to and management of environmental risks. Depending on the specific aspect considered, we would expect the share of environmental words in shareholder statements to either increase or decrease.



in column (10). This suggests that shareholders pay particular attention to issues such as a company's oversight and management of fraud, executive misconduct, corruption, money laundering or antitrust violations. When these issues are managed effectively, shareholders are thus less likely to address them during AGMs.

Overall, while these findings underscore the importance of ESG performance in shaping shareholder soft engagement at AGMs, they once again also highlight the complexity of this relationship. As noted earlier, we do not find a systematic correspondence between a firm's performance in a specific theme and the proportion of shareholder communication related to that exact same theme. Instead, the overall ESG performance and the management of specific issues appear to drive shareholder soft engagement, and thus, the share of environmental, social and governance language in AGM statements.

#### **IV.4.4 What is the tone of shareholder soft engagement on ESG issues?**

As discussed in Section IV.4.3, ESG performance influences shareholder soft engagement on ESG issues, shaping the *content* of shareholder statements, as measured by the share of environmental, social and governance words. In a next step, we analyze the *tone* of such statements. Isolating the tone allows us to go beyond the analysis of *what* is being said to focus on *how* it is being said (Price et al., 2012). The underlying expectation is shareholders may engage on sustainability issues to address perceived deficiencies, voice concerns, or express discontent with a poor sustainability track record. Thus, the better the ESG performance of a firm, the lower the soft engagement of shareholders in the form of negative questions and comments at the respective AGM. We expect this dynamic to be reflected in the proportion of negative words in shareholder statements during AGMs. To do so, we estimate equation IV.5 by regressing the tone of shareholders on the overall ESG score along with firm controls as well as year and industry fixed effects. The results are presented in Table IV.11.

Building on Hillert et al. (2024), we consider tf.idf adjusted negativity measures derived from the Harvard-IV dictionary in columns (1)-(2) and include adjusted negativity

Table IV.11: Relationship between ESG Performance and HAR &amp; LMD tone.

|                                  | $HAR_{tf.idf}^-$<br>(1) | $HAR_{tf.idf}^-$<br>(2) | $LMD_{tf.idf}^-$<br>(3) | $LMD_{tf.idf}^-$<br>(4) |
|----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| ESG score <sub>t</sub>           | -0.063***<br>(0.024)    |                         | -0.069***<br>(0.025)    |                         |
| Environmental score <sub>t</sub> |                         | -0.029<br>(0.021)       |                         | -0.032<br>(0.023)       |
| Social score <sub>t</sub>        |                         | -0.057**<br>(0.024)     |                         | -0.069***<br>(0.025)    |
| Governance score <sub>t</sub>    |                         | -0.051<br>(0.031)       |                         | -0.055*<br>(0.033)      |
| Controls                         | Yes                     | Yes                     | Yes                     | Yes                     |
| Industry FE                      | Yes                     | Yes                     | Yes                     | Yes                     |
| Year FE                          | Yes                     | Yes                     | Yes                     | Yes                     |
| Observations                     | 1,360                   | 1,360                   | 1,360                   | 1,360                   |
| Adjusted <i>R</i> -squared       | 0.472                   | 0.471                   | 0.422                   | 0.421                   |

*Remark:* This table reports coefficients from OLS regressions of different measures of shareholder tone on ESG scores and company characteristics.  $LMD_{tf.idf}^-$  is the negativity of a transcript according to the Loughran and McDonald (2011) dictionary weighted by their term frequency and inverse document frequency.  $HAR_{tf.idf}^-$  is the negativity of a transcript according to the Harvard IV-4 psychosocial dictionary weighted by their term frequency and inverse document frequency. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

measures based on the LMD dictionary in columns (3)-(4). As expected, we obtain, both in columns (1) and (3), negative and statistically significant coefficients at the 1% level on *ESG score*. The magnitude of the coefficients is comparable across both specifications and suggest that a higher overall ESG performance is associated with a less negative tone of shareholder statements, as captured by the LMD and Harvard-IV dictionaries. Once again, we use industry-adjusted ESG scores, which capture particularly well how a firm is performing relative to its industry peer group.

When substituting the overall ESG score with individual pillar scores, the results in columns (2) and (4) indicate that the social score has a more pronounced effect on reducing the negativity of shareholders' tone during AGMs. Specifically, we obtain negative and statistically significant coefficients at the 1% or 5% level on *social score* in both columns, which underscores the importance of the social dimension for

shareholders and corroborates our earlier findings. Furthermore, we find some evidence suggesting that the governance performance is associated with a marginal reduction in the proportion of negative words in shareholder statements, as shown by the negative and significant coefficient on *governance score* in column (4). Overall, the results once again underscore the importance of the overall ESG performance, and they also underscore the importance of the social and governance dimensions (in line with figure IV.1) for the tone of shareholders at AGMs in the form of negative statements.

In Table IV.12, we extend our analysis by disaggregating the pillar scores into their respective theme scores. In Panel A, we employ adjusted negativity measures based on the Harvard-IV dictionary as our main variables of interest, while in Panel B, we perform the same analysis using the LMD dictionary. The results show that, irrespective of the dictionary used, issues related to the use of natural resources, waste management, human capital and business ethics are negatively associated with the negative tone of shareholder statements at AGMs. Notably, these themes corroborate our prior findings in Table IV.10 and underscore that when shareholders engage on these issues, they do so with a negative tone. These results are also in line with the results for the regression specifications in columns (1) and (3) in Table IV.11, but contrast with columns (2) and (4) of the same table, where we found no strong statistical evidence for the link between the environmental score and shareholder negative tone. This further highlights that not all aspects of sustainability influence shareholder tone in the same way, underscoring the complex relationship between ESG performance and shareholder soft engagement on ESG issues at AGMs.

Table IV.12: Relationship between ESG performance and HAR &amp; LMD tone.

| Panel A: Harvard-IV Dictionary                 |                                |                                |                                |                                |                                |                                |                                |                                |                                |                                 |
|------------------------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|---------------------------------|
|                                                | $\text{HAR}_{tf.idf}^-$<br>(1) | $\text{HAR}_{tf.idf}^-$<br>(2) | $\text{HAR}_{tf.idf}^-$<br>(3) | $\text{HAR}_{tf.idf}^-$<br>(4) | $\text{HAR}_{tf.idf}^-$<br>(5) | $\text{HAR}_{tf.idf}^-$<br>(6) | $\text{HAR}_{tf.idf}^-$<br>(7) | $\text{HAR}_{tf.idf}^-$<br>(8) | $\text{HAR}_{tf.idf}^-$<br>(9) | $\text{HAR}_{tf.idf}^-$<br>(10) |
| Environmental opportunities score <sub>t</sub> | -0.066<br>(0.051)              |                                |                                |                                |                                |                                |                                |                                |                                |                                 |
| Waste management score <sub>t</sub>            |                                | -0.059**<br>(0.027)            |                                |                                |                                |                                |                                |                                |                                |                                 |
| Climate change theme score <sub>t</sub>        |                                |                                | 0.003<br>(0.018)               |                                |                                |                                |                                |                                |                                |                                 |
| Natural resource usage score <sub>t</sub>      |                                |                                |                                | -0.062**<br>(0.025)            |                                |                                |                                |                                |                                |                                 |
| Log(scope 1)                                   |                                |                                |                                |                                | 0.020<br>(0.021)               |                                |                                |                                |                                |                                 |
| Product safety score <sub>t</sub>              |                                |                                |                                |                                |                                | -0.038<br>(0.028)              |                                |                                |                                |                                 |
| Human capital score <sub>t</sub>               |                                |                                |                                |                                |                                |                                | -0.031*<br>(0.017)             |                                |                                |                                 |
| Social opportunities score <sub>t</sub>        |                                |                                |                                |                                |                                |                                |                                | -0.054<br>(0.046)              |                                |                                 |
| Corporate gov. score <sub>t</sub>              |                                |                                |                                |                                |                                |                                |                                |                                | -0.003<br>(0.020)              |                                 |
| Business Ethics score <sub>t</sub>             |                                |                                |                                |                                |                                |                                |                                |                                |                                | -0.062*<br>0.036                |
| Controls                                       | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                             |
| Industry FE                                    | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                             |
| Year FE                                        | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                            | Yes                             |
| Observations                                   | 341                            | 506                            | 1,098                          | 966                            | 1304                           | 794                            | 1,093                          | 289                            | 1099                           | 773                             |
| Adjusted R-squared                             | 0.460                          | 0.572                          | 0.499                          | 0.524                          | 0.550                          | 0.511                          | 0.502                          | 0.476                          | 0.499                          | 0.515                           |

Continued on next page...

Panel B: Loughran and McDonald Dictionary

|                                                | $LMD_{tf.idf}^-$<br>(1) | $LMD_{tf.idf}^-$<br>(2) | $LMD_{tf.idf}^-$<br>(3) | $LMD_{tf.idf}^-$<br>(4) | $LMD_{tf.idf}^-$<br>(5) | $LMD_{tf.idf}^-$<br>(6) | $LMD_{tf.idf}^-$<br>(7) | $LMD_{tf.idf}^-$<br>(8) | $LMD_{tf.idf}^-$<br>(9) | $LMD_{tf.idf}^-$<br>(10) |
|------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|--------------------------|
| Environmental opportunities score <sub>t</sub> | -0.032<br>(0.039)       |                         |                         |                         |                         |                         |                         |                         |                         |                          |
| Waste management score <sub>t</sub>            |                         | -0.056**<br>(0.026)     |                         |                         |                         |                         |                         |                         |                         |                          |
| Climate change theme score <sub>t</sub>        |                         |                         | 0.000<br>(0.018)        |                         |                         |                         |                         |                         |                         |                          |
| Natural resource usage score <sub>t</sub>      |                         |                         |                         | -0.066***<br>(0.025)    |                         |                         |                         |                         |                         |                          |
| Log(scope 1)                                   |                         |                         |                         |                         | 0.021<br>(0.023)        |                         |                         |                         |                         |                          |
| Product safety score <sub>t</sub>              |                         |                         |                         |                         |                         | -0.037<br>(0.030)       |                         |                         |                         |                          |
| Human capital score <sub>t</sub>               |                         |                         |                         |                         |                         |                         | -0.037**<br>(0.017)     |                         |                         |                          |
| Social opportunities score <sub>t</sub>        |                         |                         |                         |                         |                         |                         |                         | -0.051<br>(0.046)       |                         |                          |
| Corporate gov. score <sub>t</sub>              |                         |                         |                         |                         |                         |                         |                         |                         | 0.006<br>(0.021)        |                          |
| Business ethics score <sub>t</sub>             |                         |                         |                         |                         |                         |                         |                         |                         |                         | -0.073*<br>0.040         |
| Controls                                       | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                      |
| Industry FE                                    | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                      |
| Year FE                                        | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                     | Yes                      |
| Observations                                   | 355                     | 514                     | 1,139                   | 992                     | 1,341                   | 819                     | 1,134                   | 293                     | 1140                    | 816                      |
| Adjusted R-squared                             | 0.395                   | 0.550                   | 0.455                   | 0.483                   | 0.410                   | 0.455                   | 0.459                   | 0.447                   | 0.455                   | 0.482                    |

*Remark:* This table reports coefficients from OLS regressions of different measures of shareholder tone on ESG scores and company characteristics. Panel A focuses on the tone as measured by the Harvard IV-4 psychosocial dictionary, while Panel B examines the tone as measured by Loughran and McDonald dictionary.  $LMD_{tf.idf}^-$  is the negativity of a transcript according to the Loughran and McDonald (2011) dictionary weighted by their term frequency and inverse document frequency.  $HAR_{tf.idf}^-$  is the negativity of a transcript according to the Harvard IV-4 psychosocial dictionary weighted by their term frequency and inverse document frequency. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

### IV.4.5 Do shareholders walk the talk?

We have established the relationship between firm ESG performance and the share of ESG-related language in shareholder statements on the one hand, and the relationship between firm ESG performance and tone of shareholder statements at AGMs on the other. In a final step, we explore the implications of shareholder tone at AGMs for both company management and other forms of shareholder engagement. Our focus is on proposals, specifically two key categories: management proposals initiated by the company’s leadership and shareholder proposals submitted by shareholders. The underlying premise is that shareholders perceiving a gap between their expectations and the firm’s track record may engage during AGMs not only through verbal criticism, but also by signaling their discontent via their voting behavior — either by opposing management-sponsored proposals or by strongly supporting shareholder proposals.

We begin by examining the relationship between shareholder tone and voting outcomes for management-sponsored proposals. The core idea is that shareholders may express their opinions not only through direct criticism during AGMs, but also by “walking the talk”, i.e., expressing reduced support for management-sponsored proposals. Specifically, voting on management-sponsored proposals may provide shareholders with an additional channel to express discontent and exert pressure on management. For example, some of these management proposals, such as say-on-pay proposals, are non-binding and highly symbolic (Fisch et al., 2018; Cuñat et al., 2015). Consequently, we expect a degree of “alignment” between the overall tone of shareholders at the AGM and voting behavior, as measured by voting outcomes for management proposals.<sup>16</sup> To do so, we estimate equation IV.6 and report the results in Table IV.13.

In columns (1), (3), (5), and (7), the main variable of interest is the mean percentage of votes cast against management proposals at a given AGM. To address potential outliers, columns (2), (4), (6), and (8) focus on the median percentage of such votes. The negative tone at the AGM is measured based on adjusted negativity scores derived from the Harvard IV-4 and LMD dictionaries. With the exception of columns (3)

<sup>16</sup>We acknowledge that some votes may be cast before the AGM and may not temporally result directly from the AGM dialogue. We therefore emphasize the notion of alignment.

Table IV.13: Relationship between shareholder tone and shareholder votes against management proposals.

|                       | Votes against |          |         |          |         |          |         |          |
|-----------------------|---------------|----------|---------|----------|---------|----------|---------|----------|
|                       | (mean)        | (median) | (mean)  | (median) | (mean)  | (median) | (mean)  | (median) |
|                       | (1)           | (2)      | (3)     | (4)      | (5)     | (6)      | (7)     | (8)      |
| $HAR_{tf.idf}^-$      | 0.319**       | 0.251*   | 0.280   | 0.221    |         |          |         |          |
|                       | (0.154)       | (0.143)  | (0.171) | (0.151)  |         |          |         |          |
| $LMD_{tf.idf}^-$      |               |          |         |          | 0.335** | 0.294**  | 0.247*  | 0.248**  |
|                       |               |          |         |          | (0.132) | (0.126)  | (0.142) | (0.121)  |
| Controls              | Yes           | Yes      | Yes     | Yes      | Yes     | Yes      | Yes     | Yes      |
| Firm FE               | No            | No       | Yes     | Yes      | No      | No       | Yes     | Yes      |
| Industry FE           | Yes           | Yes      | No      | No       | Yes     | Yes      | No      | No       |
| Year FE               | Yes           | Yes      | Yes     | Yes      | Yes     | Yes      | Yes     | Yes      |
| Observations          | 1,302         | 1,302    | 1,302   | 1,302    | 1,337   | 1,337    | 1,337   | 1,337    |
| Adjusted $R$ -squared | 0.392         | 0.498    | 0.554   | 0.573    | 0.398   | 0.490    | 0.533   | 0.548    |

*Remark:* This table reports the coefficients from OLS regressions of shareholder approval rates on the negativity of shareholder communication. *Votes against* denotes either the mean or the median of the votes against management proposals for each AGM.  $HAR_{tf.idf}^-$  is the negativity of a transcript from the respective AGM according to the Harvard IV-4 psychosocial dictionary weighted its term frequency and inverse document frequency.  $LMD_{tf.idf}^-$  is the negativity of a transcript according to the Loughran and McDonald (2011) dictionary weighted by its term frequency and inverse document frequency. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry or firm fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

and (4), all coefficients on  $LMD_{tf.idf}^-$  and  $HAR_{tf.idf}^-$  are positive and significant at the 5 or 10% level. We therefore find evidence for the relationship between shareholder negative tone at AGMs and the voting outcomes of management-sponsored proposals. More specifically, an increase of one standard deviation in the negativity of shareholder communication is associated with an increase of around 0.28 percentage points (on average) in votes against management proposals, when considering the average of the statistically significant coefficients.

We extend our analysis by considering a specific category of management proposals, namely the ones related to the election or re-election of directors, and use them as a proxy for gauging management support. Several studies underscore that votes on directors are used by shareholders as a way to express their dissent (see e.g., Cai et al., 2009; Yermack, 2010; Van der Elst, 2011). Given the importance of director

proposals in the context of shareholder activism, we examine the relationship between negative tone and director approval rates, as reported in Table IV.14. Compared to the findings in Table IV.13, the regression coefficients in this analysis are both larger in magnitude and statistically significant across all specifications, except for column (3). Notably, the coefficients on  $LMD_{tf.idf}^-$  in columns (5) and (6) are positive and statistically significant at the 1% level, while the coefficients on  $HAR_{tf.idf}^-$  in columns (1) and (2) are similarly positive and significant at the 5% level. Since nearly every AGM includes at least one director proposal, this allows for a comparison of the magnitude of the coefficients between Table IV.13 (which also contains proposals on directors) and Table IV.14. The results indicate that, on average, an increase in the negativity of shareholder tone is associated with higher disapproval rates for director proposals compared to other management proposals. When comparing the averages of statistically significant coefficients from Table IV.14 to those in Table IV.13, the results indicate an average increase of 0.33 basis points in votes against directors associated with a more negative tone of shareholders, compared to an average increase of 0.28 basis points in votes against management proposals.

While we have established that stronger ESG performance is associated with a reduction in the negativity in tone, we acknowledge that the negativity captured in the analysis above may not solely or directly result from poor ESG performance. Other factors may contribute to the negative tone, such as poor financial performance (see e.g., Dimitrov and Jain 2011), or the fact that a firm has paid its CEO more compensation than expected (see e.g., Yermack, 2010). As a next step, we therefore turn to shareholder-sponsored proposals and examine whether we find a relationship between shareholder tone expressed at AGMs, the share of ESG communication, and the voting outcomes for ESG-related proposals. The rationale behind this analysis is that an increased use of ESG-related language, coupled with a negative tone, may signal heightened shareholder concerns about ESG issues. These heightened concerns may be associated with higher approval rates for ESG proposals submitted by shareholders. We estimate equation IV.7 and report the results in Table IV.15. This time, the main variable of interest in each specification corresponds to the approval rates for ESG-



Table IV.14: Relationship between shareholder tone and shareholder votes against directors.

|                       | Votes against      |                    |                  |                   |                     |                     |                   |                    |
|-----------------------|--------------------|--------------------|------------------|-------------------|---------------------|---------------------|-------------------|--------------------|
|                       | (mean)<br>(1)      | (median)<br>(2)    | (mean)<br>(3)    | (median)<br>(4)   | (mean)<br>(5)       | (median)<br>(6)     | (mean)<br>(7)     | (median)<br>(8)    |
| $HAR_{tf.idf}^-$      | 0.364**<br>(0.163) | 0.346**<br>(0.149) | 0.282<br>(0.172) | 0.251*<br>(0.151) |                     |                     |                   |                    |
| $LMD_{tf.idf}^-$      |                    |                    |                  |                   | 0.404***<br>(0.146) | 0.389***<br>(0.135) | 0.289*<br>(0.148) | 0.294**<br>(0.126) |
| Controls              | Yes                | Yes                | Yes              | Yes               | Yes                 | Yes                 | Yes               | Yes                |
| Firm FE               | No                 | No                 | Yes              | Yes               | No                  | No                  | Yes               | Yes                |
| Industry FE           | Yes                | Yes                | No               | No                | Yes                 | Yes                 | No                | No                 |
| Year FE               | Yes                | Yes                | Yes              | Yes               | Yes                 | Yes                 | Yes               | Yes                |
| Observations          | 1,298              | 1,298              | 1,298            | 1,298             | 1,334               | 1,334               | 1,334             | 1,334              |
| Adjusted $R$ -squared | 0.469              | 0.483              | 0.612            | 0.590             | 0.471               | 0.480               | 0.598             | 0.574              |

*Remark:* This table reports the coefficients from OLS regressions of shareholder approval rates on the negativity of shareholder communication. *Votes against* denotes either the mean or the median of the votes against director proposals for each AGM.  $HAR_{tf.idf}^-$  is the negativity of a transcript from the respective AGM according to the Harvard IV-4 psychosocial dictionary weighted its term frequency and inverse document frequency.  $LMD_{tf.idf}^-$  is the negativity of a transcript according to the Loughran and McDonald (2011) dictionary weighted by its term frequency and inverse document frequency. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry or firm fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

related proposals, captured either by the mean or median percentage of votes in favor of such proposals at each AGM. Once again, we include the median percentage of votes to account for potential outliers.

Table IV.15: Relationship between shareholder tone, ESG communication and shareholder votes for ESG proposals.

|                                        | Votes for         |                   |                    |                     |                     |                   |                    |                   |                   |                   |                   |                   |                   |                   |                      |                      |                      |                      |
|----------------------------------------|-------------------|-------------------|--------------------|---------------------|---------------------|-------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|----------------------|----------------------|----------------------|----------------------|
|                                        | (mean)            | (median)          | (mean)             | (median)            | (mean)              | (median)          | (mean)             | (median)          | (mean)            | (median)          | (mean)            | (median)          | (mean)            | (median)          | (mean)               | (median)             | (mean)               | (median)             |
|                                        | (1)               | (2)               | (3)                | (4)                 | (5)                 | (6)               | (7)                | (8)               | (9)               | (10)              | (11)              | (12)              | (13)              | (14)              | (15)                 | (16)                 | (17)                 | (18)                 |
| $HAR_{tf.idf}^-$                       | -0.003<br>(0.002) | -0.003<br>(0.002) |                    |                     |                     |                   | -0.001<br>(0.003)  | -0.001<br>(0.003) |                   |                   | 0.001<br>(0.002)  | 0.001<br>(0.002)  |                   |                   | 0.004*<br>(0.002)    | 0.004*<br>(0.002)    |                      |                      |
| $LMD_{tf.idf}^-$                       |                   |                   | -0.003*<br>(0.002) | -0.003**<br>(0.002) |                     |                   |                    |                   | -0.003<br>(0.003) | -0.003<br>(0.002) |                   |                   | 0.001<br>(0.002)  | 0.000<br>(0.002)  |                      |                      | 0.005**<br>(0.002)   | 0.004<br>(0.002)     |
| $ENV_{tf.idf}$                         |                   |                   |                    |                     | 0.001<br>(0.002)    | 0.001<br>(0.002)  | 0.003<br>(0.002)   | 0.002<br>(0.002)  | 0.003<br>(0.002)  | 0.002<br>(0.002)  | 0.002<br>(0.002)  | 0.001<br>(0.002)  | 0.002<br>(0.002)  | 0.002<br>(0.002)  | 0.002<br>(0.002)     | 0.001<br>(0.002)     | 0.002<br>(0.002)     | 0.001<br>(0.002)     |
| $SOC_{tf.idf}$                         |                   |                   |                    |                     | -0.003**<br>(0.002) | -0.002<br>(0.002) | -0.002*<br>(0.001) | -0.002<br>(0.001) | -0.002<br>(0.001) | -0.001<br>(0.001) | -0.001<br>(0.002) | -0.001<br>(0.002) | -0.001<br>(0.002) | -0.001<br>(0.002) | -0.002<br>(0.001)    | -0.002<br>(0.001)    | -0.002<br>(0.001)    | -0.002<br>(0.002)    |
| $GOV_{tf.idf}$                         |                   |                   |                    |                     | -0.002<br>(0.002)   | -0.002<br>(0.003) | -0.002<br>(0.003)  | -0.002<br>(0.003) | -0.001<br>(0.002) | -0.001<br>(0.003) | -0.002<br>(0.003) | -0.002<br>(0.003) | -0.002<br>(0.003) | -0.002<br>(0.003) | -0.001<br>(0.003)    | -0.001<br>(0.003)    | -0.001<br>(0.002)    | -0.001<br>(0.003)    |
| $HAR_{tf.idf}^- \times ENV_{tf.idf}$   |                   |                   |                    |                     |                     |                   | 0.000<br>(0.000)   | 0.000<br>(0.000)  |                   |                   |                   |                   |                   |                   |                      |                      |                      |                      |
| $LMD_{tf.idf}^- \times ENV_{tf.idf}$   |                   |                   |                    |                     |                     |                   |                    |                   | 0.000<br>(0.000)  | 0.000<br>(0.000)  |                   |                   |                   |                   |                      |                      |                      |                      |
| $HAR_{tf.idf}^- \times SOC_{tf.idf}$   |                   |                   |                    |                     |                     |                   |                    |                   |                   |                   | -0.001<br>(0.001) | -0.001<br>(0.001) |                   |                   |                      |                      |                      |                      |
| $LMD_{tf.idf}^- \times SOC_{tf.idf}^-$ |                   |                   |                    |                     |                     |                   |                    |                   |                   |                   |                   |                   | -0.001<br>(0.001) | -0.001<br>(0.001) |                      |                      |                      |                      |
| $HAR_{tf.idf}^- \times GOV_{tf.idf}$   |                   |                   |                    |                     |                     |                   |                    |                   |                   |                   |                   |                   |                   |                   | -0.002***<br>(0.001) | -0.002***<br>(0.000) |                      |                      |
| $LMD_{tf.idf}^- \times GOV_{tf.idf}$   |                   |                   |                    |                     |                     |                   |                    |                   |                   |                   |                   |                   |                   |                   |                      |                      | -0.002***<br>(0.001) | -0.002***<br>(0.001) |
| Controls                               | Yes               | Yes               | Yes                | Yes                 | Yes                 | Yes               | Yes                | Yes               | Yes               | Yes               | Yes               | Yes               | Yes               | Yes               | Yes                  | Yes                  | Yes                  | Yes                  |
| Industry FE                            | Yes               | Yes               | Yes                | Yes                 | Yes                 | Yes               | Yes                | Yes               | Yes               | Yes               | Yes               | Yes               | Yes               | Yes               | Yes                  | Yes                  | Yes                  | Yes                  |
| Year FE                                | Yes               | Yes               | Yes                | Yes                 | Yes                 | Yes               | Yes                | Yes               | Yes               | Yes               | Yes               | Yes               | Yes               | Yes               | Yes                  | Yes                  | Yes                  | Yes                  |
| Observations                           | 1298              | 1298              | 1334               | 1334                | 1357                | 1357              | 1286               | 1286              | 1319              | 1319              | 1286              | 1286              | 1319              | 1319              | 1286                 | 1286                 | 1319                 | 1319                 |
| Adj. <i>R</i> -squared                 | 0.422             | 0.425             | 0.422              | 0.424               | 0.392               | 0.399             | 0.425              | 0.427             | 0.425             | 0.427             | 0.427             | 0.429             | 0.427             | 0.428             | 0.432                | 0.433                | 0.432                | 0.433                |

*Remark:* This table reports the coefficients from OLS regressions of shareholder approval rates on the negativity of shareholder communication. *Votes* for denotes either the mean or the median of the votes for shareholder ESG proposals for each AGM.  $HAR_{tf.idf}^-$  is the negativity of a transcript from the respective AGM according to the Harvard IV-4 psychosocial dictionary weighted its term frequency and inverse document frequency.  $LMD_{tf.idf}^-$  is the negativity of a transcript according to the Loughran and McDonald (2011) dictionary weighted by its term frequency and inverse document frequency.  $ENV_{tf.idf}$ ,  $SOC_{tf.idf}$  and  $GOV_{tf.idf}$  are the shares of environmental, social and governance words weighted by their term frequency and inverse document frequency, respectively. Control variables is a vector of firm-specific variables controlling for *firm size*, *total assets*, *leverage ratio*, *capex to total assets* and *fixed assets to total assets*. All specifications include time and industry or firm fixed effects. Robust standard errors (in parentheses) are clustered by firm. \*\*\*, \*\* and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

Overall, the results provide little support for our hypothesis. In most specifications, a more negative shareholder tone is associated with a statistically insignificant decrease in support for ESG proposals. In columns (3) and (4), we obtain a statistically negative and significant coefficient at the 10% level on  $LMD_{tf.idf}^-$ . The coefficients for ESG communication in columns (5) and (6) vary between positive and negative values and are predominantly statistically insignificant. Lastly, the results in columns (15)–(18) fail to establish a clear pattern. Consequently, we cannot infer from these results that increased shareholder soft engagement on ESG issues is aligned with higher approval rates for ESG-related shareholder proposals. While some shareholders who raise ESG concerns verbally during AGMs might also be more inclined to vote in favor of such proposals (see e.g., Dikolli et al., 2022), this engagement does not appear to have a mobilizing effect and generate broader support for shareholder proposals. There could be several explanations for this results. First, these findings are not entirely surprising given the limited number of ESG-related shareholder proposals that pass with majority votes (see e.g., Berkman et al., 2024). Furthermore, as highlighted in this study, AGMs attract a diverse array of shareholders with varying interests, emphasizing the need to look beyond proposal voting as the sole indicator of shareholder engagement.

## IV.5 Conclusion

Although shareholders’ right to speak at AGMs is a public and cost-effective avenue for shareholder engagement, little is known about the content and tone of their questions and comments in interacting with management. In particular, the relationship between this form of soft engagement and sustainability concerns has not yet been explored. Using a large sample of AGM transcripts, this paper aims to address this gap by examining the dynamics of shareholder soft engagement on ESG issues.

By analyzing the spectrum of sustainability issues raised and examining how different types of institutional and non-institutional shareholders engage on these topics, our study sheds light on the role of AGMs as an important platform for shareholder soft engagement. Overall, we show that sustainability topics are an integral part of

shareholder communication at AGMs for all shareholder categories. This is, however, particularly true for institutional shareholders. These findings are consistent with prior research highlighting the role of shareholders serving as “norm promoters” on capital markets (Sjöström, 2009). In addition, our study provides robust evidence of the relationship between the proportion of words on sustainability aspects and the negative tone at shareholder meetings, suggesting that shareholders who address sustainability issues do so by adopting a negative tone. Finally, we also show that shareholders align to some degree their words with actions, in particular by being less supportive of management-sponsored and directors proposals.

Our findings also have important implications for practice. First, they underscore that aside from the questions and comments raised, the sentiment expressed by shareholders during AGMs can serve as an important barometer of firm’s ability (or inability) to meet certain shareholder, and in a broader context, societal expectations. By identifying and analyzing these patterns, firms can better understand the concerns of their diverse shareholder base and adapt their strategies accordingly. Second, the relevance of sustainability-related topics reflects an increasing expectation towards firms to focus more on explicitly and effectively on ESG performance. As such, AGMs as more than procedural gatherings. They are strategic opportunities to demonstrate accountability and progress in sustainability efforts. While the emergence of an “ESG backlash” beginning in 2022–2023 may alter this dynamic, firms and their management teams should carefully reflect on what these shifting sentiments mean for their ESG positioning at AGMs and adapt accordingly.

# Chapter V

## Carbon footprints and equity risk assessments

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*Relative share:*

30%

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- Seminar with the scientific staff of the German Council of Economic Experts, 2022, Germany (virtual).
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# Carbon footprints and equity risk assessments

## Abstract

We examine the relationship between greenhouse gas (GHG) emissions and equity risks. First, we find that firms with higher levels of scope 1 and scope 2 GHG emissions are associated with higher equity risks. Our results hold for both size-adjusted and industry-adjusted emissions. In contrast, our results do not reveal any clear relationship between scope 3 GHG emissions and equity risks. We further disentangle the risk effects associated with GHG emissions by considering the disclosure of this information per se. We show that investors attribute lower equity risks to GHG reporting firms than to non-reporting firms, indicating a strong value placed on transparency in this reporting area. Overall, our evidence is consistent with the view that investors increasingly consider GHG emissions in their investment decision-making.

**JEL Classification:** G11, G32, G34, O16, Q54, Q56

**Keywords:** GHG emissions, carbon disclosure, equity risks

## V.1 Introduction

In recent years, a growing body of literature has documented the importance of non-financial activities, often referred to as “corporate social responsibility” (CSR), to obtain a more comprehensive picture of a company’s risk profile, particularly in the context of equity risks (see e.g., Oikonomou et al., 2012; Albuquerque et al., 2019; Bannier et al., 2022). Notably, the evidence suggests that CSR practices can help mitigate risks by creating moral capital for firms, thus serving as a form of “insurance-like” protection (Godfrey et al., 2009). Such protection reduces the likelihood of adverse events and contributes to safeguarding shareholder value in the event of such occurrences (Godfrey et al., 2009; Diemont et al., 2015; Sassen et al., 2016; Hoepner et al., 2022; Monti et al., 2019; Albuquerque et al., 2020).

Despite the increasing focus on CSR, one area that has received relatively little scholarly attention is the role of corporate greenhouse gas (GHG) emissions as a distinct component of CSR.<sup>1</sup> In this paper, we address this gap by exploring the relationship between GHG emissions and equity risks. Specifically, we examine the three GHG emission scopes outlined in the GHG Protocol (World Business Council for Sustainable Development and World Resources Institute, 2004), a widely adopted framework for assessing a firm’s total carbon footprint (Kauffmann and Teichmann, 2012). The GHG Protocol distinguishes between scope 1 (direct emissions), scope 2 (indirect emissions from purchased energy), and scope 3 (indirect emissions across the value chain).<sup>2</sup>

Bolton and Kacperczyk (2021) provide initial evidence of a potential link between GHG emissions and equity risks by identifying a carbon risk premium reflected in higher stock returns of firms with higher levels of GHG emissions. Interestingly, their study finds a positive and significant relationship between GHG emissions and stock returns

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<sup>1</sup>For an overview of GHGs, please refer to Section V.3.2. Even though GHGs include a variety of chemical gases, the literature applies the terms “carbon” and “GHG” synonymously.

<sup>2</sup>A limited focus only one part of corporate GHG emissions, such as direct GHG emissions (scope 1), may lead to misinterpreting the company’s actual GHG exposure (World Business Council for Sustainable Development and World Resources Institute, 2004). For example, a car manufacturing company could have an extremely efficient factory run on renewable energy with very low scope 1 emissions, while producing highly fuel-inefficient cars at the same time, which would result in high scope 3 emissions. Most importantly, a firm’s efforts to reduce scope 1 GHG emissions may not have the same impact on investors’ perception as similar efforts to reduce scope 3 GHG emissions.

across all three scopes. In particular, they report that firms with higher direct emissions (scope 1) as well as those with higher indirect emissions (scope 2 and scope 3) exhibit higher stock returns. These findings suggest that investors require a risk premium to hold shares in firms with higher GHG emissions. As returns are expected to compensate for risk, we posit that higher levels of scope 1, scope 2, and scope 3 GHG emissions are associated with higher firm equity risks.

Our study is based on a large sample of European firms and covers the period 2010–2020. Following Hoepner et al. (2022) and Bannier et al. (2022), we employ different measures of equity risks that capture both standard and downside risks. In addition to examining GHG emissions, we also account for the regulatory disclosure setting in which this data is reported, building on the growing literature on mandatory CSR-related disclosures (Christensen et al., 2017; Mittelbach-Hörmanseder et al., 2020; Jouvenot and Krueger, 2019; Grewal, 2021). Since our analysis focuses on a European sample, we leverage the unique GHG disclosure regulations in France and the United Kingdom (UK) to examine whether the strength and significance of the relationship between GHG emissions and equity risk varies across different reporting contexts.<sup>3</sup>

In doing so, our paper yields three main sets of findings. First, we find a positive and statistically significant relationship between scope 1 GHG emissions and equity risks, as well as between scope 2 GHG emissions and equity risks. This relationship is even stronger in the case of scope 2 GHG emissions, where the coefficients and significance are comparatively higher. These results hold when using both size-adjusted GHG emissions and industry-adjusted GHG emissions as explanatory variables. For scope 3 GHG emissions, in contrast, we do not find a clear association with equity risks. Taken together, these findings suggest that firms with higher scope 1 or scope 2 emissions relative to their industry peers of similar size are associated with higher equity risks.

In the second part of our analysis, we further disentangle these relationships by examining the role of the disclosure setting. Given that France and the UK have im-

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<sup>3</sup>A law passed in 2012 in the United Kingdom requires all UK-incorporated publicly traded companies to report scope 1 and scope 2 GHG emissions in their annual financial reports. In France, the Grenelle II Act, which was passed in 2011, introduces similar GHG reporting requirements for companies with at least 500 employees. The regulation includes direct and indirect emissions linked to the consumption of electricity, heat or steam (scopes 1 and 2).



plemented mandatory GHG reporting regulations — and that firms from these two countries comprise roughly 43% of our sample — we split the sample into two sub-groups. The first sub-sample includes only UK and French firms, while the second excludes them entirely. Interestingly, our results indicate that the relationship between scope 1 and scope 2 GHG emissions and equity risks is weaker in the UK and French sub-sample, both in terms of coefficient sizes and statistical significance. Conversely, the relationship is stronger in the sub-sample of firms from countries without mandatory GHG disclosure requirements. This finding suggests that investors’ perceptions of risk are shaped by the broader institutional disclosure environment, aligning with prior literature (e.g., Mittelbach-Hörmanseder et al., 2020), who find that the value relevance of CSR disclosure decreases in countries where CSR information is prioritized by regulation.

Finally, we examine the equity risks associated with GHG disclosure itself by comparing firms that report GHG emissions to those that do not. To achieve this, we expand our sample to include all European companies for which equity risk measures and control variables are available. Our findings indicate that, overall, firms disclosing GHG information exhibit lower equity risks compared to their non-disclosing counterparts. This relationship remains robust even after accounting for potential selection bias through a matching procedure, which helps balance out structural differences between the two groups. These results suggest that investors value transparency regarding GHG emissions, aligning with the notion that capital markets consider not only a firm’s GHG emissions levels, but also the act of disclosure (Matsumura et al., 2013).

Overall, our findings highlight the complex mechanisms underlying investors’ response to GHG emissions. As noted by Matsumura et al. (2013), “markets penalize all firms for their carbon emissions, but a further penalty is imposed on firms that do not disclose emissions information” (pp. 695–696, Matsumura et al. 2013). While firms with higher GHG emissions — particularly in scope 1 and scope 2 — are associated with higher equity risks, the disclosure of emissions data appears to mitigate some of this risk perception. In this regard, disclosure may act as a trust-building mechanism between firms and investors. By contrast, firms that opt not to disclose their emissions

may be subject to an additional risk premium imposed by the market. Taken together, our results reinforce the view that investors consider GHG emissions a material risk factor.

The remainder of this paper proceeds as follows: Section V.2 reviews the literature and derives our hypotheses. Section V.3 outlines the data and delineates the variables construction as well as the methodological approach. Section V.4 presents our results regarding the relationship between the three different GHG emissions scopes and equity risks. Section V.5 investigates the strength and significance of this relationship in a mandatory disclosure setting. Section V.6 provides further insights by comparing the equity risks associated with GHG reporting companies versus non-reporting companies. Section V.7 discusses potential implications of our results and concludes.

## V.2 Literature review and hypotheses

Our analysis of the relationship between greenhouse gas emissions and equity risks builds upon several interconnected strands of literature. Specifically, we contribute to the expanding body of research on corporate carbon-related risks (Hoffmann and Busch, 2008; Jung et al., 2018; Bolton and Kacperczyk, 2021). Carbon-related risks, encompassing business model vulnerabilities, reputational challenges, and regulatory pressures, can have important broader financial implications. Understanding how firms manage these risks is therefore critical.

From a business model perspective, Garvey et al. (2018) report that there is a “fundamental connection between carbon emissions and overall productive efficiency” (p.59, Garvey et al. 2018). Their research suggests that firms emitting lower GHG levels than their industry peers tend to operate more efficiently, resulting in improved future profitability. On the reputational front, firms perceived as environmentally irresponsible by society are more susceptible to reputational damage, which can undermine their competitive position and future cash flows (Sullivan and Gouldson, 2012; Jung et al., 2018). Regulatory risks are another critical aspect of carbon-related risks. Firms with high GHG emissions are more vulnerable to the future costs associated with government

policies on carbon dioxide emissions, including carbon taxes and emissions trading schemes (Sullivan and Gouldson, 2012; Litterman, 2016; Jung et al., 2018; Trinks et al., 2020).

In light of these risks, investors increasingly appear to demand compensation for exposure to carbon-intensive business models. Bolton and Kacperczyk (2021) identify a “carbon premium”, suggesting that investors require a risk premium for investing in firms with high GHG emissions. Ilhan et al. (2020) find that carbon emissions increase downside risk, as reflected in out of the money put option prices. Conversely, Sassen et al. (2016) report that a higher environmental performance reduces idiosyncratic risk, while Monti et al. (2019) find that CSR activities are negatively associated with stock price volatility, downside risk and idiosyncratic risk. Given the substantial evidence supporting a negative relationship between high CSR performance and equity risks, alongside the growing tendency of investors to consider carbon-related risks in their financial decision-making, we expect a positive association between GHG emissions and equity risks. Based on this reasoning, we propose the following hypotheses:

**Hypothesis 1a:** *Firms with higher scope 1 emissions are associated with higher equity risks*

**Hypothesis 1b:** *Firms with higher scope 2 emissions are associated with higher equity risks*

**Hypothesis 1c:** *Firms with higher scope 3 emissions are associated with higher equity risks*

In addition to firm-specific differences, important differences also exist across industries (Brännlund et al., 2015). Within the EU, the transport, energy, and manufacturing sectors were among the largest contributors to GHG emissions in 2019, accounting for 26%, 24%, and 12% of total emissions, respectively (Eurostat, 2021). These industry-specific disparities are also evident in our dataset. While most of the GHG emissions in the utilities and real estate sectors are scope 1 emissions, this category of emissions represents only a very small portion of total GHG emissions in the financial sector. We therefore propose an additional measure of GHG emissions and benchmark these emissions for each industry in our sample. This allows us to identify whether a firm emits

more scope 1, scope 2 or scope 3 GHG than its industry peers. Based on the previous hypotheses, we posit that firms with higher GHG emissions than their industry peers are associated with higher equity risks. In this context, we formulate the following hypotheses:

**Hypothesis 2a:** *Firms with higher industry-adjusted scope 1 emissions are associated with higher equity risks*

**Hypothesis 2b:** *Firms with higher industry-adjusted scope 2 emissions are associated with higher equity risks*

**Hypothesis 2c:** *Firms with higher industry-adjusted scope 3 emissions are associated with higher equity risks*

To further investigate the determinants of equity risks associated with GHG emissions, we focus on the role of GHG disclosure. The disclosure of GHG information can serve as an initial indicator of a firm’s awareness of carbon risks and its efforts in carbon risk management (Jung et al., 2018). Conversely, a lack of disclosure may suggest that carbon-related issues are not a priority for the firm (Sullivan and Gouldson, 2012). Supporting this perspective, several studies show that firms disclosing GHG emissions are more likely to integrate carbon risks into their overall risk management systems and subsequently improve their carbon performance (Subramaniam et al., 2015; Jung et al., 2018; Bauckloh et al., 2022; Jouvenot and Krueger, 2019).

In addition, GHG disclosure makes firm’s exposure to carbon-related risks more predictable. For example, environmental disclosures contribute to a more precise assessment of a firm’s competitive position (Clarkson et al., 2013), future cash flows (Aerts et al., 2008), and asset pricing (Liesen et al., 2016). Matsumura et al. (2013) find that higher GHG emissions are associated with lower firm valuations, but that voluntary disclosure of GHG emissions can mitigate these negative valuation effects. This highlights the importance of the disclosure setting — whether mandatory or voluntary — in shaping investor perceptions. Building on this reasoning, we hypothesize the following:

**Hypothesis 3:** *Firms that disclose their GHG emissions are associated with lower equity risks than firms that do not disclose their GHG emissions.*

Table V.1: Yearly composition of reporting firms.

| Year  | N     | %      |
|-------|-------|--------|
| 2010  | 428   | 5.33%  |
| 2011  | 478   | 5.96%  |
| 2012  | 499   | 6.22%  |
| 2013  | 521   | 6.49%  |
| 2014  | 555   | 6.92%  |
| 2015  | 620   | 7.73%  |
| 2016  | 677   | 8.44%  |
| 2017  | 791   | 9.86%  |
| 2018  | 1,030 | 12.84% |
| 2019  | 1,201 | 14.97% |
| 2020  | 1,223 | 15.24% |
| Total | 8,023 | 100%   |

*Remark:* This table presents the yearly composition and development of the sample of GHG reporting firms.

## V.3 Data, variables and methodology

### V.3.1 Sample overview

Our sample comprises all European firms that have available GHG emissions data in the Refinitiv database over the period from 2010 to 2020.<sup>4</sup> The final data set displays 8,023 firm-year observations. Since the number of companies reporting their GHG emissions increases over time, data coverage from Refinitiv improves and, hence, leads to a rise in the number of observations in our sample over time. Table V.1 illustrates the yearly data coverage and its development over the sample period. We focus on a European sample due to higher data availability with regard to GHG emissions. In addition, similar to prior studies on GHG disclosure (e.g., Grewal, 2021; Jouvenot and Krueger, 2019), the reporting schemes in countries such as France and the UK allow us to cover a large number of firms over a long period of time.

Table V.2 displays the industry composition of our sample according to TRBC

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<sup>4</sup>We are aware that our sample period includes the Covid-19 crisis, which led to significant downturns in capital markets. As we calculate equity risks based on the stock return distribution, this could have an impact on the relationship. However, we can replicate our findings, when excluding the Covid-19 period (year 2020). Results are available upon request from the authors.

Business Sector codes in Panel A, as well as the country composition in Panel B for all firms disclosing GHG data. About 9.32% of the firms in our sample belong to the Industrial & Commercial services sector, followed by firms in the Industrial goods sector with 8.62%, the Real estate sector with 6.36% and the Cyclical consumer services sector with 5.81%. Panel B in Table V.2 shows the distribution of firms across European countries. About 32% of the companies are headquartered in the UK, followed by France with 10.6%. This is likely due to the fact that both the UK and France have mandatory GHG emissions reporting schemes, which are legally binding for specific publicly listed companies and for firms with 500 or more employees. As more than 40% of our sample consists of firms headquartered in these two countries, we perform separate analyses with and without these firms in a robustness check as shown in Section V.5.

### V.3.2 Variables

#### Dependent variables

Following Bannier et al. (2022), we employ a variety of equity risk variables to capture firm standard risk and downside risk. First, we calculate the stock volatility, i.e., standard deviation,  $\sigma$  of a firm's daily stock returns in the respective year. Second, we estimate the idiosyncratic risk  $\sigma_\epsilon$  based on the annual beta calculated from daily returns with the capital asset pricing model. To calculate the beta values in a first step, we use the daily Fama-French market returns that can be downloaded from Kenneth French's website. The idiosyncratic risk  $\sigma_\epsilon$  is then estimated according to the following formula:

$$\sigma_{\epsilon_{i,t}} = \sqrt{\sigma_{i,t}^2 - \beta_{i,t}^2 * \sigma_{m_t}^2} \quad (\text{V.1})$$

Here,  $\sigma_{i,t}$  captures firm  $i$ 's stock volatility in year  $t$ , the CAPM estimation of a firm's yearly beta value is represented by the  $\beta_{i,t}$  and, finally,  $\sigma_{m_t}$  captures the volatility of the Fama-French market return based on daily returns in year  $t$ . Hence,  $\sigma_{\epsilon_{i,t}}$  is the unsystematic risk of a firm's return distribution, i.e., the risk which is not attributable to overall market developments.

With regard to downside risk measures, we follow Hoepner et al. (2022), Monti et al.

Table V.2: Industry and country sample composition for GHG reporting firms.

| Panel A: Industry Composition                   |       |       | Panel B: Country Composition |       |        |
|-------------------------------------------------|-------|-------|------------------------------|-------|--------|
| Industry                                        | N     | %     | Country                      | N     | %      |
| Academic & educational services                 | 4     | 0.05% | Austria                      | 122   | 1.52%  |
| Applied resources                               | 157   | 1.96% | Belgium                      | 179   | 2.23%  |
| Automobiles & auto parts                        | 210   | 2.62% | Cyprus                       | 2     | 0.02%  |
| Banking & investment services                   | 333   | 4.15% | Czech Republic               | 11    | 0.14%  |
| Chemicals                                       | 336   | 4.19% | Denmark                      | 209   | 2.61%  |
| Collective investments                          | 2     | 0.02% | Faroe Islands                | 3     | 0.04%  |
| Consumer goods conglomerates                    | 47    | 0.59% | Finland                      | 288   | 3.59%  |
| Cyclical consumer products                      | 413   | 5.15% | France                       | 850   | 10.59% |
| Cyclical consumer services                      | 466   | 5.81% | Germany                      | 730   | 9.10%  |
| Energy – fossil fuels                           | 452   | 5.64% | Gibraltar                    | 3     | 0.04%  |
| Financial technology (fintech) & infrastructure | 12    | 0.15% | Greece                       | 54    | 0.67%  |
| Food & beverages                                | 355   | 4.43% | Guernsey                     | 2     | 0.02%  |
| Food & drug retailing                           | 147   | 1.83% | Hungary                      | 22    | 0.27%  |
| Healthcare services & equipment                 | 207   | 2.58% | Iceland                      | 2     | 0.02%  |
| Industrial & commercial services                | 747   | 9.32% | Ireland, Republic of         | 176   | 2.19%  |
| Industrial goods                                | 691   | 8.62% | Isle of Man                  | 15    | 0.19%  |
| Insurance                                       | 308   | 3.84% | Italy                        | 383   | 4.77%  |
| Investment holding companies                    | 29    | 0.36% | Jersey                       | 25    | 0.31%  |
| Mineral resources                               | 391   | 4.88% | Luxembourg                   | 95    | 1.18%  |
| Personal & household products & services        | 109   | 1.36% | Malta                        | 6     | 0.07%  |
| Pharmaceuticals & medical research              | 253   | 3.16% | Netherlands                  | 296   | 3.69%  |
| Real estate                                     | 510   | 6.36% | Norway                       | 222   | 2.77%  |
| Renewable energy                                | 41    | 0.51% | Poland                       | 75    | 0.93%  |
| Retailers                                       | 294   | 3.67% | Portugal                     | 78    | 0.97%  |
| Software & IT services                          | 273   | 3.40% | Romania                      | 1     | 0.01%  |
| Technology equipment                            | 251   | 3.13% | Russia                       | 118   | 1.47%  |
| Telecommunications services                     | 292   | 3.64% | Slovenia                     | 3     | 0.04%  |
| Transportation                                  | 307   | 3.83% | Spain                        | 387   | 4.82%  |
| Uranium                                         | 0     | 0.00% | Sweden                       | 595   | 7.42%  |
| Utilities                                       | 386   | 4.81% | Switzerland                  | 483   | 6.02%  |
|                                                 |       |       | Ukraine                      | 9     | 0.11%  |
|                                                 |       |       | United Kingdom               | 2,579 | 32.15% |
| Total                                           | 8,023 | 100%  | Total                        | 8,023 | 100%   |

*Remark:* This table presents the industry composition according to TRBC Business Sector codes (Panel A) as well as the country composition (Panel B) for the sample of European GHG reporting firms.

(2019) and Bannier et al. (2022) and apply the value at risk (VaR), the conditional value at risk (CVaR) as well as lower partial moments (LPM) of the second and third order. We calculate the yearly values for the VaR as the 5%-quantile of the distribution of daily stock returns. Instead of the negative figures, we work with their absolute values in the later analyses so that higher VaR values can be interpreted as higher downside equity risks. The expected shortfall or CVaR captures all daily returns below the value at risk of a firm in a respective year. It estimates the average of all these daily returns below the VaR threshold. We also apply the CVaR in absolute values. Moreover, we calculate LPM(0,2) and LPM(0,3) following Bawa (1975) and Fishburn (1977), based on daily stock returns in the respective year. Both variables do only take returns below a 0%-threshold into account. Following Bannier et al. (2022), we employ the square root of LPM(0,2) and the cube root of LPM(0,3). The LPM(0,2) is calculated as follows:

$$LPM(0, 2) = \sqrt{\frac{1}{N} \sum_{i=1}^N (R_{n,i})^2} \quad (V.2)$$

The LPM(0,3) is calculated according to the following equation:

$$LPM(0, 3) = \sqrt[3]{\frac{1}{N} \sum_{i=1}^N (|R_{n,i}|)^3} \quad (V.3)$$

In both equations (V.2 & V.3),  $R_{n,i}$  captures all daily negative stock returns of firm  $i$ .  $N$  represents the number of these negative returns in the respective years.

### **Explanatory variables**

We follow the approach in Jouvenot and Krueger (2019) and retrieve firm-level GHG emissions data from the Refinitiv (formerly Thomson Reuters) database. As of today, firm-level carbon emissions data are gathered by seven main providers: CDP, Refinitiv, MSCI, Sustainalytics, Trucost, Bloomberg, and ISS (Bolton and Kacperczyk, 2021). GHG data are consistent across data providers, which justifies relying on a single data provider (Busch et al., 2020; Jouvenot and Krueger, 2019).



The firm-level GHG emissions data retrieved from Refinitiv are categorized into three distinct scopes, as defined by the GHG Protocol (World Business Council for Sustainable Development and World Resources Institute, 2004), a widely recognized standard for measuring corporate emissions (Kauffmann and Teichmann, 2012). Scope 1 encompasses direct GHG emissions that originate from sources owned or controlled by the firm, such as emissions from on-site operations or company-owned vehicles. Scope 2 includes indirect GHG emissions resulting from the consumption of purchased energy, such as electricity, heat, or steam, required for the production of goods and services. Lastly, scope 3 covers all other indirect GHG emissions across the firm’s value chain, both upstream (e.g., emissions from suppliers) and downstream (e.g., emissions from the use or disposal of the firm’s products) (World Business Council for Sustainable Development and World Resources Institute, 2004). According to Refinitiv, all three scopes measure CO<sub>2</sub> or CO<sub>2</sub> equivalent in tonnes and include the following greenhouse gases: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydroflourorcarbons (HFCS), perflourinated compound (PFCS), sulfur hexaflouride (SF<sub>6</sub>) and nitrogen triflouride (NF<sub>3</sub>).

Scope 1 and Scope 2 emissions are generally easier to measure, and mandatory disclosure schemes covering these scopes are in place in certain countries, such as the UK and France (Grewal, 2021; Bolton and Kacperczyk, 2021). Consequently, these emissions have been more systematically reported and are typically estimated with greater accuracy by firms. As a result, there is relatively little variation in the reported scope 1 and scope 2 emissions data across different data providers (Busch et al., 2020; Bolton and Kacperczyk, 2021). In contrast, scope 3 emissions are significantly more challenging to estimate accurately and are often not subject to mandatory reporting requirements (World Business Council for Sustainable Development and World Resources Institute, 2004; Depoers et al., 2014; Busch et al., 2020).

As form size is one of the main determinants of carbon intensity at the firm level, it is reasonable to focus on the amount of emissions relative to a proxy for firm size rather than on the absolute emissions level (UNEP FI, 2013; Kim et al., 2015; Goergen et al., 2017; Jung et al., 2018). Thus, we follow the prior literature (e.g., Bolton and

Kacperczyk, 2021) and scale all three of our explanatory variables (*GHG scope 1*, *GHG scope 2* and *GHG scope 3*) by the total sales of each company, resulting in tons per \$100 total sales.

In addition to firm size, carbon emissions also depend on the industry in which a firm operates (Brännlund et al., 2015). For this reason, we develop a second measure of GHG emissions that also takes into account industry effects by benchmarking a firm's emissions (scope 1, scope 2 and scope 3) against the respective industry. More precisely, we subtract the annual averages of the scope 1, scope 2 and scope 3 emissions in the respective TRBC business sectors from the firm's scope 1, scope 2 or scope 3 GHG emissions, resulting in the variables *BM GHG scope 1*, *BM GHG scope 2* and *BM GHG scope 3*, each scaled by total sales. For these variables, values greater than zero indicate higher GHG emissions in comparison to the respective industry peers and vice versa.

### **Control variables**

In order to reduce the issue of omitted variables in our analyses, we make use of an extensive number of firm-specific control variables that have been shown to be relevant in the earlier literature. El Ghoul et al. (2011) show a special relevance of a firm's *Leverage* - calculated as total liabilities divided by total assets - and its *Size* - calculated as the natural logarithm of total assets - for the firm's risk. A higher *Leverage* is associated with increased cost of equity premiums, while increased firm *Size* seems to mitigate and reduce a firm's risk more generally. Several studies indicate the importance of *Profitability* and *Sales growth* to control for company characteristics (e.g., Titman and Wessels, 1988; Capon et al., 1990). More specifically, Brailsford et al. (2002) provides evidence for the risk-reducing capabilities of both variables, as a higher *Profitability* and larger growth rates result in lower risks for firms. Consequently, we include *Profitability*, calculated as operating income divided by total assets and the firms' *Sales growth*, computed as the annual growth rate of total revenues into the regression models. Finally, our set of control variables also comprises the *Dividend yield*. Hoepner et al. (2022) and Oikonomou et al. (2012) show a special relevance of the *Dividend yield* for firms' equity risks, which sets the distributed dividends in a year into relation to the firms' share

price. They argue that the dividend yield reflects management's expectation of future earnings and may correspondingly mitigate the market's equity risk assessment. We winsorize all control and risk variables at 1% in order to limit the influence of outliers.

### **Descriptive statistics**

Table V.3 presents the descriptive statistics of our sample. Panel A illustrates the values for our equity risk measures. The average firm has a stock volatility of 2% and an idiosyncratic volatility of 1.7%. With regard to downside risk measures, the mean value at risk indicates that the 5% worst return is at -3.1%. Below this VaR threshold, the average negative return (expected shortfall) lies at -4.5%, which is reflected in the mean value of the CVaR. The Lower Partial Moment variables, with a threshold of returns below 0, indicate that the LPM(0,2) is on average 2.0%. The LPM(0,3) takes a value of 2.7%.

The values for the GHG emissions variables in Panel B suggest that firms emit on average 3 million tons of scope 1 GHG emissions and are responsible for 0.48 million tons of scope 2 GHG emissions. Scope 3 GHG emissions, with a mean value of 12.45 million tons, represent a much larger proportion of emissions than scope 1 and scope 2 emissions. As previously mentioned, the calculation of scope 3 GHG emissions is rather difficult for some industries and their reporting is not legally binding in Europe. Our descriptive statistics support this fact, as the number of observations for scope 3 emissions is significantly lower than for scope 1 and scope 2 emissions.

The following three emissions variables take the firm's size into account and scale the different GHG emissions scopes according to total sales. With regard to scope 1, the average firm emits 0.02 tons per \$100 of total sales, while the mean value for scope 2 is significantly lower at 0.007 emissions. Scope 3 GHG emissions are on average at 0.062 tons per \$100 of total sales. Finally, these size-adjusted GHG emissions are benchmarked against the respective industrial sector. Since the sector averages are subtracted from the size-dependent emissions of the companies, the averages of the three scopes are naturally 0.

The control variables displayed in Panel C show that the average GHG reporting

Table V.3: Descriptive statistics.

|                                                 | N     | Mean   | Std. dev. | Min.   | Max.    |
|-------------------------------------------------|-------|--------|-----------|--------|---------|
| <i>Panel A: Risk measures</i>                   |       |        |           |        |         |
| $\sigma$                                        | 8,023 | 2.007  | 0.875     | 0.816  | 5.404   |
| $\sigma_\epsilon$                               | 8,023 | 1.731  | 0.816     | 0.720  | 5.106   |
| VaR                                             | 8,023 | 3.115  | 1.295     | 1.190  | 7.822   |
| CVaR                                            | 8,023 | 4.547  | 2.073     | 1.724  | 12.439  |
| LPM(0,2)                                        | 8,023 | 2.018  | 0.879     | 0.837  | 5.431   |
| LPM(0,3)                                        | 8,023 | 2.652  | 1.316     | 1.039  | 8.176   |
| <i>Panel B: Greenhouse gas variables</i>        |       |        |           |        |         |
| <i>GHG emissions</i>                            |       |        |           |        |         |
| GHG Scope 1 (in Mio. tons)                      | 7,640 | 2.998  | 13.885    | 0.000  | 181.700 |
| GHG Scope 2 (in Mio. tons)                      | 7,552 | 0.479  | 1.680     | 0.000  | 28.100  |
| GHG Scope 3 (in Mio. tons)                      | 5,078 | 12.452 | 62.186    | 0.000  | 1154.66 |
| <i>Size-adjusted GHG emissions</i>              |       |        |           |        |         |
| GHG Scope 1 / Sales                             | 7,638 | 0.021  | 0.107     | 0.000  | 6.110   |
| GHG Scope 2 / Sales                             | 7,550 | 0.007  | 0.112     | -0.001 | 8.217   |
| GHG Scope 3 / Sales                             | 5,076 | 0.062  | 1.246     | -0.002 | 87.035  |
| <i>Industry and size-adjusted GHG emissions</i> |       |        |           |        |         |
| BM GHG Scope 1                                  | 7,638 | 0.000  | 0.100     | -0.189 | 5.962   |
| BM GHG Scope 2                                  | 7,550 | 0.000  | 0.110     | -0.184 | 8.033   |
| BM GHG Scope 3                                  | 5,076 | 0.001  | 1.217     | -3.962 | 83.073  |
| <i>Panel C: Control variables</i>               |       |        |           |        |         |
| Leverage                                        | 8,023 | 0.616  | 0.195     | 0.121  | 1.100   |
| Sales growth                                    | 8,023 | 0.044  | 0.204     | -0.547 | 1.298   |
| Profitability                                   | 8,023 | 0.071  | 0.078     | -0.199 | 0.365   |
| Dividend yield                                  | 8,023 | 0.021  | 0.024     | 0.000  | 0.111   |
| Size                                            | 8,023 | 22.646 | 1.874     | 17.780 | 27.503  |

*Remark:* This table presents the descriptive statistics for GHG reporting firms. *Panel A* provides descriptive statistics for the equity risk measures, *Panel B* for the GHG emissions variables and *Panel C* for the control variables.

firm in our sample has a *Leverage* close to 62% and that its revenues grow yearly by 4.4%. On average, the *Profitability* of the analyzed firms is 7.1% and the *Dividend yield* has a value of 2.1%. *Size* is calculated as the natural logarithm of total assets and is on average 22.65.

### V.3.3 Methodology

To examine the relationship between GHG emissions and firm equity risks, we estimate panel fixed-effects regressions that account for variance over time by including time fixed-effects over the sample period from 2010 to 2020. Equation V.4 presents the regression equation:

$$y_{i,t} = \beta_1 GHG_{i,t} + \gamma' \mathbf{x}_{i,t} + v_i + \varphi_t + \epsilon_{i,t} . \quad (\text{V.4})$$

In our regression results, the coefficient  $\beta_1$  represents the variable of interest as it captures the effect of the GHG emissions variables, i.e., scope 1, scope 2 and scope 3, either adjusted for size only, or adjusted for both size and industry, on firm equity risks. Furthermore,  $x_{i,t}$  is a vector of additional control variables, which are outlined in Section V.3.2 and  $v_i + \varphi_t$  are time-constant firm effects and firm-constant time effects that are unobservable.  $\epsilon_{i,t}$  denotes the error-term.

Although the relation between CSR and risk may be less prone to endogeneity concerns than the relation between CSR and firm value (Cheng et al., 2013), we take several attenuating measures: In order to reduce the problem of omitted variables in our analyses, we make use of an extensive number of firm-specific control variables that have been shown to be relevant in the earlier literature. In addition, we include year-fixed effects in all our firm-level analyses to control for unobservable time effects and hence facilitate the identification of the marginal effect of interest. Furthermore, even though a firm's decision to report GHG data is unlikely to be completely random, this effect is, however, largely mitigated by the fact that almost half of our sample consists of firms that are headquartered in countries with mandatory reporting schemes. We also employ an extensive propensity score matching procedure to address a potential

selection bias four our analysis of H3.

## V.4 GHG emissions and equity risks

### V.4.1 Size-adjusted GHG emissions

In a first step, we test our hypotheses H1a, H1b, and H1c as outlined in section V.2. The results are shown in Table V.4. In Panel A, we report the results for size-adjusted scope 1 GHG emissions. In Panel B, we show the results for size-adjusted scope 2 GHG emissions, and in Panel C for size-adjusted scope 3 GHG emissions.

Table V.4: Size-adjusted GHG emissions and equity risks.

|                                        | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|----------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                        | $\sigma$             | $\sigma_{\epsilon}$  | VaR                  | CVaR                 | LPM(0,2)             | LPM(0,3)             |
| Panel A: Scope 1 GHG emissions / Sales |                      |                      |                      |                      |                      |                      |
| GHG emissions                          | 0.226***<br>(0.071)  | 0.200**<br>(0.091)   | 0.050<br>(0.121)     | 0.383*<br>(0.230)    | 0.200*<br>(0.103)    | 0.450***<br>(0.167)  |
| Leverage                               | 0.846***<br>(0.144)  | 0.859***<br>(0.145)  | 0.967***<br>(0.188)  | 1.542***<br>(0.316)  | 0.696***<br>(0.134)  | 0.969***<br>(0.206)  |
| Sales growth                           | -0.146***<br>(0.043) | -0.118***<br>(0.041) | -0.269***<br>(0.065) | -0.442***<br>(0.110) | -0.175***<br>(0.046) | -0.260***<br>(0.075) |
| Profitability                          | -2.656***<br>(0.223) | -2.668***<br>(0.225) | -3.747***<br>(0.295) | -6.468***<br>(0.520) | -2.689***<br>(0.218) | -4.106***<br>(0.352) |
| Dividend yield                         | -1.487**<br>(0.677)  | -1.288**<br>(0.649)  | 0.604<br>(1.027)     | 4.691***<br>(1.742)  | 1.079<br>(0.729)     | 3.069**<br>(1.241)   |
| Size                                   | -0.085**<br>(0.039)  | -0.121***<br>(0.038) | 0.007<br>(0.056)     | -0.056<br>(0.093)    | -0.034<br>(0.041)    | -0.072<br>(0.064)    |
| Constant                               | 3.600***<br>(0.865)  | 4.024***<br>(0.839)  | 2.673**<br>(1.273)   | 4.981**<br>(2.091)   | 2.449***<br>(0.912)  | 3.702***<br>(1.430)  |

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|                                        | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|----------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                        | $\sigma$             | $\sigma_{\epsilon}$  | VaR                  | CVaR                 | LPM(0,2)             | LPM(0,3)             |
| Firm-year obs.                         | 7,638                | 7,638                | 7,638                | 7,638                | 7,638                | 7,638                |
| Obs.                                   | 1,382                | 1,382                | 1,382                | 1,382                | 1,382                | 1,382                |
| $R^2$                                  | 0.557                | 0.422                | 0.580                | 0.568                | 0.538                | 0.441                |
| Time FE                                | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Panel B: Scope 2 GHG emissions / Sales |                      |                      |                      |                      |                      |                      |
| GHG emissions                          | 0.171***<br>(0.014)  | 0.168***<br>(0.014)  | 0.155***<br>(0.019)  | 0.427***<br>(0.032)  | 0.193***<br>(0.014)  | 0.358***<br>(0.023)  |
| Leverage                               | 0.761***<br>(0.141)  | 0.776***<br>(0.141)  | 0.912***<br>(0.186)  | 1.395***<br>(0.315)  | 0.623***<br>(0.133)  | 0.863***<br>(0.208)  |
| Sales growth                           | -0.153***<br>(0.042) | -0.121***<br>(0.040) | -0.278***<br>(0.065) | -0.454***<br>(0.108) | -0.180***<br>(0.045) | -0.273***<br>(0.075) |
| Profitability                          | -2.648***<br>(0.225) | -2.656***<br>(0.227) | -3.736***<br>(0.294) | -6.445***<br>(0.520) | -2.676***<br>(0.220) | -4.086***<br>(0.355) |
| Dividend yield                         | -1.586**<br>(0.698)  | -1.376**<br>(0.669)  | 0.432<br>(1.057)     | 4.391**<br>(1.804)   | 1.005<br>(0.756)     | 3.004**<br>(1.291)   |
| Size                                   | -0.079**<br>(0.038)  | -0.115***<br>(0.037) | 0.016<br>(0.056)     | -0.033<br>(0.093)    | -0.024<br>(0.041)    | -0.058<br>(0.064)    |
| Constant                               | 3.517***<br>(0.857)  | 3.966***<br>(0.831)  | 2.502**<br>(1.259)   | 4.575**<br>(2.078)   | 2.272**<br>(0.909)   | 3.453**<br>(1.436)   |
| Firm-year obs.                         | 7,550                | 7,550                | 7,550                | 7,550                | 7,550                | 7,550                |
| Obs.                                   | 1,375                | 1,375                | 1,375                | 1,375                | 1,375                | 1,375                |
| $R^2$                                  | 0.564                | 0.427                | 0.587                | 0.574                | 0.542                | 0.442                |
| Time FE                                | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Panel C: Scope 3 GHG emissions / Sales |                      |                      |                      |                      |                      |                      |
| GHG emissions                          | 0.000                | 0.002**              | 0.002                | -0.003*              | 0.002***             | -0.001               |

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|                | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|----------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                | $\sigma$             | $\sigma_\epsilon$    | VaR                  | CVaR                 | LPM(0,2)             | LPM(0,3)             |
| Leverage       | (0.001)<br>0.570***  | (0.001)<br>0.563***  | (0.001)<br>0.550**   | (0.002)<br>0.975**   | (0.001)<br>0.409**   | (0.001)<br>0.598**   |
| Sales growth   | (0.189)<br>-0.149*** | (0.192)<br>-0.126**  | (0.241)<br>-0.236*** | (0.422)<br>-0.409*** | (0.180)<br>-0.160*** | (0.281)<br>-0.246*** |
| Profitability  | (0.053)<br>-2.474*** | (0.050)<br>-2.433*** | (0.077)<br>-3.492*** | (0.131)<br>-6.153*** | (0.054)<br>-2.528*** | (0.092)<br>-3.896*** |
| Dividend yield | (0.296)<br>-2.116**  | (0.293)<br>-2.011**  | (0.355)<br>0.120     | (0.644)<br>3.389     | (0.268)<br>0.413     | (0.448)<br>2.003     |
| Size           | (0.861)<br>-0.058    | (0.845)<br>-0.095**  | (1.230)<br>0.035     | (2.218)<br>-0.032    | (0.929)<br>-0.019    | (1.611)<br>-0.069    |
| Constant       | (0.046)<br>3.112***  | (0.044)<br>3.599***  | (0.069)<br>2.171     | (0.109)<br>4.660*    | (0.049)<br>2.225**   | (0.076)<br>3.782**   |
|                | (1.039)              | (0.991)              | (1.587)              | (2.487)              | (1.098)              | (1.719)              |
| Firm-year obs. | 5,076                | 5,076                | 5,076                | 5,076                | 5,076                | 5,076                |
| Obs.           | 1,008                | 1,008                | 1,008                | 1,008                | 1,008                | 1,008                |
| $R^2$          | 0.567                | 0.410                | 0.597                | 0.587                | 0.559                | 0.467                |
| Time FE        | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents the fixed-effects estimation of the relationship between *scope 1 GHG emissions / total sales*, *scope 2 GHG emissions / total sales* and *scope 3 GHG emissions / total sales* and firms' equity risks. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

We find that size-adjusted scope 1 GHG emissions are significantly and positively related to equity risks. The regression coefficients are statistically significant at the 1% level in columns (1) and (6), and at the 10% level in columns (2), (4), and (5). The only exception pertains to the VaR in column (3), for which our results are not statistically significant. Overall, these findings suggest that higher levels of size-adjusted scope



1 GHG emissions are associated with increased standard and downside equity risks. Specifically, firms emitting comparatively more scope 1 emissions than their peers of similar size, as measured by total sales, exhibit higher equity risks in these dimensions.

With regard to the magnitude of our results, the coefficients suggest that, for instance, a one standard deviation (0.107) increase in scope 1 GHG emissions, meaning an increase of 10.7 tons per \$10,000 total sales, is related to a 0.024% higher stock volatility. Consequently, the stock volatility of the average firm (2.007%) would be approximately 2.03%. Therefore, while the economic effect is relatively modest and scope 1 GHG emissions do not seem to be the main driver of a company's equity risks, they are nevertheless a significant factor to consider.

Turning to size-adjusted scope 2 GHG emissions, we find an even stronger relationship, as outlined in Panel B. We observe that size-adjusted scope 2 GHG emissions are positively associated with equity risks. The coefficients are significant at the 1% level across all regression specifications. Thus, a firm that emits higher levels of scope 2 GHG emissions than other firms of similar size, as measured by total sales, is linked to higher standard and downside equity risks. With regard to the economic size, we find that an increase of the sales-adjusted scope 2 emissions by one standard deviation (0.112) is associated with an increase of stock volatility from 2.007% by 0.019% to 2.026%.

Finally, we investigate the relationship between size-adjusted scope 3 GHG emissions and equity risks. The results are presented in Panel C. While the idiosyncratic risk in column (2) as well as the LPM(0,2) in column (5) display significantly positive coefficients, the CVaR in model (3) suggests a significantly negative relationship. At the same time, the coefficients in columns (1), (4) and (6) do not display any statistically significant relationship between scope 3 GHG emissions and equity risks. Since these results are rather inconclusive, we cannot identify a clear relationship between scope 3 GHG emissions and firms equity risks and, thus, have to reject hypothesis H1c. This result is supported by a prior study from Jouvenot and Krueger (2019) who also do not find statistical significance for scope 3 GHG emissions in their analyses.

In sum, we find a positive relationship between size-adjusted scope 1 GHG emissions and equity risks, as well as between size-adjusted scope 2 GHG emissions and equity

risks. With regard to our control variables, we find that a higher leverage ratio is linked to higher equity risks. Moreover, firms with higher sales growth or higher profitability display lower equity risks, which are also consistent with findings in the earlier literature (see e.g., El Ghouli et al., 2011; Brailsford et al., 2002).

## V.4.2 Industry-adjusted GHG emissions

So far, our analysis has accounted for differences in firm size by scaling corporate GHG emissions to total sales. However, GHG emissions also depend heavily on the industry in which a firm operates (Brännlund et al., 2015; European Commission, 2021a; Eurostat, 2021). In a next step, we therefore investigate whether our previous findings are simply indicative of variations in equity risks across industries. In other words, our previous results may reflect investors' expectations that GHG-intensive industries are inherently more risky. This time, we employ explanatory variables that benchmark GHG emissions against the respective industry as described in Section V.3.2. More specifically, our explanatory variables are adjusted for both size and industry.

Table V.6 outlines the results of the regression specifications for industry-adjusted GHG emissions. In Panel A, we report the results for industry-adjusted scope 1 GHG emissions. In Panel B, we show the results for industry-adjusted scope 2 GHG emissions, and in Panel C for industry-adjusted scope 3 GHG emissions.

Table V.6: Industry-adjusted GHG emissions and equity risks.

|                         | (1)                 | (2)                 | (3)                 | (4)                 | (5)                 | (6)                 |
|-------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|                         | $\sigma$            | $\sigma_{\epsilon}$ | VaR                 | CVaR                | LPM(0,2)            | LPM(0,3)            |
| Panel A: BM GHG scope 1 |                     |                     |                     |                     |                     |                     |
| BM GHG                  | 0.185***<br>(0.067) | 0.163**<br>(0.080)  | 0.017<br>(0.115)    | 0.283<br>(0.215)    | 0.164*<br>(0.094)   | 0.362**<br>(0.149)  |
| Leverage                | 0.848***<br>(0.144) | 0.861***<br>(0.145) | 0.968***<br>(0.188) | 1.545***<br>(0.317) | 0.698***<br>(0.134) | 0.973***<br>(0.206) |
| Sales growth            | -0.148***           | -0.120***           | -0.270***           | -0.447***           | -0.177***           | -0.265***           |

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|                         | (1)                            | (2)                            | (3)                           | (4)                           | (5)                            | (6)                            |
|-------------------------|--------------------------------|--------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------------------|
|                         | $\sigma$                       | $\sigma_{\epsilon}$            | VaR                           | CVaR                          | LPM(0,2)                       | LPM(0,3)                       |
| Profitability           | (0.043)<br>-2.658***           | (0.041)<br>-2.670***           | (0.065)<br>-3.747***          | (0.111)<br>-6.471***          | (0.046)<br>-2.691***           | (0.076)<br>-4.111***           |
| Dividend yield          | (0.223)<br>-1.460**            | (0.225)<br>-1.265*             | (0.295)<br>0.607              | (0.521)<br>4.733***           | (0.219)<br>1.102               | (0.353)<br>3.121**             |
| Size                    | (0.677)<br>-0.087**            | (0.648)<br>-0.122***           | (1.027)<br>0.006              | (1.741)<br>-0.059             | (0.729)<br>-0.035              | (1.241)<br>-0.076              |
| Constant                | (0.039)<br>3.642***<br>(0.866) | (0.038)<br>4.062***<br>(0.840) | (0.056)<br>2.694**<br>(1.272) | (0.093)<br>5.067**<br>(2.094) | (0.041)<br>2.486***<br>(0.913) | (0.064)<br>3.787***<br>(1.434) |
| Firm-year obs.          | 7,638                          | 7,638                          | 7,638                         | 7,638                         | 7,638                          | 7,638                          |
| Obs.                    | 1,382                          | 1,382                          | 1,382                         | 1,382                         | 1,382                          | 1,382                          |
| $R^2$                   | 0.557                          | 0.422                          | 0.580                         | 0.568                         | 0.538                          | 0.441                          |
| Time FE                 | Yes                            | Yes                            | Yes                           | Yes                           | Yes                            | Yes                            |
| Panel B: BM GHG scope 2 |                                |                                |                               |                               |                                |                                |
| BM GHG                  | 0.180***<br>(0.018)            | 0.169***<br>(0.016)            | 0.178***<br>(0.032)           | 0.455***<br>(0.042)           | 0.198***<br>(0.017)            | 0.355***<br>(0.030)            |
| Leverage                | 0.760***<br>(0.141)            | 0.775***<br>(0.141)            | 0.910***<br>(0.186)           | 1.392***<br>(0.315)           | 0.622***<br>(0.133)            | 0.862***<br>(0.208)            |
| Sales growth            | -0.153***<br>(0.042)           | -0.121***<br>(0.041)           | -0.277***<br>(0.065)          | -0.453***<br>(0.108)          | -0.180***<br>(0.045)           | -0.272***<br>(0.075)           |
| Profitability           | -2.646***<br>(0.225)           | -2.655***<br>(0.227)           | -3.733***<br>(0.294)          | -6.438***<br>(0.520)          | -2.674***<br>(0.220)           | -4.083***<br>(0.355)           |
| Dividend yield          | -1.583**<br>(0.698)            | -1.374**<br>(0.669)            | 0.436<br>(1.056)              | 4.399**<br>(1.803)            | 1.008<br>(0.755)               | 3.009**<br>(1.291)             |
| Size                    | -0.078**<br>(0.038)            | -0.115***<br>(0.037)           | 0.017<br>(0.056)              | -0.031<br>(0.093)             | -0.023<br>(0.041)              | -0.058<br>(0.064)              |
| Constant                | 3.508***                       | 3.967***                       | 2.479**                       | 4.550**                       | 2.268**                        | 3.459**                        |

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|                         | (1)       | (2)               | (3)       | (4)       | (5)       | (6)       |
|-------------------------|-----------|-------------------|-----------|-----------|-----------|-----------|
|                         | $\sigma$  | $\sigma_\epsilon$ | VaR       | CVaR      | LPM(0,2)  | LPM(0,3)  |
|                         | (0.857)   | (0.831)           | (1.260)   | (2.078)   | (0.909)   | (1.435)   |
| Firm-year obs.          | 7,550     | 7,550             | 7,550     | 7,550     | 7,550     | 7,550     |
| Obs.                    | 1,375     | 1,375             | 1,375     | 1,375     | 1,375     | 1,375     |
| $R^2$                   | 0.564     | 0.427             | 0.587     | 0.574     | 0.542     | 0.442     |
| Time FE                 | Yes       | Yes               | Yes       | Yes       | Yes       | Yes       |
| Panel C: BM GHG scope 3 |           |                   |           |           |           |           |
| BM GHG                  | 0.000     | 0.001             | 0.003     | -0.001    | 0.002*    | -0.001    |
|                         | (0.001)   | (0.001)           | (0.002)   | (0.003)   | (0.001)   | (0.002)   |
| Leverage                | 0.570***  | 0.563***          | 0.550**   | 0.975**   | 0.408**   | 0.599**   |
|                         | (0.189)   | (0.192)           | (0.241)   | (0.422)   | (0.180)   | (0.281)   |
| Sales growth            | -0.149*** | -0.126**          | -0.236*** | -0.409*** | -0.160*** | -0.246*** |
|                         | (0.053)   | (0.050)           | (0.077)   | (0.131)   | (0.054)   | (0.092)   |
| Profitability           | -2.474*** | -2.433***         | -3.491*** | -6.151*** | -2.528*** | -3.895*** |
|                         | (0.296)   | (0.293)           | (0.354)   | (0.644)   | (0.268)   | (0.448)   |
| Dividend yield          | -2.116**  | -2.013**          | 0.120     | 3.394     | 0.412     | 2.004     |
|                         | (0.861)   | (0.845)           | (1.230)   | (2.217)   | (0.929)   | (1.611)   |
| Size                    | -0.058    | -0.095**          | 0.035     | -0.032    | -0.019    | -0.069    |
|                         | (0.046)   | (0.044)           | (0.069)   | (0.109)   | (0.049)   | (0.076)   |
| Constant                | 3.112***  | 3.597***          | 2.168     | 4.661*    | 2.222**   | 3.782**   |
|                         | (1.038)   | (0.991)           | (1.587)   | (2.486)   | (1.098)   | (1.719)   |
| Firm-year obs.          | 5,076     | 5,076             | 5,076     | 5,076     | 5,076     | 5,076     |
| Obs.                    | 1,008     | 1,008             | 1,008     | 1,008     | 1,008     | 1,008     |
| $R^2$                   | 0.567     | 0.410             | 0.597     | 0.587     | 0.559     | 0.467     |

|         |     |     |     |     |     |     |
|---------|-----|-----|-----|-----|-----|-----|
| Time FE | Yes | Yes | Yes | Yes | Yes | Yes |
|---------|-----|-----|-----|-----|-----|-----|

*Remark:* This table presents the fixed-effects estimation of the relationship between *BM GHG scope 1 emissions*, *BM GHG scope 2 emissions* and *BM GHG scope 3 emissions* and firms' equity risks. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

In Panel A, four out of six regression specifications indicate a significantly positive relationship between scope 1 GHG emissions and equity risks. We observe that the coefficient for the regression specification in column (1) is significant at the 10% level, whereas in columns (2) and (6), the coefficients are significant at the 5% level. Once again, the coefficient for the VaR in column (3) is not statistically significant. Furthermore, we do not find statistical significance with regard to the coefficient in column (4) pertaining to the CVaR.

In Panel B, we find a strongly positive relationship between scope 2 GHG emissions and equity risks across all our regression specifications. The coefficients are significant at the 1% level. These results indicate that a company that generates higher levels of scope 2 GHG emissions than industry peers of similar size is associated with higher standard as well as downside equity risks. In terms of magnitude, the results are also economically comparable to the previous analysis on size-adjusted GHG emissions.

With regard to industry-adjusted scope 3 GHG emissions, the regression specifications in Panel C do not return conclusive results when adjusting for size and industry, except for a weakly significantly positive coefficient of the LPM(0,2) in column (5). Together with our results from size-adjusted GHG emissions, as described in V.4.1, we conclude that there is no clear relationship between scope 3 emissions and firm equity risks, which leads us to reject H2c.

## V.5 Mandatory GHG reporting and equity risks

Next, we investigate whether the significance and strength of the relationship between GHG emissions and equity risks vary depending on the disclosure setting, particularly

when GHG disclosure is mandated by law. Notably, UK and French firms, which together account for approximately 43% of our sample, are subject to mandatory GHG reporting requirements (Grewal et al., 2019). Publicly listed firms incorporated in the UK are required to disclose scope 1 and scope 2 GHG emissions in their annual financial reports. Similarly, France introduced comparable reporting obligations through the Grenelle II Act of 2011, which mandated large companies with 500 or more employees to comply by 2012, while smaller companies — those with fewer than 500 employees and total assets or annual sales below €100 million — were required to comply by 2014 (Grewal, 2021).

To assess whether the previously observed risk associations differ under these disclosure settings, we conduct our analysis on two distinct sub-samples. The first sub-sample excludes firms headquartered in the UK and France, allowing us to observe patterns in the absence of mandatory disclosure requirements. The second sub-sample specifically focuses on firms headquartered in the UK and France, where mandatory disclosure is enforced. For both sub-samples, we perform separate analyses for each scope category of GHG emissions.

Table V.8 presents the regression results for the sample excluding UK and French firms. Consistent with our previous findings, Panel A shows a significantly positive relationship between equity risks and size-adjusted scope 1 GHG emissions. Notably, the results indicate that both the overall significance and coefficient sizes increase when UK and French firms are excluded, compared to the full sample results reported in Table V.4. The coefficients across all six regression specifications are significant at the 1% level. Similarly, the analysis for size-adjusted scope 2 GHG emissions in Panel B reaffirms a positive relationship with equity risks. All coefficients are significant at the 1% level, and their magnitudes are larger in this sub-sample analysis than in the full sample. In contrast, the results for size-adjusted scope 3 GHG emissions in Panel C reveal no significant relationship with equity risks, aligning with our earlier observations. Overall, the relationship between GHG emissions and equity risks is weaker in the presence of mandatory disclosure.

Table V.8: Size-adjusted GHG emissions and equity risks (sample without UK &amp; France).

|                                        | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|----------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                        | $\sigma$             | $\sigma_\epsilon$    | VaR                  | CVaR                 | LPM(0,2)             | LPM(0,3)             |
| Panel A: Scope 1 GHG emissions / Sales |                      |                      |                      |                      |                      |                      |
| GHG emissions                          | 0.440***<br>(0.070)  | 0.487***<br>(0.057)  | 0.422***<br>(0.134)  | 1.043***<br>(0.201)  | 0.498***<br>(0.073)  | 0.900***<br>(0.104)  |
| Leverage                               | 0.536***<br>(0.145)  | 0.527***<br>(0.147)  | 0.661***<br>(0.207)  | 1.009***<br>(0.355)  | 0.433***<br>(0.148)  | 0.550**<br>(0.246)   |
| Sales growth                           | -0.166***<br>(0.051) | -0.128**<br>(0.051)  | -0.283***<br>(0.078) | -0.524***<br>(0.134) | -0.208***<br>(0.055) | -0.327***<br>(0.087) |
| Profitability                          | -1.877***<br>(0.267) | -1.884***<br>(0.276) | -2.360***<br>(0.389) | -4.170***<br>(0.666) | -1.688***<br>(0.284) | -2.702***<br>(0.445) |
| Dividend yield                         | -2.782***<br>(0.669) | -2.474***<br>(0.661) | -1.435<br>(1.044)    | 1.930<br>(1.762)     | -0.158<br>(0.722)    | 1.648<br>(1.253)     |
| Size                                   | -0.057<br>(0.047)    | -0.078<br>(0.048)    | 0.060<br>(0.069)     | -0.010<br>(0.118)    | 0.005<br>(0.049)     | -0.035<br>(0.080)    |
| Constant                               | 3.137***<br>(1.065)  | 3.252***<br>(1.101)  | 1.570<br>(1.569)     | 4.113<br>(2.694)     | 1.668<br>(1.122)     | 3.003*<br>(1.817)    |
| Firm-year obs.                         | 4,365                | 4,365                | 4,365                | 4,365                | 4,365                | 4,365                |
| Obs.                                   | 840                  | 840                  | 840                  | 840                  | 840                  | 840                  |
| $R^2$                                  | 0.572                | 0.397                | 0.580                | 0.567                | 0.543                | 0.445                |
| Time FE                                | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Panel B: Scope 2 GHG emissions / Sales |                      |                      |                      |                      |                      |                      |
| GHG emissions                          | 0.204***<br>(0.016)  | 0.205***<br>(0.017)  | 0.213***<br>(0.024)  | 0.510***<br>(0.039)  | 0.233***<br>(0.017)  | 0.411***<br>(0.026)  |
| Leverage                               | 0.496***<br>(0.146)  | 0.500***<br>(0.148)  | 0.635***<br>(0.209)  | 0.948***<br>(0.354)  | 0.403***<br>(0.148)  | 0.511**<br>(0.246)   |

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|                                        | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  |
|----------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                        | $\sigma$             | $\sigma_{\epsilon}$  | VaR                  | CVaR                 | LPM(0,2)             | LPM(0,3)             |
| Sales growth                           | -0.179***<br>(0.051) | -0.137***<br>(0.051) | -0.292***<br>(0.077) | -0.533***<br>(0.132) | -0.213***<br>(0.054) | -0.337***<br>(0.086) |
| Profitability                          | -1.897***<br>(0.272) | -1.881***<br>(0.279) | -2.407***<br>(0.391) | -4.246***<br>(0.669) | -1.715***<br>(0.286) | -2.740***<br>(0.449) |
| Dividend yield                         | -2.777***<br>(0.690) | -2.473***<br>(0.680) | -1.473<br>(1.078)    | 1.832<br>(1.830)     | -0.140<br>(0.749)    | 1.687<br>(1.302)     |
| Size                                   | -0.044<br>(0.047)    | -0.074<br>(0.049)    | 0.084<br>(0.069)     | 0.017<br>(0.119)     | 0.018<br>(0.049)     | -0.019<br>(0.080)    |
| Constant                               | 2.879***<br>(1.062)  | 3.171***<br>(1.105)  | 1.050<br>(1.570)     | 3.547<br>(2.700)     | 1.382<br>(1.124)     | 2.683<br>(1.823)     |
| Firm-year obs.                         | 4,272                | 4,272                | 4,272                | 4,272                | 4,272                | 4,272                |
| Obs.                                   | 828                  | 828                  | 828                  | 828                  | 828                  | 828                  |
| $R^2$                                  | 0.585                | 0.409                | 0.591                | 0.581                | 0.556                | 0.458                |
| Time FE                                | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Panel C: Scope 3 GHG emissions / Sales |                      |                      |                      |                      |                      |                      |
| GHG emissions                          | -0.001<br>(0.001)    | 0.001<br>(0.001)     | 0.000<br>(0.001)     | -0.004*<br>(0.002)   | 0.002**<br>(0.001)   | -0.001<br>(0.001)    |
| Leverage                               | 0.469**<br>(0.190)   | 0.450**<br>(0.195)   | 0.493*<br>(0.254)    | 0.673<br>(0.425)     | 0.300<br>(0.190)     | 0.352<br>(0.304)     |
| Sales growth                           | -0.229***<br>(0.062) | -0.195***<br>(0.061) | -0.361***<br>(0.091) | -0.651***<br>(0.141) | -0.260***<br>(0.057) | -0.408***<br>(0.088) |
| Profitability                          | -2.053***<br>(0.345) | -2.014***<br>(0.348) | -2.452***<br>(0.469) | -4.280***<br>(0.815) | -1.793***<br>(0.343) | -2.794***<br>(0.561) |
| Dividend yield                         | -3.219***<br>(0.867) | -2.873***<br>(0.864) | -2.104<br>(1.307)    | 1.279<br>(2.292)     | -0.534<br>(0.945)    | 1.159<br>(1.668)     |
| Size                                   | -0.049<br>(0.056)    | -0.085<br>(0.058)    | 0.115<br>(0.088)     | 0.012<br>(0.136)     | 0.009<br>(0.060)     | -0.061<br>(0.089)    |

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|                | (1)                | (2)                 | (3)              | (4)              | (5)              | (6)               |
|----------------|--------------------|---------------------|------------------|------------------|------------------|-------------------|
|                | $\sigma$           | $\sigma_{\epsilon}$ | VaR              | CVaR             | LPM(0,2)         | LPM(0,3)          |
| Constant       | 3.018**<br>(1.280) | 3.454***<br>(1.310) | 0.344<br>(2.001) | 3.777<br>(3.088) | 1.636<br>(1.359) | 3.718*<br>(2.032) |
| Firm-year obs. | 3,003              | 3,003               | 3,003            | 3,003            | 3,003            | 3,003             |
| Obs.           | 601                | 601                 | 601              | 601              | 601              | 601               |
| $R^2$          | 0.592              | 0.412               | 0.600            | 0.600            | 0.581            | 0.495             |
| Time FE        | Yes                | Yes                 | Yes              | Yes              | Yes              | Yes               |

*Remark:* This table presents the fixed-effects estimation of the relationship between *scope 1 GHG emissions / total sales*, *scope 2 GHG emissions / total sales* and *scope 3 GHG emissions / total sales* and firms' equity risks for a sample of European companies without UK and French firms. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_{\epsilon}$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table V.10 reports the results for the sub-sample with only French and UK firms. In comparison to the previous findings in Table V.8, we observe in Panel A that the coefficient sizes as well as the significance for the relationship between size-adjusted scope 1 emissions and equity risks become smaller. The difference is even more striking in the case of scope 2 GHG emissions, reported in Panel B, as the statistical significance disappears completely for all coefficients of the regression specifications.

Table V.10: Size-adjusted GHG emissions and equity risks (sample with only UK & France).

|                                        | (1)                 | (2)                 | (3)                 | (4)               | (5)               | (6)                 |
|----------------------------------------|---------------------|---------------------|---------------------|-------------------|-------------------|---------------------|
|                                        | $\sigma$            | $\sigma_{\epsilon}$ | VaR                 | CVaR              | LPM(0,2)          | LPM(0,3)            |
| Panel A: Scope 1 GHG emissions / Sales |                     |                     |                     |                   |                   |                     |
| GHG emissions                          | 0.138***<br>(0.035) | 0.083*<br>(0.044)   | -0.103**<br>(0.042) | 0.127*<br>(0.074) | 0.089*<br>(0.047) | 0.285***<br>(0.083) |
| Leverage                               | 1.152***            | 1.180***            | 1.297***            | 2.052***          | 0.941***          | 1.327***            |

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|                                        | (1)                           | (2)                          | (3)                            | (4)                            | (5)                            | (6)                           |
|----------------------------------------|-------------------------------|------------------------------|--------------------------------|--------------------------------|--------------------------------|-------------------------------|
|                                        | $\sigma$                      | $\sigma_\epsilon$            | VaR                            | CVaR                           | LPM(0,2)                       | LPM(0,3)                      |
| Sales growth                           | (0.217)<br>-0.114*<br>(0.063) | (0.215)<br>-0.088<br>(0.060) | (0.273)<br>-0.219**<br>(0.095) | (0.467)<br>-0.352**<br>(0.161) | (0.196)<br>-0.138**<br>(0.066) | (0.302)<br>-0.208*<br>(0.114) |
| Profitability                          | -2.935***<br>(0.326)          | -2.958***<br>(0.325)         | -4.383***<br>(0.385)           | -7.640***<br>(0.710)           | -3.208***<br>(0.292)           | -4.874***<br>(0.495)          |
| Dividend yield                         | 0.721<br>(2.474)              | 0.841<br>(2.225)             | 4.469<br>(3.472)               | 9.331<br>(5.675)               | 3.312<br>(2.460)               | 4.746<br>(3.904)              |
| Size                                   | -0.149***<br>(0.055)          | -0.193***<br>(0.051)         | -0.098<br>(0.077)              | -0.181<br>(0.131)              | -0.105*<br>(0.057)             | -0.151<br>(0.094)             |
| Constant                               | 4.782***<br>(1.191)           | 5.379***<br>(1.110)          | 4.804***<br>(1.707)            | 7.530***<br>(2.877)            | 3.899***<br>(1.259)            | 5.291**<br>(2.048)            |
| Firm-year obs.                         | 3,273                         | 3,273                        | 3,273                          | 3,273                          | 3,273                          | 3,273                         |
| Obs.                                   | 542                           | 542                          | 542                            | 542                            | 542                            | 542                           |
| $R^2$                                  | 0.587                         | 0.492                        | 0.622                          | 0.602                          | 0.570                          | 0.466                         |
| Time FE                                | Yes                           | Yes                          | Yes                            | Yes                            | Yes                            | Yes                           |
| Panel B: Scope 2 GHG emissions / Sales |                               |                              |                                |                                |                                |                               |
| GHG emissions                          | 1.728<br>(1.719)              | 1.684<br>(1.927)             | 2.494<br>(2.307)               | -0.420<br>(4.007)              | 0.668<br>(1.569)               | -0.997<br>(2.463)             |
| Leverage                               | 1.038***<br>(0.212)           | 1.061***<br>(0.210)          | 1.229***<br>(0.271)            | 1.861***<br>(0.469)            | 0.844***<br>(0.197)            | 1.186***<br>(0.310)           |
| Sales growth                           | -0.106*<br>(0.062)            | -0.076<br>(0.058)            | -0.213**<br>(0.096)            | -0.369**<br>(0.159)            | -0.140**<br>(0.066)            | -0.230**<br>(0.115)           |
| Profitability                          | -2.928***<br>(0.327)          | -2.968***<br>(0.325)         | -4.362***<br>(0.385)           | -7.597***<br>(0.707)           | -3.187***<br>(0.293)           | -4.841***<br>(0.499)          |
| Dividend yield                         | 0.330<br>(2.572)              | 0.492<br>(2.313)             | 3.912<br>(3.585)               | 8.757<br>(5.959)               | 3.126<br>(2.587)               | 4.683<br>(4.126)              |
| Size                                   | -0.145***                     | -0.186***                    | -0.097                         | -0.165                         | -0.099*                        | -0.143                        |

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|                                        | (1)                            | (2)                            | (3)                            | (4)                           | (5)                            | (6)                           |
|----------------------------------------|--------------------------------|--------------------------------|--------------------------------|-------------------------------|--------------------------------|-------------------------------|
|                                        | $\sigma$                       | $\sigma_{\epsilon}$            | VaR                            | CVaR                          | LPM(0,2)                       | LPM(0,3)                      |
| Constant                               | (0.054)<br>4.761***<br>(1.170) | (0.050)<br>5.309***<br>(1.092) | (0.076)<br>4.833***<br>(1.674) | (0.130)<br>7.338**<br>(2.856) | (0.057)<br>3.830***<br>(1.252) | (0.095)<br>5.233**<br>(2.057) |
| Firm-year obs.                         | 3,278                          | 3,278                          | 3,278                          | 3,278                         | 3,278                          | 3,278                         |
| Obs.                                   | 547                            | 547                            | 547                            | 547                           | 547                            | 547                           |
| $R^2$                                  | 0.587                          | 0.489                          | 0.623                          | 0.597                         | 0.564                          | 0.455                         |
| Time FE                                | Yes                            | Yes                            | Yes                            | Yes                           | Yes                            | Yes                           |
| Panel C: Scope 3 GHG emissions / Sales |                                |                                |                                |                               |                                |                               |
| GHG emissions                          | -0.011<br>(0.060)              | 0.041<br>(0.086)               | 0.079<br>(0.167)               | 0.067<br>(0.113)              | 0.000<br>(0.052)               | 0.016<br>(0.090)              |
| Leverage                               | 0.879***<br>(0.324)            | 0.874***<br>(0.326)            | 0.911**<br>(0.387)             | 1.721**<br>(0.696)            | 0.701**<br>(0.294)             | 1.072**<br>(0.466)            |
| Sales growth                           | -0.066<br>(0.077)              | -0.049<br>(0.073)              | -0.091<br>(0.110)              | -0.176<br>(0.194)             | -0.064<br>(0.080)              | -0.111<br>(0.143)             |
| Profitability                          | -2.558***<br>(0.464)           | -2.529***<br>(0.458)           | -4.070***<br>(0.446)           | -7.314***<br>(0.890)          | -2.960***<br>(0.374)           | -4.589***<br>(0.665)          |
| Dividend yield                         | 0.627<br>(3.107)               | -0.144<br>(2.964)              | 6.353<br>(3.949)               | 7.710<br>(6.855)              | 2.617<br>(2.976)               | 2.921<br>(4.643)              |
| Size                                   | -0.085<br>(0.071)              | -0.123*<br>(0.065)             | -0.083<br>(0.091)              | -0.130<br>(0.167)             | -0.072<br>(0.072)              | -0.106<br>(0.128)             |
| Constant                               | 3.444**<br>(1.600)             | 3.956***<br>(1.461)            | 4.533**<br>(2.065)             | 6.376*<br>(3.764)             | 3.210**<br>(1.616)             | 4.346<br>(2.828)              |
| Firm-year obs.                         | 2,073                          | 2,073                          | 2,073                          | 2,073                         | 2,073                          | 2,073                         |
| Obs.                                   | 407                            | 407                            | 407                            | 407                           | 407                            | 407                           |
| $R^2$                                  | 0.574                          | 0.453                          | 0.632                          | 0.603                         | 0.568                          | 0.466                         |

|         |     |     |     |     |     |     |
|---------|-----|-----|-----|-----|-----|-----|
| Time FE | Yes | Yes | Yes | Yes | Yes | Yes |
|---------|-----|-----|-----|-----|-----|-----|

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*Remark:* This table presents the fixed-effects estimation of the relationship between *scope 1 GHG emissions / total sales*, *scope 2 GHG emissions / total sales* and *scope 3 GHG emissions / total sales* and firms' equity risks for a sample of UK and French firms. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2),  $VaR$  in model (3),  $CVaR$  in model (4) as well as the second and third order lower partial moments  $LPM(0,2)$  in model (5) and  $LPM(0,3)$  in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Repeating the same analyses with industry-adjusted GHG emissions, the results are qualitatively very similar. Table V.12 presents the results corresponding to industry-adjusted scope 1 and scope 2 GHG emissions for the sub-sample without UK and French firms. Although the coefficient sizes and significance are smaller than in Table V.8 where we investigated size-adjusted GHG emissions in the sub-sample without UK and France, they are still greater than in Table V.6 in which we analyzed industry-adjusted GHG emissions based on our full sample.

Table V.12: Industry-adjusted scope 1 and scope 2 GHG emissions and equity risks (sample without UK &amp; France).

|                | Panel A: BM GHG scope 1 |                          |                      |                      |                      |                      | Panel B: BM GHG scope 2 |                          |                      |                      |                      |                      |
|----------------|-------------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|-------------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
|                | (1)<br>$\sigma$         | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      | (1)<br>$\sigma$         | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      |
| BM GHG         | 0.284*<br>(0.165)       | 0.341***<br>(0.131)      | 0.229<br>(0.238)     | 0.642<br>(0.463)     | 0.350**<br>(0.169)   | 0.625**<br>(0.290)   | 0.210***<br>(0.018)     | 0.205***<br>(0.018)      | 0.230***<br>(0.028)  | 0.534***<br>(0.045)  | 0.241***<br>(0.018)  | 0.417***<br>(0.029)  |
| Leverage       | 0.545***<br>(0.146)     | 0.535***<br>(0.148)      | 0.671***<br>(0.207)  | 1.030***<br>(0.354)  | 0.441***<br>(0.148)  | 0.565**<br>(0.247)   | 0.495***<br>(0.146)     | 0.500***<br>(0.148)      | 0.632***<br>(0.209)  | 0.944***<br>(0.354)  | 0.402***<br>(0.148)  | 0.509**<br>(0.246)   |
| Sales growth   | -0.171***<br>(0.051)    | -0.133***<br>(0.051)     | -0.289***<br>(0.078) | -0.538***<br>(0.134) | -0.213***<br>(0.055) | -0.337***<br>(0.087) | -0.178***<br>(0.051)    | -0.137***<br>(0.051)     | -0.291***<br>(0.077) | -0.531***<br>(0.132) | -0.212***<br>(0.054) | -0.335***<br>(0.086) |
| Profitability  | -1.893***<br>(0.268)    | -1.901***<br>(0.277)     | -2.378***<br>(0.390) | -4.210***<br>(0.669) | -1.706***<br>(0.286) | -2.734***<br>(0.448) | -1.894***<br>(0.272)    | -1.879***<br>(0.279)     | -2.402***<br>(0.391) | -4.238***<br>(0.669) | -1.712***<br>(0.286) | -2.736***<br>(0.449) |
| Dividend yield | -2.742***<br>(0.667)    | -2.428***<br>(0.657)     | -1.401<br>(1.042)    | 2.022<br>(1.758)     | -0.110<br>(0.720)    | 1.734<br>(1.251)     | -2.777***<br>(0.690)    | -2.473***<br>(0.679)     | -1.472<br>(1.077)    | 1.833<br>(1.829)     | -0.139<br>(0.748)    | 1.687<br>(1.302)     |
| Size           | -0.065<br>(0.047)       | -0.086*<br>(0.049)       | 0.050<br>(0.069)     | -0.030<br>(0.119)    | -0.003<br>(0.050)    | -0.050<br>(0.080)    | -0.043<br>(0.047)       | -0.074<br>(0.049)        | 0.085<br>(0.069)     | 0.020<br>(0.119)     | 0.019<br>(0.049)     | -0.019<br>(0.080)    |
| Constant       | 3.327***<br>(1.073)     | 3.437***<br>(1.108)      | 1.793<br>(1.577)     | 4.591*<br>(2.711)    | 1.856<br>(1.132)     | 3.350*<br>(1.834)    | 2.867***<br>(1.061)     | 3.173***<br>(1.105)      | 1.017<br>(1.569)     | 3.501<br>(2.700)     | 1.368<br>(1.124)     | 2.675<br>(1.824)     |
| Firm-year obs. | 4,365                   | 4,365                    | 4,365                | 4,365                | 4,365                | 4,365                | 4,272                   | 4,272                    | 4,272                | 4,272                | 4,272                | 4,272                |
| Obs.           | 840                     | 840                      | 840                  | 840                  | 840                  | 840                  | 828                     | 828                      | 828                  | 828                  | 828                  | 828                  |
| $R^2$          | 0.571                   | 0.395                    | 0.579                | 0.566                | 0.542                | 0.444                | 0.585                   | 0.409                    | 0.591                | 0.581                | 0.556                | 0.458                |
| Time FE        | Yes                     | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  | Yes                     | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents the fixed-effects estimation of the relationship between *BM GHG scope 1 emissions* and *BM GHG scope 2 emissions* and firms' equity risks for a sample of European companies without UK and French firms. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

In Table V.13 we provide the results for industry-adjusted scope 1 and scope 2 GHG emissions for the sub-sample with only French and UK firms. As expected, we find much smaller coefficient sizes than in Table V.6 where we analyze industry-adjusted GHG emissions based on our full sample. Furthermore, we also lose almost all statistical significance for scope 2 GHG emissions in Panel B. Finally, the results for industry-adjusted scope 3 emissions are presented in Tables V.14 and V.15 and once again do not indicate a significant relationship between GHG emissions and equity risks in either disclosure setting. Overall, these results underline the robustness of our earlier findings.

Table V.13: Industry-adjusted scope 1 and scope 2 GHG emissions and equity risks (sample with only UK &amp; France).

|                | Panel A: BM GHG scope 1 |                          |                      |                      |                      |                      | Panel B: BM GHG scope 2 |                          |                      |                      |                      |                      |
|----------------|-------------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|-------------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
|                | (1)<br>$\sigma$         | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      | (1)<br>$\sigma$         | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      |
| BM GHG         | 0.140***<br>(0.039)     | 0.084*<br>(0.047)        | -0.080<br>(0.066)    | 0.138<br>(0.092)     | 0.092*<br>(0.052)    | 0.267***<br>(0.074)  | 0.950<br>(0.691)        | 0.751<br>(0.683)         | 1.617*<br>(0.930)    | 1.097<br>(1.822)     | 0.292<br>(0.765)     | -0.521<br>(1.420)    |
| Leverage       | 1.153***<br>(0.217)     | 1.181***<br>(0.215)      | 1.296***<br>(0.273)  | 2.054***<br>(0.467)  | 0.942***<br>(0.196)  | 1.330***<br>(0.302)  | 1.034***<br>(0.212)     | 1.058***<br>(0.211)      | 1.221***<br>(0.271)  | 1.857***<br>(0.468)  | 0.843***<br>(0.196)  | 1.188***<br>(0.310)  |
| Sales growth   | -0.114*<br>(0.063)      | -0.088<br>(0.060)        | -0.217**<br>(0.095)  | -0.352**<br>(0.162)  | -0.138**<br>(0.067)  | -0.209*<br>(0.114)   | -0.108*<br>(0.061)      | -0.079<br>(0.058)        | -0.215**<br>(0.095)  | -0.361**<br>(0.156)  | -0.141**<br>(0.065)  | -0.228**<br>(0.113)  |
| Profitability  | -2.936***<br>(0.327)    | -2.959***<br>(0.326)     | -4.384***<br>(0.386) | -7.641***<br>(0.711) | -3.208***<br>(0.292) | -4.873***<br>(0.496) | -2.920***<br>(0.326)    | -2.962***<br>(0.325)     | -4.347***<br>(0.383) | -7.582***<br>(0.706) | -3.184***<br>(0.293) | -4.845***<br>(0.499) |
| Dividend yield | 0.751<br>(2.477)        | 0.859<br>(2.227)         | 4.448<br>(3.469)     | 9.359*<br>(5.676)    | 3.331<br>(2.461)     | 4.808<br>(3.908)     | 0.406<br>(2.584)        | 0.551<br>(2.323)         | 4.044<br>(3.604)     | 8.856<br>(5.976)     | 3.148<br>(2.591)     | 4.641<br>(4.113)     |
| Size           | -0.149***<br>(0.055)    | -0.193***<br>(0.051)     | -0.097<br>(0.077)    | -0.182<br>(0.131)    | -0.106*<br>(0.057)   | -0.152<br>(0.094)    | -0.145***<br>(0.053)    | -0.186***<br>(0.050)     | -0.098<br>(0.076)    | -0.164<br>(0.130)    | -0.099*<br>(0.057)   | -0.143<br>(0.095)    |
| Constant       | 4.792***<br>(1.192)     | 5.385***<br>(1.111)      | 4.794***<br>(1.707)  | 7.539***<br>(2.877)  | 3.906***<br>(1.259)  | 5.315***<br>(2.047)  | 4.779***<br>(1.166)     | 5.330***<br>(1.089)      | 4.855***<br>(1.672)  | 7.312**<br>(2.848)   | 3.838***<br>(1.250)  | 5.222**<br>(2.059)   |
| Firm-year obs. | 3,273                   | 3,273                    | 3,273                | 3,273                | 3,273                | 3,273                | 3,278                   | 3,278                    | 3,278                | 3,278                | 3,278                | 3,278                |
| Obs.           | 542                     | 542                      | 542                  | 542                  | 542                  | 542                  | 547                     | 547                      | 547                  | 547                  | 547                  | 547                  |
| $R^2$          | 0.587                   | 0.492                    | 0.622                | 0.602                | 0.570                | 0.465                | 0.587                   | 0.489                    | 0.623                | 0.598                | 0.564                | 0.455                |
| Time FE        | Yes                     | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  | Yes                     | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents the fixed-effects estimation of the relationship between *BM GHG scope 1 emissions* and *BM GHG scope 2 emissions* and firms' equity risks for a sample of UK and French firms. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table V.14: Industry-adjusted scope 3 GHG emissions and equity risks (sample without UK &amp; France).

|                | <i>BM GHG scope 3</i> |                          |                      |                      |                      |                      |
|----------------|-----------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
|                | (1)<br>$\sigma$       | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      |
| BM GHG         | -0.001<br>(0.001)     | 0.000<br>(0.001)         | 0.000<br>(0.002)     | -0.004*<br>(0.002)   | 0.002<br>(0.001)     | -0.001<br>(0.002)    |
| Leverage       | 0.470**<br>(0.190)    | 0.450**<br>(0.195)       | 0.493*<br>(0.254)    | 0.674<br>(0.425)     | 0.300<br>(0.190)     | 0.353<br>(0.304)     |
| Sales growth   | -0.229***<br>(0.062)  | -0.195***<br>(0.061)     | -0.361***<br>(0.091) | -0.651***<br>(0.141) | -0.260***<br>(0.057) | -0.408***<br>(0.088) |
| Profitability  | -2.053***<br>(0.345)  | -2.015***<br>(0.348)     | -2.452***<br>(0.469) | -4.278***<br>(0.815) | -1.795***<br>(0.343) | -2.793***<br>(0.561) |
| Dividend yield | -3.219***<br>(0.867)  | -2.873***<br>(0.863)     | -2.104<br>(1.306)    | 1.282<br>(2.291)     | -0.536<br>(0.945)    | 1.160<br>(1.668)     |
| Size           | -0.049<br>(0.056)     | -0.085<br>(0.058)        | 0.115<br>(0.088)     | 0.012<br>(0.136)     | 0.009<br>(0.060)     | -0.061<br>(0.089)    |
| Constant       | 3.019**<br>(1.280)    | 3.454***<br>(1.310)      | 0.344<br>(2.001)     | 3.782<br>(3.086)     | 1.634<br>(1.360)     | 3.720*<br>(2.032)    |
| Firm-year obs. | 3,003                 | 3,003                    | 3,003                | 3,003                | 3,003                | 3,003                |
| Obs.           | 601                   | 601                      | 601                  | 601                  | 601                  | 601                  |
| $R^2$          | 0.592                 | 0.412                    | 0.600                | 0.600                | 0.581                | 0.495                |
| Time FE        | Yes                   | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents the fixed-effects estimation of the relationship between *BM GHG scope 3 emissions* and firms' equity risks for a sample of European companies without UK and French firms. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .



Table V.15: Industry-adjusted scope 3 GHG emissions and equity risks (sample with only UK &amp; France).

|                | <i>BM GHG scope 3</i> |                          |                      |                      |                      |                      |
|----------------|-----------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
|                | (1)<br>$\sigma$       | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      |
| BM GHG         | -0.019<br>(0.033)     | -0.013<br>(0.035)        | 0.002<br>(0.044)     | 0.003<br>(0.057)     | -0.009<br>(0.028)    | -0.012<br>(0.047)    |
| Leverage       | 0.877***<br>(0.324)   | 0.875***<br>(0.325)      | 0.915**<br>(0.387)   | 1.725**<br>(0.696)   | 0.700**<br>(0.294)   | 1.072**<br>(0.465)   |
| Sales growth   | -0.066<br>(0.077)     | -0.049<br>(0.073)        | -0.091<br>(0.110)    | -0.177<br>(0.194)    | -0.064<br>(0.080)    | -0.111<br>(0.143)    |
| Profitability  | -2.561***<br>(0.464)  | -2.532***<br>(0.458)     | -4.073***<br>(0.446) | -7.316***<br>(0.889) | -2.961***<br>(0.374) | -4.592***<br>(0.665) |
| Dividend yield | 0.622<br>(3.101)      | -0.124<br>(2.959)        | 6.392<br>(3.944)     | 7.743<br>(6.847)     | 2.618<br>(2.970)     | 2.929<br>(4.636)     |
| Size           | -0.086<br>(0.070)     | -0.126*<br>(0.064)       | -0.085<br>(0.090)    | -0.132<br>(0.166)    | -0.072<br>(0.072)    | -0.108<br>(0.128)    |
| Constant       | 3.467**<br>(1.592)    | 4.004***<br>(1.454)      | 4.583**<br>(2.058)   | 6.415*<br>(3.753)    | 3.225**<br>(1.609)   | 4.376<br>(2.815)     |
| Firm-year obs. | 2,073                 | 2,073                    | 2,073                | 2,073                | 2,073                | 2,073                |
| Obs.           | 407                   | 407                      | 407                  | 407                  | 407                  | 407                  |
| $R^2$          | 0.574                 | 0.453                    | 0.631                | 0.603                | 0.568                | 0.466                |
| Time FE        | Yes                   | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents the fixed-effects estimation of the relationship between *BM GHG scope 3 emissions* and firms' equity risks for a sample of UK and French firms. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated according to equation V.4. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

## V.6 Comparison of GHG reporters and non-reporters

### V.6.1 Total Sample

Building on the extensive body of research highlighting the risk-mitigating effects of climate-related disclosures (e.g., Clarkson et al., 2013; Aerts et al., 2008; Liesen et al., 2016; Subramaniam et al., 2015; Jung et al., 2018), we examine whether the disclosure of GHG emissions data, as opposed to no disclosure at all, is associated with lower equity risks, as proposed in hypothesis H3.

To test this hypothesis, we construct a new sample consisting of all European firms for which the necessary data to calculate equity risks and control variables are available. We capture the reporting status of the firms via the dummy variable *GHG reporter*. This variable takes the value 1 if the firm discloses at least one of the scope 1 or scope 2 GHG emissions in the respective year, and 0 otherwise.

Table V.16 outlines the industry composition of this larger set of firms, for which we subsequently compare sub-samples of reporting and non-reporting firms. Interestingly, the sub-sample of non-reporting companies consists of a high proportion of companies from the Software & IT services and Pharmaceuticals & Medical research sectors. On the contrary, companies from the Chemical, Insurance and Telecommunication services sectors are represented to a much greater extent in the sub-sample of companies reporting GHG emissions.

Table V.17 displays the descriptive statistics of our variables of interest. The average non-reporting firm displays higher levels of equity risks across all six risk metrics, as illustrated in Panel A. Panel B provides the statistics for the control variables. The average non-reporting firm is significantly less leveraged, shows higher sales growth, is less profitable, pays lower dividends and is smaller in size.

Table V.16: Industry sample composition for GHG reporting and non-reporting firms.

| Industry                                        | GHG reporters |        | Non-GHG reporters |         | Difference non-reporter – reporter |                |
|-------------------------------------------------|---------------|--------|-------------------|---------|------------------------------------|----------------|
|                                                 | N             | %      | N                 | %       | Diff.                              | Standard error |
| Academic & educational services                 | 4             | 0.050% | 34                | 0.173%  | 0.123%**                           | 0.049%         |
| Applied resources                               | 157           | 1.957% | 354               | 1.797%  | -0.160%                            | 0.178%         |
| Automobiles & auto parts                        | 210           | 2.617% | 387               | 1.965%  | -0.653%***                         | 0.192%         |
| Banking & investment services                   | 333           | 4.151% | 945               | 4.797%  | 0.647%**                           | 0.278%         |
| Chemicals                                       | 336           | 4.188% | 422               | 2.142%  | -2.046%***                         | 0.216%         |
| Collective investments                          | 2             | 0.025% | 160               | 0.812%  | 0.787%***                          | 0.101%         |
| Consumer goods conglomerates                    | 47            | 0.586% | 55                | 0.279%  | -0.307%***                         | 0.080%         |
| Cyclical consumer products                      | 413           | 5.148% | 1,055             | 5.356%  | 0.208%                             | 0.297%         |
| Cyclical consumer services                      | 466           | 5.808% | 1,229             | 6.239%  | 0.431%                             | 0.317%         |
| Energy - fossil fuels                           | 452           | 5.634% | 799               | 4.056%  | -1.578%***                         | 0.275%         |
| Financial technology (fintech) & infrastructure | 12            | 0.150% | 48                | 0.244%  | 0.094%                             | 0.062%         |
| Food & beverages                                | 355           | 4.425% | 912               | 4.630%  | 0.205%                             | 0.277%         |
| Food & Drug retailing                           | 147           | 1.832% | 164               | 0.833%  | -1.000%***                         | 0.139%         |
| Healthcare services & equipment                 | 207           | 2.580% | 811               | 4.117%  | 1.537%***                          | 0.249%         |
| Industrial & commercial services                | 747           | 9.311% | 1,600             | 8.123%  | -1.188%***                         | 0.369%         |
| Industrial goods                                | 691           | 8.613% | 1,778             | 9.026%  | 0.414%                             | 0.377%         |
| Insurance                                       | 308           | 3.839% | 246               | 1.249%  | -2.590%***                         | 0.185%         |
| Investment holding companies                    | 29            | 0.361% | 133               | 0.675%  | 0.314%***                          | 0.101%         |
| Mineral resources                               | 391           | 4.873% | 623               | 3.163%  | -1.711%***                         | 0.248%         |
| Personal & household products & services        | 109           | 1.359% | 105               | 0.533%  | -0.826%***                         | 0.116%         |
| Pharmaceuticals & medical research              | 253           | 3.153% | 1,221             | 6.199%  | 3.045%***                          | 0.297%         |
| Real estate                                     | 510           | 6.357% | 1,235             | 6.270%  | -0.087%                            | 0.322%         |
| Renewable energy                                | 41            | 0.511% | 157               | 0.797%  | 0.286%**                           | 0.112%         |
| Retailers                                       | 294           | 3.664% | 523               | 2.655%  | -1.009%***                         | 0.224%         |
| Software & IT services                          | 273           | 3.403% | 2,121             | 10.768% | 7.365%***                          | 0.369%         |
| Technology equipment                            | 251           | 3.129% | 1,101             | 5.589%  | 2.461%***                          | 0.285%         |
| Telecommunications services                     | 292           | 3.640% | 261               | 1.325%  | -2.315%***                         | 0.185%         |
| Transportation                                  | 307           | 3.826% | 614               | 3.117%  | -0.709%***                         | 0.237%         |
| Uranium                                         | -             | 0.000% | 7                 | 0.036%  | 0.036%*                            | 0.021%         |
| Utilities                                       | 386           | 4.811% | 597               | 3.031%  | -1.780***                          | 0.245%         |
| No assigned industry                            | -             | 0.000% | 1                 | 0.005%  | 0.005%                             | 0.008%         |

*Remark:* This table presents the industry composition according to TRBC Business Sector codes for the GHG reporting firms as well as the non-reporting firms of the sample. Additionally, it reports differences between these two categories of firms. These differences are calculated and tested for significance using *t*-tests. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table V.17: Descriptive statistics for reporting and non-reporting firms.

|                                   | GHG reporter |        |           |        |        | Non-GHG reporter |        |           |        |        | Difference non-reporter – reporter |           |
|-----------------------------------|--------------|--------|-----------|--------|--------|------------------|--------|-----------|--------|--------|------------------------------------|-----------|
|                                   | N            | Mean   | Std. dev. | Min.   | Max.   | N                | Mean   | Std. dev. | Min.   | Max.   | Diff.                              | Std. Err. |
| <i>Panel A: Risk measures</i>     |              |        |           |        |        |                  |        |           |        |        |                                    |           |
| $\sigma$                          | 8,023        | 2.007  | 0.875     | 0.816  | 5.404  | 19,698           | 2.403  | 1.215     | 0.662  | 7.902  | 0.396***                           | 0.015     |
| $\sigma_{\epsilon}$               | 8,023        | 1.731  | 0.816     | 0.720  | 5.106  | 19,698           | 2.298  | 1.201     | 0.651  | 7.842  | 0.567***                           | 0.015     |
| VaR                               | 8,023        | 3.115  | 1.295     | 1.190  | 7.822  | 19,698           | 3.561  | 1.626     | 0.649  | 10.070 | 0.446***                           | 0.020     |
| CVaR                              | 8,023        | 4.547  | 2.073     | 1.724  | 12.439 | 19,698           | 5.229  | 2.522     | 1.164  | 15.411 | 0.682***                           | 0.032     |
| LPM(0,2)                          | 8,023        | 2.018  | 0.879     | 0.837  | 5.431  | 19,667           | 2.508  | 1.298     | 0.836  | 8.583  | 0.490***                           | 0.016     |
| LPM(0,3)                          | 8,023        | 2.652  | 1.316     | 1.039  | 8.176  | 19,667           | 3.245  | 1.837     | 1.039  | 12.343 | 0.593***                           | 0.023     |
| <i>Panel B: Control variables</i> |              |        |           |        |        |                  |        |           |        |        |                                    |           |
| Leverage                          | 8,023        | 0.616  | 0.195     | 0.121  | 1.100  | 19,698           | 0.518  | 0.227     | 0.028  | 1.225  | -0.099***                          | 0.003     |
| Sales growth                      | 8,023        | 0.044  | 0.204     | -0.547 | 1.298  | 19,698           | 0.167  | 0.720     | -0.999 | 6.532  | 0.122***                           | 0.008     |
| Profitability                     | 8,023        | 0.071  | 0.078     | -0.199 | 0.365  | 19,698           | 0.023  | 0.175     | -0.950 | 0.365  | -0.048***                          | 0.002     |
| Dividend yield                    | 8,023        | 0.021  | 0.024     | 0.000  | 0.111  | 19,698           | 0.018  | 0.027     | 0.000  | 0.161  | -0.002***                          | 0.000     |
| Size                              | 8,023        | 22.646 | 1.874     | 17.780 | 27.503 | 19,698           | 19.900 | 2.186     | 15.311 | 27.503 | -2.747***                          | 0.028     |

*Remark:* This table presents the descriptive statistics for GHG reporting and non-reporting firms separately. *Panel A* provides descriptive statistics for the equity risk measures, *Panel B* for the greenhouse gas emission variables and *Panel C* for the control variables. Additionally, it reports differences between these two categories of firms. These differences are calculated and tested for significance using *t*-tests. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

In a next step, we run OLS regressions on the combined sample of reporting and non-reporting firms and present the results in Table V.18.<sup>5</sup> The coefficients are significant at the 1% level for all regression specifications and negatively related with equity risks. In particular, the negative coefficients of the dummy variable *GHG reporter* indicate that GHG reporting firms are associated with lower standard equity risks (in columns 1 and 2) and lower downside equity risks (in columns 3 to 6). Overall, investors appear to attribute lower risks to firms that disclose GHG emissions data in line with hypothesis H4. These results are also economically relevant as the disclosure of GHG emissions data is related to a reduction in the volatility of returns ( $\sigma$ ) by 0.102%. The economics size is even slightly larger with regard to the VaR (0.12%) and CVaR (0.132%).

### V.6.2 Matching GHG reporters and non-reporters

The industry breakdown in Table V.16 and the descriptive statistics in Table V.17 reveal differences in characteristics between firms that disclose GHG emissions data and those that do not. These differences raise the possibility that selection bias, rather than investors' varying risk perceptions, could be driving the observed results. To account for structural differences between the two sub-samples, we repeat the analysis on a matched sample.

Specifically, we apply a propensity score nearest neighbor matching approach, following Rosenbaum and Rubin (1983). In this method, each reporting firm is matched with one firm from the (much larger) pool of non-reporting firms. Matching is performed using all firm-level control variables, as well as the corresponding year and industry.<sup>6</sup>

Tables V.19 and V.20 demonstrate the quality of the matching for the industry composition and the descriptive statistics respectively. The matching procedure is able to reduce most differences and to mitigate the potential selection bias between reporting

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<sup>5</sup>We perform OLS regressions due to the binary character of our main explanatory variable (GHG reporter)

<sup>6</sup>First, the matching process utilizes a GHG reporting dummy as dependent variable and hence matches non-reporting firms to reporting firms. We perform the Stata command `ps2match` including the following items: one nearest neighbour is matched, no replacement, caliper of 0.2. The caliper of 0.2 ensures an appropriate level of comparability between the two firms. The applied estimator is a logit regression. We perform the matching separately for every year.

Table V.18: Equity risks of GHG reporters and non-reporters.

|                | (1)<br>$\sigma$      | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      |
|----------------|----------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
| GHG reporter   | -0.102***<br>(0.013) | -0.201***<br>(0.012)     | -0.120***<br>(0.018) | -0.132***<br>(0.028) | -0.094***<br>(0.013) | -0.090***<br>(0.020) |
| Leverage       | 0.274***<br>(0.035)  | 0.258***<br>(0.034)      | 0.388***<br>(0.045)  | 0.624***<br>(0.070)  | 0.266***<br>(0.036)  | 0.362***<br>(0.053)  |
| Sales growth   | 0.085***<br>(0.015)  | 0.085***<br>(0.015)      | 0.072***<br>(0.018)  | 0.078***<br>(0.029)  | 0.034**<br>(0.014)   | 0.034<br>(0.022)     |
| Profitability  | -2.478***<br>(0.061) | -2.436***<br>(0.061)     | -3.232***<br>(0.076) | -5.184***<br>(0.119) | -2.450***<br>(0.062) | -3.444***<br>(0.095) |
| Dividend yield | -4.663***<br>(0.265) | -4.552***<br>(0.267)     | -5.088***<br>(0.361) | -6.594***<br>(0.574) | -3.915***<br>(0.303) | -4.770***<br>(0.437) |
| Size           | -0.087***<br>(0.003) | -0.112***<br>(0.003)     | -0.095***<br>(0.004) | -0.176***<br>(0.006) | -0.126***<br>(0.003) | -0.162***<br>(0.005) |
| Constant       | 4.102***<br>(0.063)  | 4.455***<br>(0.063)      | 5.389***<br>(0.087)  | 8.445***<br>(0.132)  | 4.974***<br>(0.072)  | 6.323***<br>(0.101)  |
| Firm-year obs. | 27,721               | 27,721                   | 27,721               | 27,721               | 27,690               | 27,690               |
| $R^2$          | 0.345                | 0.354                    | 0.329                | 0.359                | 0.344                | 0.310                |
| Time FE        | Yes                  | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents OLS estimations of the relationship between GHG disclosure and equity risks. The variable *GHG reporter* becomes 1, if the firm reports GHG data and 0 if not. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated using OLS. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

and non-reporting firms in the sample. In particular, the differences in industry composition and most control variables disappear almost completely, with smaller differences remaining for leverage ratio and firm size.

Table V.19: Industry sample composition – post matching.

| Industry                               | GHG reporters |         | Non-GHG reporters |        | Difference non-reporter – reporter |                |
|----------------------------------------|---------------|---------|-------------------|--------|------------------------------------|----------------|
|                                        | N             | %       | N                 | %      | Diff.                              | Standard error |
| Academic                               | 2             | 0.039%  | 3                 | 0.058% | 0.019%                             | 0.043%         |
| Applied resources                      | 110           | 2.133%  | 104               | 2.017% | -0.116%                            | 0.281%         |
| Automobiles & auto parts               | 120           | 2.327%  | 114               | 2.211% | -0.116%                            | 0.293%         |
| Banking & investment services          | 213           | 4.131%  | 210               | 4.073% | -0.058%                            | 0.391%         |
| Chemicals                              | 146           | 2.832%  | 176               | 3.413% | 0.582%*                            | 0.343%         |
| Collective investments                 | 2             | 0.039%  | 1                 | 0.019% | -0.019%                            | 0.034%         |
| Consumer goods conglomerates           | 27            | 0.524%  | 33                | 0.640% | 0.116%                             | 0.150%         |
| Cyclical consumer products             | 275           | 5.334%  | 291               | 5.644% | 0.310%                             | 0.449%         |
| Cyclical consumer services             | 334           | 6.478%  | 308               | 5.974% | -0.504%                            | 0.476%         |
| Energy - fossil fuels                  | 285           | 5.528%  | 280               | 5.431% | -0.097%                            | 0.448%         |
| Financial technology (fintech) & infr. | 7             | 0.136%  | 7                 | 0.136% | 0.000%                             | 0.073%         |
| Food & beverages                       | 229           | 4.441%  | 248               | 4.810% | 0.369%                             | 0.414%         |
| Food & drug retailing                  | 80            | 1.552%  | 73                | 1.416% | -0.136%                            | 0.238%         |
| Healthcare services & equipment        | 148           | 2.870%  | 143               | 2.773% | -0.097%                            | 0.326%         |
| Industrial & commercial services       | 516           | 10.008% | 512               | 9.930% | -0.078%                            | 0.590%         |
| Industrial goods                       | 449           | 8.708%  | 452               | 8.766% | 0.058%                             | 0.556%         |
| Insurance                              | 129           | 2.502%  | 156               | 3.026% | 0.524%                             | 0.323%         |
| Investment holding companies           | 13            | 0.252%  | 20                | 0.388% | 0.136%                             | 0.111%         |
| Mineral resources                      | 216           | 4.189%  | 230               | 4.461% | 0.272%                             | 0.401%         |
| Personal & household products & serv.  | 31            | 0.601%  | 36                | 0.698% | 0.097%                             | 0.158%         |
| Pharmaceuticals & medical research     | 156           | 3.026%  | 153               | 2.967% | -0.058%                            | 0.336%         |
| Real estate                            | 397           | 7.700%  | 411               | 7.971% | 0.272%                             | 0.529%         |
| Renewable energy                       | 31            | 0.601%  | 33                | 0.640% | 0.039%                             | 0.155%         |
| Retailers                              | 197           | 3.821%  | 187               | 3.627% | -0.194%                            | 0.373%         |
| Software & IT services                 | 234           | 4.538%  | 191               | 3.704% | -0.834%**                          | 0.391%         |
| Technology equipment                   | 198           | 3.840%  | 173               | 3.355% | -0.485%                            | 0.367%         |
| Telecommunications services            | 112           | 2.172%  | 113               | 2.192% | 0.019%                             | 0.288%         |
| Transportation                         | 213           | 4.131%  | 223               | 4.325% | 0.194%                             | 0.396%         |
| Uranium                                | 0             | 0.000%  | 0                 | 0.000% | 0.000%                             | 0.000%         |
| Utilities                              | 286           | 5.547%  | 275               | 5.334% | -0.213%                            | 0.447%         |

*Remark:* This table presents the industry composition according to TRBC Business Sector codes for the GHG disclosing firms as well as the non-disclosing firms of the sample after the matching procedure as outlined in section V.6.2. Additionally, it reports differences between these two categories of firms. These differences are calculated and tested for significance using  $t$ -tests. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table V.20: Descriptive statistics – post matching.

|                                   | GHG reporter |        |           |        |        | Non-GHG reporter |        |           |        |        | Difference non-reporter – reporter |           |
|-----------------------------------|--------------|--------|-----------|--------|--------|------------------|--------|-----------|--------|--------|------------------------------------|-----------|
|                                   | N            | Mean   | Std. dev. | Min.   | Max.   | N                | Mean   | Std. dev. | Min.   | Max.   | Diff.                              | Std. err. |
| <i>Panel A: Risk measures</i>     |              |        |           |        |        |                  |        |           |        |        |                                    |           |
| $\sigma$                          | 5,156        | 2.081  | 0.901     | 0.816  | 5.404  | 5,156            | 2.196  | 0.984     | 0.662  | 7.902  | 0.115***                           | 0.019     |
| $\sigma_\epsilon$                 | 5,156        | 1.832  | 0.858     | 0.720  | 5.106  | 5,156            | 2.031  | 0.948     | 0.651  | 7.842  | 0.199***                           | 0.018     |
| VaR                               | 5,156        | 3.208  | 1.320     | 1.190  | 7.822  | 5,156            | 3.351  | 1.401     | 0.649  | 10.070 | 0.143***                           | 0.027     |
| CVaR                              | 5,156        | 4.696  | 2.118     | 1.724  | 12.439 | 5,156            | 4.856  | 2.207     | 1.164  | 15.411 | 0.160***                           | 0.043     |
| LPM(0,2)                          | 5,156        | 2.089  | 0.905     | 0.837  | 5.431  | 5,147            | 2.220  | 1.029     | 0.836  | 8.583  | 0.131***                           | 0.019     |
| LPM(0,3)                          | 5,156        | 2.751  | 1.364     | 1.039  | 8.176  | 5,147            | 2.877  | 1.484     | 1.039  | 12.343 | 0.126***                           | 0.028     |
| <i>Panel B: Control variables</i> |              |        |           |        |        |                  |        |           |        |        |                                    |           |
| Leverage                          | 5,156        | 0.587  | 0.193     | 0.121  | 1.100  | 5,156            | 0.597  | 0.209     | 0.028  | 1.225  | 0.010**                            | 0.004     |
| Sales growth                      | 5,156        | 0.055  | 0.212     | -0.547 | 1.298  | 5,156            | 0.050  | 0.236     | -0.999 | 2.902  | -0.005                             | 0.004     |
| Profitability                     | 5,156        | 0.069  | 0.082     | -0.199 | 0.365  | 5,156            | 0.071  | 0.080     | -0.650 | 0.365  | 0.001                              | 0.002     |
| Dividend yield                    | 5,156        | 0.020  | 0.025     | 0.000  | 0.111  | 5,156            | 0.020  | 0.025     | 0.000  | 0.161  | 0.001                              | 0.000     |
| Size                              | 5,156        | 21.772 | 1.450     | 17.780 | 26.752 | 5,156            | 22.085 | 1.944     | 16.075 | 27.503 | 0.313***                           | 0.034     |

*Remark:* This table presents the descriptive statistics for GHG reporting and non-reporting firms separately after the matching procedure as outlined in section V.6.2. *Panel A* provides descriptive statistics for the equity risk measures, *Panel B* for the greenhouse gas emission variables and *Panel C* for the control variables. Additionally, it reports differences between these two categories of firms. These differences are calculated and tested for significance using *t*-tests. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .



In Table V.21 we report the regression results based on the matched sample. As can be seen, the results for the matched sample underline the findings from the OLS regressions in Table V.18. Across all equity risk measures, the GHG reporter dummy remains significantly negative at the 1% level. This indicates that even after matching to balance structural differences between reporting and non-reporting firms, GHG reporting firms continue to exhibit lower equity risks compared to their non-reporting counterparts, supporting hypothesis H4. The results are also economically meaningful. For GHG reporting firms, volatility ( $\sigma$ ) is reduced by 0.14%, while VaR and CVaR are lowered by 0.174% and 0.208%, respectively. Overall, these findings align with Matsumura et al. (2013).

Table V.21: Equity risks of GHG reporters and non-reporters (matched sample).

|                | (1)<br>$\sigma$      | (2)<br>$\sigma_\epsilon$ | (3)<br>VaR           | (4)<br>CVaR          | (5)<br>LPM(0,2)      | (6)<br>LPM(0,3)      |
|----------------|----------------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
| GHG reporter   | -0.141***<br>(0.015) | -0.232***<br>(0.015)     | -0.174***<br>(0.022) | -0.208***<br>(0.034) | -0.156***<br>(0.016) | -0.160***<br>(0.024) |
| Leverage       | 0.451***<br>(0.051)  | 0.430***<br>(0.051)      | 0.611***<br>(0.069)  | 0.953***<br>(0.110)  | 0.402***<br>(0.051)  | 0.571***<br>(0.077)  |
| Sales growth   | -0.110**<br>(0.052)  | -0.080<br>(0.052)        | -0.217***<br>(0.067) | -0.416***<br>(0.108) | -0.156***<br>(0.051) | -0.273***<br>(0.077) |
| Profitability  | -2.437***<br>(0.144) | -2.451***<br>(0.144)     | -3.468***<br>(0.190) | -5.456***<br>(0.311) | -2.476***<br>(0.140) | -3.466***<br>(0.214) |
| Dividend yield | -5.377***<br>(0.401) | -5.389***<br>(0.408)     | -6.292***<br>(0.579) | -8.604***<br>(0.903) | -4.331***<br>(0.425) | -5.698***<br>(0.613) |
| Size           | -0.075***<br>(0.006) | -0.098***<br>(0.006)     | -0.093***<br>(0.008) | -0.148***<br>(0.013) | -0.078***<br>(0.006) | -0.106***<br>(0.009) |
| Constant       | 3.805***<br>(0.136)  | 4.072***<br>(0.136)      | 5.353***<br>(0.192)  | 7.756***<br>(0.297)  | 3.846***<br>(0.140)  | 4.974***<br>(0.204)  |
| Firm-year obs. | 10,312               | 10,312                   | 10,312               | 10,312               | 10,303               | 10,303               |
| $R^2$          | 0.328                | 0.296                    | 0.337                | 0.359                | 0.320                | 0.288                |
| Time FE        | Yes                  | Yes                      | Yes                  | Yes                  | Yes                  | Yes                  |

*Remark:* This table presents OLS estimations of the relationship between disclosing GHG emission and firms' equity risks for a matched sample. The variable *GHG reporter* becomes 1 if the firm reports GHG data, and 0 if not. The dependent variables are the stock volatility  $\sigma$  in model (1), idiosyncratic risk  $\sigma_\epsilon$  in model (2), *VaR* in model (3), *CVaR* in model (4) as well as the second and third order lower partial moments *LPM(0,2)* in model (5) and *LPM(0,3)* in model (6). Regressions are estimated using OLS. Standard errors are robust and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

## V.7 Discussion and conclusion

This paper examines the relationship between GHG emissions and firm equity risks for a broad sample of European companies between 2010 and 2020. In the first part of the paper, we show that scope 1 and scope 2 GHG emissions are positively associated with firm equity risks, whereas scope 3 emissions do not show a significant relationship. In the second part, we find that mandatory regulatory frameworks for GHG disclosure have a risk-mitigating effect, and overall, that firms that disclose GHG emissions are associated with lower equity risks compared to those that do not disclose such information.

Regarding the first part of the findings, scope 1 emissions, being direct emissions from a firm’s controlled sources, may be considered as particularly relevant by investors, as they reflect management’s ability to address direct operational challenges. In addition, scope 2 emissions may also be particularly relevant as they offer insights into the firm’s vulnerability to external energy-related risks. In contrast, scope 3 emissions may not be perceived as risk-relevant due to the challenges in terms of measurement and control, as most scope 3 activities occur outside the firm’s direct operations (Depoers et al., 2014; Bolton and Kacperczyk, 2021).

The second part of the findings add novel perspectives to the literature on CSR disclosure and its effects on equity risks (Clarkson et al., 2013; Dhaliwal et al., 2014; Liesen et al., 2016; Matsumura et al., 2013; Jouvenot and Krueger, 2019; Mittelbach-Hörmanseder et al., 2020). As Matsumura et al. (2013) put it, “the markets penalize all firms for their carbon emissions, but a further penalty is imposed on firms that do not disclose emissions information” (pp. 695–696, Matsumura et al. 2013). Our findings align with this perspective, offering additional empirical support. They demonstrate that investors incorporate GHG emissions into their equity risk assessments and value transparency.

This study does have limitations that warrant consideration. First, self-selection bias may affect the results, as a firm’s decision to disclose GHG data is unlikely to be entirely random. However, this concern is mitigated by the fact that nearly half of the sample comprises firms headquartered in countries with mandatory reporting require-

ments. Second, like many CSR studies, this analysis may be subject to endogeneity, making it difficult to establish causality. Even though almost half of our sample discloses GHG data due to mandatory reporting regime, the study remains associative, and reverse causality cannot be ruled out. It is therefore possible that corporate financial performance and GHG performance are mutually reinforcing, as noted in previous research (e.g., Mittelbach-Hörmanseder et al., 2020).

Despite these limitations, the findings have important implications for firms, regulators, and investors. They underscore the importance of GHG reporting and the need for policymakers to incentivize reliable disclosures. For investors, the results show that GHG emissions offer valuable insights for portfolio decisions and risk assessments. Future research could delve deeper into the risk implications of scope 3 GHG emissions disclosures, given that they constitute the largest portion of emissions for most industries.

# Chapter VI

## Evaluating TCFD reporting – A new application of zero-shot analysis to climate-related financial disclosures

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# Evaluating TCFD reporting – A new application of zero-shot analysis to climate-related financial disclosures

## Abstract

We examine climate-related disclosures in a large sample of reports published by banks that officially endorsed the recommendations of the Task Force for Climate-related Financial Disclosures (TCFD). In doing so, we introduce a new application of the zero-shot text classification. By developing a set of fine-grained TCFD labels, we show that zero-shot analysis is a useful tool for classifying climate-related disclosures without further model training. Overall, our findings indicate that corporate climate-related disclosures increased after the launch of the TCFD recommendations and following individual endorsements. However, there are marked differences in the extent of reporting by recommended disclosure topic, suggesting that some recommendations have not yet been fully met. Our findings yield important conclusions for the design of climate-related disclosure frameworks.

**JEL Classification:** G21, Q56, M48

**Keywords:** TCFD, climate-related disclosures, natural language processing

## VI.1 Introduction

Published in 2017, the recommendations of the Financial Stability Board’s Task Force on Climate-related Financial Disclosures (TCFD) have been described by the UK Government as “one of the most effective frameworks for companies to analyse, understand and ultimately disclose climate-related financial information” (p. 6, Department for Business, Energy & Industrial Strategy 2021).

The TCFD recommendations, which have been formally endorsed by more than 4,000 companies worldwide to date, are a set of voluntary disclosure guidelines aimed at providing consistent climate-related information to investors and other key company stakeholders (Friederich et al., 2021). Compared to other reporting frameworks (e.g., Carbon Disclosure Project, Global Reporting Initiative), a particular focus of the TCFD recommendations is on disclosing information about the integration of climate-related considerations into risk management, control structures and strategic aspects of business operations (TCFD, 2017a,b). Overall, the recommendations are organized into four primary disclosure categories (Governance, Strategy, Risk Management, Metrics and Targets) and eleven corresponding recommended disclosures associated with each category (TCFD, 2017a). For an overview of the TCFD recommendations, see Table VI.1.

Since reliable information on climate-related exposure is critical for making informed investment decisions and appropriately pricing risks, an increasing number of investors have been exerting pressure on companies to issue reports that include comprehensive climate-related disclosures (Krueger et al., 2020). In addition, several countries, including the UK and Switzerland, have taken steps to make TCFD reporting mandatory for large companies in their jurisdictions. From a company perspective, the disclosure of climate-related information often signals awareness and preparedness for climate-related issues, while the absence of disclosure may, on the contrary, indicate that such issues are not being sufficiently addressed by the company (Sullivan and Gouldson, 2012; Bingle et al., 2022). Illustrating these arguments, Jung et al. (2018) and Subramaniam et al. (2015) show that firms are more likely to integrate risks associated with climate

Table VI.1: The TCFD disclosure categories and underlying recommended disclosures.

| <b>Broad disclosure categories</b>        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Governance</b>                         | Disclose the organization's governance around climate-related risks and opportunities.                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Strategy</b>                           | Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.                                                                                                                                                                                                                                                                                                           |
| <b>Risk management</b>                    | Disclose how the organization identifies, assesses, and manages climate-related risks.                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Metrics and targets</b>                | Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.                                                                                                                                                                                                                                                                                                                                                       |
| <b>Underlying recommended disclosures</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Governance</b>                         | <ul style="list-style-type: none"> <li>a) Describe the board's oversight of climate-related risks and opportunities.</li> <li>b) Describe management's role in assessing and managing climate-related risks and opportunities.</li> </ul>                                                                                                                                                                                                                                                             |
| <b>Strategy</b>                           | <ul style="list-style-type: none"> <li>a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.</li> <li>b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.</li> <li>c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.</li> </ul> |
| <b>Risk management</b>                    | <ul style="list-style-type: none"> <li>a) Describe the organization's processes for identifying and assessing climate-related risks.</li> <li>b) Describe the organization's processes for managing climate-related risks.</li> <li>c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.</li> </ul>                                                                                               |
| <b>Metrics and targets</b>                | <ul style="list-style-type: none"> <li>a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.</li> <li>b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.</li> <li>c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.</li> </ul>                   |

Source: TCFD (2017a)



change into their overall risk management when such firms also disclose climate-related information.

Against this background, it is surprising to find that research on climate-related disclosures remains sparse. More importantly, prior studies on the TCFD recommendations mostly focus on the quantity of information disclosed at the aggregate TCFD category level, and have left an analysis of the reported content within each category largely untouched. A more in-depth analysis within each of the four TCFD pillars is essential, as the quality and financial materiality of the disclosed information may vary depending on the industry (Friederich et al., 2021). For example, Bingler et al. (2022) investigate climate-related disclosures based on the four core TCFD disclosure categories from 2015 to 2020. Their findings reveal that firms selectively disclose climate-related information, mainly concentrating on Governance and Risk Management, which the authors regard as the least material categories. Similarly, Ding et al. (2023) analyze how carbon emissions affect voluntary climate-related disclosures at the TCFD category level. Their results show that firms with higher levels of carbon emissions disclose more climate-related information. Specifically, they report a positive relationship between carbon emissions and disclosures at the category level for strategy, risk management and metrics and targets. Finally, Friederich et al. (2021) analyze the types of climate risks (physical or transition) reported in corporate annual reports. Their study provides evidence that disclosures related to transition risks have experienced a more pronounced increase compared to disclosures concerning physical risks, which are still lagging behind. While the authors take a more granular approach with regard to the materiality of climate-related disclosures, their findings do not encompass all the recommended TCFD disclosures, as climate risks make up only a small portion of the multifaceted issues to be addressed in TCFD reporting.

A shared characteristic of these studies is to rely on computerized textual analysis techniques, such as natural language processing (NLP), for the evaluation of climate-related disclosures. An important contribution in this regard is the work by Bingler et al. (2022), who introduced “ClimateBERT”, a BERT model specifically fine-tuned to identify climate-related information within company disclosures based on the broad

TCFD categories. Similarly, Friederich et al. (2021) employ multiple pretrained BERT-related models, including DistilBERT and RoBERTa, to examine references to climate risks in company reports. Overall, these studies present mixed results regarding the effectiveness of climate-related disclosures in delivering high-quality and material information, primarily due to challenges such as greenwashing, a lack of transparency, and insufficient availability of quantitative data (Mehra et al., 2022).

Motivated by the importance of a detailed and comprehensive analysis of climate-related disclosures not only at the broad TCFD category level, but also within each individual category, we contribute to the literature in two ways. First, we provide novel insights into the state of disclosures related to the TCFD recommendations by examining a sample of 3,335 reports published by TCFD-supporting banks between 2010 and 2021. Our focus on the banking industry is due to two key factors. On the one hand, it aligns with the fact that the TCFD recommendations primarily target financial institutions (TCFD, 2017b). On the other hand, it acknowledges the varying materiality of sustainability-related information across different industries. Within the financial sector, the identification and reporting of carbon-related asset concentrations hold particular importance due to the impact of climate change on credit risk and the potential risks associated with stranded assets (Beyene et al., 2021; FSB, 2015). Thus, we build a sample of TCFD-supporting banks by retrieving all banks that have publicly declared their support to TCFD and are listed as official supporters on TCFD’s website. To leverage information on the TCFD recommendations beyond the four core disclosure categories, we develop a set of 14 fine-grained labels that are designed to capture the most central aspects of the TCFD recommendations for banks using similar semantics.

Second, we contribute to the literature on the use of NLP in the context of climate-related financial disclosures by introducing the zero-shot text classification as a new method for systematic and automated extraction of textual information from large amounts of reports including climate-related data. The zero-shot approach offers a critical advantage over other language models as it allows for sentence classification based on labels for which it has received no specific prior training. Our model relies on a multi-label approach and assigns probabilities (ranging from 0 to 100%) to each

extracted text sequence in our sample of 3,335 reports. These probabilities represent the likelihood that a given text sequence aligns with a specific label. A higher probability suggests that the semantics of a text sequence match the semantics of the corresponding label, indicating that the sequence addresses the topic specified by the label. Thus, when a text sequence explicitly and precisely discusses a topic related to a label, it receives a higher label probability through the zero-shot text classification. In our analyses, we interpret higher label probabilities as proxies of disclosure quality. Furthermore, a higher label probability can also serve as an indication of the extent of disclosure on a particular topic, as a more detailed coverage of the topic is likely to result in a higher probability. As our method does not require any labeled training data, it also does not impose any restrictions on the number of labels (or classes), which allows us to perform a more detailed analysis of the underlying TCFD recommended disclosures. Additionally, the TCFD recommendations are well-suited for the zero-shot analysis, as they provide us with an already-existing framework and semantics (Ding et al., 2023).

In contrast, a weakness of ClimateBERT (Webersinke et al., 2021) and, more generally, of algorithms trained to identify and classify climate-related content, is that such models require an extensive training set of human-labeled sentences. Manual labeling of sentences is not only time-consuming, but can also be error-prone. Therefore, for quality and consistency reasons, highly-trained and specialized “labelers” are required, which can also make the labeling process costly. Furthermore, the more classes (or categories of labels) to be included into the classification scheme of the model, the more labeled data is needed to ensure that each class comes with a reasonable amount of examples attached to it, which can be a limiting factor in some scenarios.

Our paper yields the following sets of findings. First, we investigate the level of disclosure within our sample of TCFD-supporting banks at the broad category level. Specifically, we develop two different types of labels: “general labels” that cover topics that are not specifically related to climate, as well as “climate-related labels” that correspond to the broad TCFD categories (i.e., climate-related governance, climate-related strategy, climate-related risk management and climate-related metrics and targets). We find that the mean probabilities relating to the general labels remain stable over the

period from 2010 to 2021, while we observe an increase in all of the probabilities for the climate-related labels at category level over the same time period. In particular, we report that the disclosures related to “climate-related strategy” and “climate-related metrics and targets” grew particularly dynamically, reaching mean probabilities of up to 22% and 20% respectively in 2021, compared to 12% in 2010. Overall, this suggests an increased attention and priority given to the development of climate-related business strategies with corresponding targets among TCFD-supporting banks.

As a next step, we analyze the mean probabilities associated with our fine-grained labels, which cover the underlying recommended disclosures. This approach enables us to provide a more nuanced assessment of reporting quality beyond each broad TCFD category. Our results indicate substantial variation and notable gaps in reporting. In the strategy area, which is the most comprehensive category and contains several specific recommended disclosures for banks, we find that label probabilities are particularly low for disclosures related to financing and investment activities for carbon-intensive industries such as the fossil fuel industry. Similarly, in comparison to other strategy-related topics, TCFD-supporting banks exhibit a reduced likelihood of explicitly addressing the use of climate-related scenario models in their reporting. Under metrics and targets, we find that the incorporation of climate-related performance metrics into remuneration policies is associated with a lower label probability compared to labels related to carbon footprints and emissions reduction targets. In the governance area, TCFD-supporting banks demonstrate comparable levels of disclosure regarding the board’s responsibility in overseeing climate-related issues and the management’s role in assessing and managing such matters.

Third, as joining TCFD necessitates internal capacity and preparation (e.g., due to data collection), not all of the banks joined directly in 2017. We follow the approach in (Bingler et al., 2022) and investigate whether climate-related disclosures increased after the official launch of the TCFD recommendations in 2017 and after banks individually endorsed the TCFD recommendations. Overall, we find that the individual support of the TCFD recommendations goes along with an increase in climate-related reporting, which is statistically significant but economically modest. In terms of magnitude, we

find a total average increase of 2.72 percentage points across all labels, which is in line with Bingler et al. (2022) who report an increase of approximately 2.2 percentage points. Examining the disclosures of the banks that became supporters after the official TCFD launch, the most notable differences are observed in the Metrics and Targets category, and pertain to carbon footprints as well as emissions reduction targets. Consequently, our results indicate that TCFD-supporting banks enhance their level of disclosures relating to carbon emissions following their official TCFD endorsement, which is consistent with the findings of Ding et al. (2023).

Altogether our findings are robust to various labels evaluation tests. We also examine whether our results are consistent with existing literature on the relationship between company size and CSR activities (e.g., Gillan et al., 2021). In line with our expectations, we report that larger banks exhibit higher disclosure probabilities compared to medium or small banks.

The remainder of this paper is organized as follows. First, we present our data, followed by our methods and model performance evaluation. Our results section is twofold. In the first part, we present the results of the zero-shot classification at the category level. In the second part, we analyze the results for the fine-grained labels covering the TCFD recommended disclosures. The results are summarized and discussed in the last section.

## VI.2 Data

We apply the zero-shot classification to a sample of 3,335 hand-collected reports between 2010 and 2021. Due to the large differences between the homepages of the TCFD-supporting banks in our sample, a fully automated scraping approach is not possible. As a preliminary step, we extract the names of the TCFD-supporting banks from TCFD’s website, based on the industry categories “banks”, “central banks” and “capital markets”. After eliminating banks that could not be identified or lacked online annual reports, we are left with 188 TCFD-supporting banks. Table VI.2 presents the bank level data.

Table VI.2: Size and region of TCFD-supporting banks.

| Region               | Large | Medium | Small | $\Sigma$ |
|----------------------|-------|--------|-------|----------|
| Asia Pacific         | 15    | 51     | 24    | 90       |
| Europe               | 23    | 26     | 17    | 66       |
| Latin America        | 0     | 4      | 3     | 7        |
| Middle East & Africa | 0     | 3      | 2     | 5        |
| North America        | 9     | 8      | 3     | 20       |
| $\Sigma$             | 47    | 92     | 49    | 188      |

*Remark:* This table presents the distribution of TCFD-supporting banks in our sample, categorized by their region of headquarters and the size of their total assets.

As a subsequent step, we proceed to categorize the banks in our sample based on two criteria: the region where their headquarters are located and their total asset size. In our analysis, we designate banks with total assets exceeding USD 500 billion as “large”, those with total assets ranging between USD 50 billion and USD 500 billion as “medium”, and banks with less than USD 50 billion as “small”. Interestingly, nearly half of our sample comprises banks from the Asia-Pacific region. European banks constitute around one-third of the sample, while North American banks represent approximately 10%. In terms of asset size, the majority of banks fall into the mid-sized category, with total assets ranging between USD 50 billion and USD 500 billion.

Next, we follow the approach in Bingler et al. (2022) and collect available bank reports for the period 2010 to 2021 to capture textual data both before and after the publication of the TCFD recommendations in June 2017. The reports are classified according to the following categories: annual reports, CDP reports, corporate governance reports, integrated reports, remuneration reports, sustainability reports, and TCFD reports. Our analysis extends beyond relying solely on TCFD reports since most TCFD supporters do not publish standalone reports specifically dedicated to climate-related disclosures but rather integrate key information into their annual and sustainability reports. This aligns with the TCFD recommendations, which indicate that climate-related disclosures should be included in “mainstream (i.e., public) annual financial

Table VI.3: Sample composition.

| Report category             | Number of reports | Average pages     | Average number of sentences |
|-----------------------------|-------------------|-------------------|-----------------------------|
| Annual Report               | 1,869             | 207.98            | 2,711.21                    |
| CDP Report                  | 75                | 63.43             | 699.79                      |
| Corporate Governance Report | 148               | 69.44             | 1,014.25                    |
| Integrated Report           | 183               | 163.98            | 2,354.95                    |
| Remuneration Report         | 83                | 36.88             | 494.42                      |
| Sustainability Report       | 896               | 81.01             | 1,158.54                    |
| TCFD Report                 | 81                | 36.68             | 544.37                      |
| <hr/>                       |                   |                   |                             |
|                             | $\sum = 3,335$    | $\bar{x} = 94.20$ | $\bar{x} = 1,282.50$        |

*Remark:* This table describes the composition of the final sample used for zero-shot classification, comprising a total of 3,335 reports across various report types.

filings” (TCFD, 2017b). The majority of reports in our sample consists of annual and sustainability reports.

After parsing the reports to ensure they are in a suitable raw text format for the zero-shot classification, we are left with a total sample of 3,335 bank reports, as illustrated in Table VI.3. In comparison to prior TCFD-related studies, the zero-shot allows us to examine a comparatively large sample of reports. As a comparison, Ding et al. (2023) apply computerized textual analysis to a sample of 140 reports from TCFD signatories, while Demaria and Rigot (2021) examine the reference documents of a sample of 40 French firms between 2015 and 2018.

## VI.3 Methodology

### VI.3.1 Parsing PDFs

The reports utilized in our study are in PDF format. Extracting and converting textual information from PDF documents for subsequent analysis using NLP techniques is not as straightforward as working with text stored in CSV or TXT files. To address this

challenge, we employ a layout-parsing model designed to detect and extract the actual text from PDF documents. In particular, we include the actual text from the reports and deliberately omit text from tables and graphs, which not only increases the quality of our data, but also saves computation time.

Our parsing model is based on Visual-Layout (VILA) groups introduced by Shen et al. (Shen et al., 2022). VILA converts textual data into groups of tokens (text lines or blocks) and assigns a layout tag to these tokens. There are several variants of VILA, such as H-VILA (Visual Layout-guided Hierarchical Model) and I-VILA (Injecting Visual Layout Indicators). After conducting several trials, we select the H-VILA block variant trained on grotoap2 using the layoutLM model (Xu et al., 2020) as it delivers the best extraction and tokenization results. The output consists of the extracted text as groups of tokens together with the corresponding layout tags. Depending on the training set, the layout tags can be figures, body content, abstract and title. For our analysis, we keep the parts tagged as body content and abstract. In order to further improve our extraction results, we take further cleaning steps, which are summarized in Table VI.4.

### VI.3.2 Zero-shot text classification

A widely used and important NLP task is text classification (Belinkov and Glass, 2019). Text classification is used to organize and analyze very large amounts of textual data by assigning classes, or so-called “labels”, based on the topic of individual text sequences, which can consist of sentences, paragraphs, or entire pages. In general, text classification is carried out using neural network models, which can be as simple as basic neural networks or more sophisticated language models equipped with classification end-layers. These models (e.g., BERT or BART) undergo pre-training on extensive text data to acquire semantic understanding (Mehra et al., 2022). These pretrained models can subsequently be employed for various NLP tasks and fine-tuned for a specific task. The fine-tuning process involves combining different combinations of pre-trained language models (i.e., the base model) with task-specific end-layers.

Fine-tuning a base model can be accomplished by training it with labeled training



Table VI.4: Cleaning steps of parsed raw texts.

| <b>Problem</b>                                                                                                                                                     | <b>Fix</b>                                                                                        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Extra whitespaces                                                                                                                                                  | Replace extra whitespaces by single whitespace                                                    |
| Words separated by hyphen                                                                                                                                          | Remove hyphen                                                                                     |
| Words separated by whitespace                                                                                                                                      | Remove whitespace                                                                                 |
| Model parsed some ff, fi and if characters as one special character                                                                                                | Replace special double characters by normal characters                                            |
| Whitespaces between word in sentence and punctuation                                                                                                               | Remove whitespace                                                                                 |
| URLs in text which do not have any semantic meaning                                                                                                                | Remove all URLs from text                                                                         |
| Parsed some sentences character by character with whitespace between them, i.e., S E N T E N C E instead of Sentence. Problem mostly occurred with figure subtexts | As most figure subtexts do not have important semantic meaning, we removed such single characters |

*Remark:* This table outlines the text cleaning steps applied to the raw parsed outputs from our H-VILA-based parsing model.

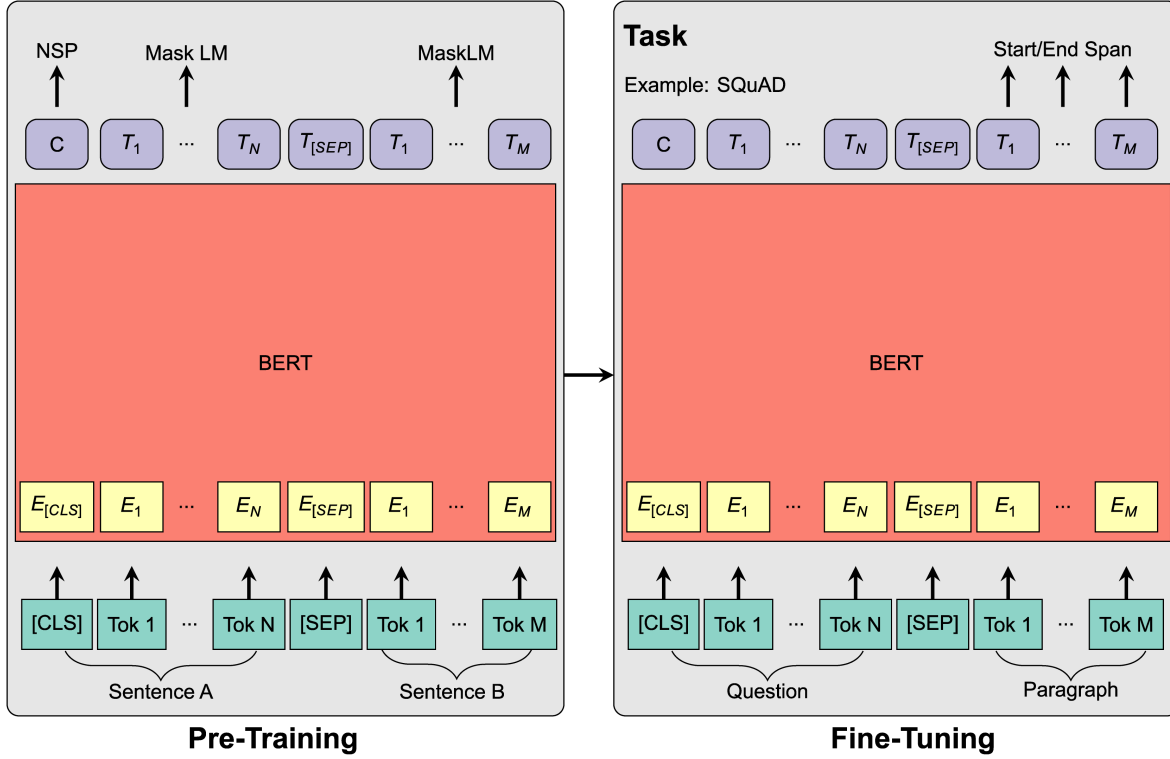
data. As a result, the accuracy of the model often relies on the size and quality of the training data. However, creating a training set for sentence classification presents several drawbacks: First, the process of manually labeling large amounts of text is extremely time-consuming and requires significant human resources. Second, the labeling process must be repeated when classes need to be changed or new labels need to be added. Third, assigning the correct label to a sentence can be challenging even for humans, as certain sentences can be interpreted in different ways. Another drawback is the potential bias introduced by human labelers, making it difficult to obtain a representative training set (Beltagy et al., 2019). Lastly, finding suitable training data poses a challenge since the training data cannot be the same as the data used for actual analysis. For instance, in the analysis of TCFD reports, the labeled reports used for model training cannot be reused. Moreover, due to the limited number of TCFD

reports published by banks and the imperfect nature of TCFD reporting by companies, there is a limitation in acquiring high-quality training data.

In this paper, we address the aforementioned drawbacks by employing a zero-shot text classification model introduced by Davison (2020). The model is able to classify text sequences based on the semantics of the input sequences and the labels without further requiring additional training. A simplified structure of our model architecture is shown in Fig VI.1. To perform the zero-shot classification, we employ BART as a base model. The model has been pre-trained on approximately 160GB of text from the English Wikipedia and BookCorpus dataset to develop an understanding of textual semantics (Mehra et al., 2022). Given that the TCFD recommendations do not specifically focus on financial language but rather general semantics, we consider BART to be well-suited for our analysis. Additionally, since the reports in our sample are in English, we can leverage the fact that the model was pre-trained on a large English language corpus. Compared to other models like BERT, the BART model (Lewis, 2019) utilizes a sequence-to-sequence translation architecture with bidirectional encoders (BERT) and a left-to-right autoregressive decoder (GPT model), combining the strengths of both. When used as a base model in conjunction with zero-shot text classification, BART demonstrates good performance results (Davison, 2020).

For our zero-shot classification, we employ a specific NLP task known as multi-natural language inference (MNLI) (Davison, 2020). This approach embeds both the sentences of a text (sequence of words) and the labels themselves into a shared latent space. In this latent space, the proximity between the sentence and the label can be computed, indicating the probability of a match. The closer the label is to the sentence, the higher the probability that the label matches the sentence. In the context of zero-shot text classification, labels are therefore used to assess the probability that a text sequence addresses one (or more) labeled topics. While the zero-shot text classification yields probabilities from 0 to 100% for each label, the ClimateBERT model used in Bingler et al. (2022) does not yield probabilities as output. Instead, it produces a binary output where one label is considered true and all others are false. For example, the classification output of one governance-related paragraph could be 1 for the label

Figure VI.1: Model architecture overview.



*Remark:* On the left hand side, the BERT model is pre-trained on all English Wikipedia articles and the BooksCorpus dataset. By masking parts of sentences ([MASK]), the model is trained to learn the semantics and to predict the missing parts. The process is repeated for all sentences in the pre-training dataset. On the right hand side, the model is fine-tuned on the MNLI task and returns probabilities for entailment, contradiction and neutral, as shown on the left hand side. Source: Own representation.

governance, and 0 for all other labels, i.e., 0 for strategy, 0 for risk Management etc. Compared to our approach, the authors measure the proportion of TCFD-related content in corporate reports by summing up the results for all labels and putting them in relation to the number of paragraphs (Bingler et al., 2022).

In contrast, our text classification model treats text sequences as premises and labels as hypotheses. It tokenizes both the sentence and the label, leveraging the underlying language to embed them. These embedded representations are then processed through the pre-trained MNLI layer. The MNLI end-layer consists of a simple fully-connected neural network that produces a vector of logit scores for three possible outcomes: “neutral”, “contradiction” and “entailment” (Davison, 2020; Lewis, 2019). Consequently, the hypothesis is evaluated against the premise, resulting in a classification of entailment,

contradiction, or neutrality. The score for “neutral” is discarded and a softmax function is applied to the “contradiction” and “entailment” scores in order to be able to interpret them as a probability on a scale from 0 to 100%. In our analyses, the scores shown are for the “entailment” only. They can be interpreted as the probability that a text sequence matches a given label, or in other words, the probability that the given label is true. This fine-tuned end-layer can subsequently be used for zero-shot classification without any additional training.

Finally, due to the interconnected nature of the TCFD recommendations and the possibility for a sentence to align with multiple recommended disclosures simultaneously, we adopt a multi-label approach. Consequently, we do not constrain the zero-shot text classification to return probabilities that sum up to one, as in the single-label approach. Instead, we employ an approach where the model can assign probabilities ranging from 0 to 1 for each label (multi-label approach), accounting for the potential overlap between a sentence and multiple labels. As a result, the probabilities assigned to all labels for each sentence do not necessarily add up to one.

### VI.3.3 Fine-grained TCFD labels

The TCFD has structured its recommendations along four core disclosure categories: Governance, Strategy, Risk Management, Metrics and Targets (see Table VI.1). Each category comprises two to three recommended disclosures, accompanied by detailed descriptions specifying the information to be included. Recognizing the varying materiality of information across industries, the TCFD has also developed additional guidance tailored to the financial sector, including banks, insurance companies, asset managers, and asset owners (TCFD, 2017b). In its guidance for banks, the TCFD emphasizes that climate-related disclosures from credit institutions should facilitate the identification of large concentrations of carbon-related assets and provide a better understanding of the financial system’s exposure to climate-related risks (TCFD, 2017b).

We proceed by creating a set of general labels covering each main category: **GO.1** *Climate-related Governance*, **ST.1** *Climate-related Strategy*, **RM.1** *Climate-related Risk Management*, **MT.1** *Climate-related Metrics and Targets*. The inclusion of “climate-

related” ensures that the zero-shot classification primarily captures sentences addressing climate-related topics. For a comprehensive overview of our fine-grained labels, please refer to Table VI.5. Next, we develop a set of targeted labels based on the recommended disclosures, their description, and the additional guidance provided for the financial sector. Under the governance pillar, we summarize the recommended disclosures, “describe the board’s oversight of climate-related risks and opportunities” and “describe management’s role in assessing and managing climate-related risks and opportunities” into two labels: **GO.1.1** *Board’s responsibility for overseeing climate-related issues* and **GO.1.2** *Executive management’s role related to the assessment and management of climate-related issues*. We include the terms “executive” and “strategic role” to highlight that these recommendations refer to the assignment of strategic responsibilities at executive management level. In addition, the TCFD often uses the expression “climate-related issues” to refer to climate-related risks and opportunities. Hence, we incorporate this expression in our labels.

In the strategy area, we employ the labels **ST.1.1** *Climate-related transition risks such as policy, legal, technology, market and reputation risks emerging from climate change* and **ST.1.2** *Climate-related physical risks such as acute weather events and chronic shifts in weather patterns* to capture the recommended disclosure that states to “describe the climate-related risks and opportunities the organization has identified over the short, medium, and long-term”. Since the TCFD specifically recommends discussing examples of transition and physical risks, we distinguish between the two types of risks in our labels. Next, we turn to the second recommended disclosure in the strategy area, which is “describe the impact of climate-related risks and opportunities on the organization’s businesses, strategy, and financial planning”. Given that issues related to “businesses, strategy, and financial planning” are particularly difficult to summarize into one label, we rather focus on the first part related to the financial impact. We aim to capture whether financial institutions perceive climate change as having a significant financial impact on their operations. Based on this, we develop the label **ST.1.3** *Material financial impact of climate-related issues*. In addition, the TCFD encourages the description of climate-related scenarios if such scenarios are used

Table VI.5: Overview of TCFD labels.

|                   |        |                                                                                                                                      |
|-------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------|
| Governance        | GO.1.  | Climate-related governance                                                                                                           |
|                   | GO.1.1 | Board's responsibility for overseeing climate-related issues                                                                         |
|                   | GO.1.2 | Executive management's strategic role related to the assessment and management of climate-related issues                             |
| Strategy          | ST.1.  | Climate-related strategy                                                                                                             |
|                   | ST.1.1 | Climate-related transition risks such as policy, legal, technology, market and reputation risks emerging from climate change         |
|                   | ST.1.2 | Climate-related physical risks such as acute weather events and chronic shifts in weather patterns                                   |
|                   | ST.1.3 | Material financial impact of climate-related issues                                                                                  |
|                   | ST.1.4 | Credit exposure to carbon-related assets                                                                                             |
|                   | ST.1.5 | Financing and investment for carbon-intensive industries such as fossil fuel industry                                                |
|                   | ST.1.6 | Use of climate-related scenario models to analyse the impact of climate-related risks                                                |
|                   | ST.1.7 | Resilience of the bank's strategy under different climate-related scenarios                                                          |
| Risk Management   | RM.1.  | Climate-related risk management                                                                                                      |
|                   | RM.1.1 | Processes to identify, assess and manage climate-related risks and integrate them into overall risk management                       |
|                   | RM.1.2 | Relationship between climate-related risks and financial risks such as credit risk, market risk, liquidity risk and operational risk |
| Metrics & Targets | MT.1.  | Climate-related metrics and targets                                                                                                  |
|                   | MT.1.1 | Carbon footprint, direct and indirect greenhouse gas emissions                                                                       |
|                   | MT.1.2 | Incorporation of climate-related performance metrics into remuneration policies                                                      |
|                   | MT.1.3 | Emissions reduction and carbon neutrality targets                                                                                    |

*Remark:* This table provides an overview of the fine-grained labels created for classifying climate-related disclosures in accordance with the TCFD's core pillars: Governance, Strategy, Risk Management, and Metrics and Targets. The labels are derived from TCFD (2017b).

(TCFD, 2017b). Therefore, we create the label **ST.1.6** *Use of climate-related scenario models to analyze the impact of climate-related risks* to assess whether the banks in our sample conduct such analyses and disclose related information.

Additionally, the TCFD recommends banks to describe significant concentrations of credit exposure to carbon-related assets. This recommendation overlaps with a similar recommended disclosure in the metrics and targets category, which requires banks to “provide the amount and percentage of carbon-related assets relative to total assets as well as the amount of lending and other financing connected with climate-related opportunities”. Considering these recommendations, we create the labels **ST.1.4** *Credit exposure to carbon-related assets* and **ST.1.5** *Financing and investment for carbon-intensive industries such as fossil fuel industry*. Finally, we turn to the last recommended disclosure under the strategy category, “describe the resilience of the organization’s strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario” and add the label **ST.1.7** *Resilience of the bank’s strategy under different climate-related scenarios*.

Within the risk management pillar, the TCFD advises to “describe the organization’s processes for identifying and assessing climate-related risks”, to “describe processes for managing climate-related risks”, and to “describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization’s overall risk management”. Using the label **RM.1.1** *Processes to identify, assess and manage climate-related risks and integrate them into overall risk management*, we combine the above recommended disclosures into one label. With respect to the additional guidance for banks, the TCFD advises to consider characterizing climate-related risks in the context of traditional banking industry risk categories such as credit risk, market risk, liquidity risks and operational risks. We therefore add the label **RM.1.2** *Relationship between climate-related risks and financial risks such as credit risk, market risk, liquidity risk and operational risk*.

Under the metrics and targets pillar, the TCFD recommends to “disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process”. In this context, organizations are encouraged

to provide key metrics used to measure and manage climate-related risks, and banks are particularly advised to disclose metrics employed to assess the impact of transitional and physical climate-related risks on their lending and other financial activities (TCFD, 2017b). Additionally, banks are required to disclose “the amount and percentage of carbon-related assets relative to total assets as well as the amount of lending and other financing connected with climate-related opportunities”. These recommendations are closely related to the recommended disclosures under the strategy and risk management pillars, as they also involve the disclosure of metrics related to climate-related transition and physical risks and their impacts (e.g., labels **ST.1.1**, **ST.1.2**, and **ST.1.3**). Thus, we focus on a specific sub-element within the recommended disclosure, i.e., “where climate-related issues are material, organizations should consider describing whether and how related performance metrics are incorporated into remuneration policies”. We label this **MT.1.2** *Incorporation of climate-related performance metrics into remuneration policies*. This label aims to assess whether banks report on the inclusion of climate-related metrics in their compensation practices, reflecting the growing importance of sustainability-related performance measures in executive remuneration (TCFD, 2017b). Next, in response to the recommended disclosure “disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks”, we create the label **MT.1.1** *Carbon footprint, direct and indirect GHG*. Lastly, the TCFD recommends to “describe the targets used to manage climate-related risks and opportunities and performance against targets”. Since the TCFD encourages the disclosure of GHG emissions targets, as it also places great emphasis on gaining a better understanding of the concentrations of carbon-related assets in the financial sector, we focus on this particular type of target and create the label **MT.1.3** *Emissions reduction and carbon neutrality targets*.

## VI.4 Label evaluation

The zero-shot text classification model used in our study does not require specific training with pre-labeled data. As a result, the model cannot be validated in the

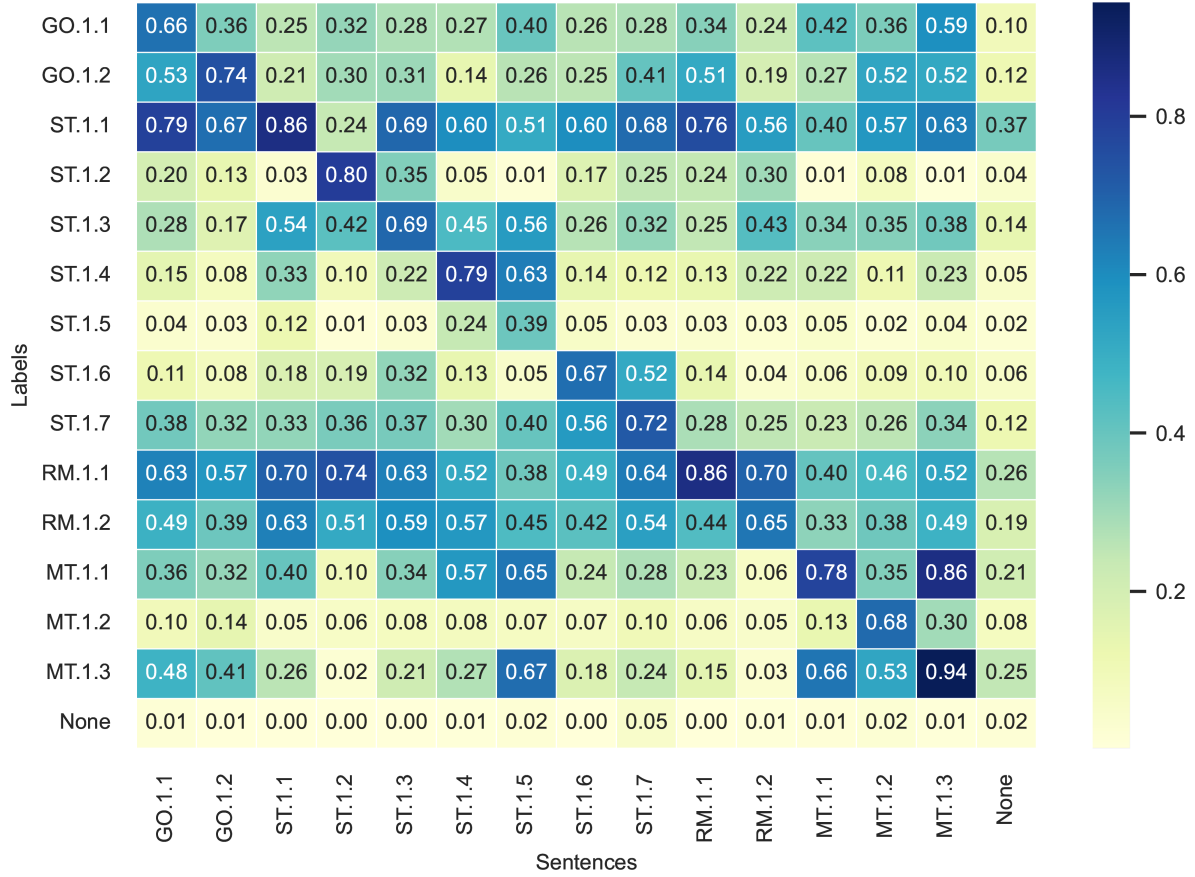


conventional manner of splitting a dataset into training and test sets and evaluating the model’s performance on the test set. Nonetheless, we can still conduct a series of evaluation tests to assess the text sequence recognition and classification performance of our zero-shot text classification model.

To create a dataset for evaluation, we manually collect sentences that align with the TCFD recommendations and assign them specific labels. These sentences are extracted from the TCFD good practice handbook (Board, 2019, 2021), which features examples of best practice disclosures selected by the TCFD. Additionally, we manually extract sentences from TCFD reports of companies outside the banking sector. We also incorporate sentences from the training repository provided by Webersinke et al. (Webersinke et al., 2021). All of these sentences have been assigned a label by the authors, which is either “governance”, “strategy”, “risk management”, “metrics and targets” or “none”. We reassign one of our fine-grained labels to these text sequences.

In the first step, we apply the zero-shot classification to the dataset using a multi-label approach. This approach allows the zero-shot model to provide results for each label independently, acknowledging that a text sentence may correspond to multiple labels. Consequently, the results returned by the zero-shot classification for each label do not sum up to one. We utilize the fine-grained labels listed in Table VI.5. We also include the label “none” in the classification task. The purpose of this label is to capture non-climate-related text sequences, i.e., text sequences that do not fit any of our fine-grained labels. Including the “none” label ensures that the labels assigned by the zero-shot are based on the semantics of the text sequences rather than by pure chance. To assess the model’s performance with respect to the “none” label, we use sentences labeled as “none” in the aforementioned training repository, as well as additional sentences labeled as “none” by us. The results of the zero-shot text classification applied to the dataset are shown in Fig VI.2. The x-axis represents the manually annotated sentences, while the y-axis shows the results from our zero-shot analysis based on the climate-related labels. The results represent the mean probability returned by the zero-shot model that the sentences in a given column deal with the topic represented by the label in the corresponding row. Darker entries represent higher likelihoods classified by the

Figure VI.2: Label evaluation matrix based on test dataset.



*Remark:* This matrix presents the results of the zero-shot text classification applied to our test dataset. The fine-grained TCFD labels are based on the recommended disclosures and the supplemental guidance for the financial sector.

model. In an optimal zero-shot text classification, the entries along the diagonal would be the darkest.

These results demonstrate that our model accurately assigns high probabilities to the appropriate labels. At the same time, we also observe that labels ST.1.1 (Climate-related transition risks), ST.1.3 (Material financial impact of climate-related issues), ST.1.7 (Resilience of the bank's strategy), RM.1.1 (Processes to identify, assess and manage climate-related risks and integrate them into overall risk management), and RM.1.2 (Relationship between climate-related risks and financial risks) perform worse than other labels in terms of text sequence recognition. For example, both the groups of sentences that we labeled as risk management sequences as well as other sentence groups were assigned the labels RM.1.1 and RM.1.2 with a probability of 60% or higher.

There could be several reasons for these results. First, the abstract nature of some topics covered may render them less suitable for zero-shot text classification. Terms such as “resilience” encompass a wide range of interpretations, posing challenges in precise reporting and potentially causing overlaps with multiple text sequences. This observation also brings attention to weaknesses in the design of the TCFD recommendations. Second, the TCFD recommendations often encompass closely interconnected themes, leading to situations where text sequences can align with multiple labels simultaneously. For example, the only label which does not have the highest probability for its own group of sentences is label MT.1.1 (Carbon footprint, direct and indirect greenhouse gas emissions), where a higher probability was assigned by the zero-shot to MT.1.3 (emissions reduction and carbon neutrality targets). Given the close relationship between these topics, it is unsurprising to observe high probabilities assigned to both sets of sentences. However, in order to maintain consistency with the semantics of the TCFD recommendations, we made a deliberate choice not to modify the labels.

The probabilities for the “none” label are consistently low across all sentences, indicating that the model does not simply label by chance, but rather incorporates the semantics of the labels in its classification. Sentences labeled as “none” received low probabilities for nearly all labels. The exception is label “climate-related transition risks” (ST.1.1), which has a slightly higher probability of 37% for the “none” sentences. This may be linked to the fact that this label encompasses many different types of risks, such as political and legal risks, technological risks, market risks, and reputation risks, all of which belong to the “transition risks” category. For some sentences describing these risks, the zero-shot classification may not directly identify the link to climate change. Furthermore, we also notice that more abstract labels such as RM.1.1 and RM.1.2 have higher values for “none” sentences as well.

In addition to our graphical analysis, we evaluate the model performance by examining the overall F1 scores and the individual F1 scores of our labels, as illustrated in Table VI.6. We evaluate the model based on test data previously used in Fig VI.2, focusing on our fine-grained labels. In contrast to the previous matrix, we calculate the F1-scores using a single-label approach, as we also performed a single-label approach

Table VI.6: Comparison of performance based on F1 scores.

| Label  | Recall | Precision | F1-Score |
|--------|--------|-----------|----------|
| GO.1.1 | 0.53   | 0.97      | 0.69     |
| GO.1.2 | 0.74   | 0.72      | 0.73     |
| ST.1.1 | 0.66   | 0.29      | 0.40     |
| ST.1.2 | 0.61   | 0.79      | 0.69     |
| ST.1.3 | 0.28   | 0.46      | 0.34     |
| ST.1.4 | 0.52   | 0.54      | 0.53     |
| ST.1.5 | 0.31   | 1.00      | 0.48     |
| ST.1.6 | 0.57   | 0.77      | 0.65     |
| ST.1.7 | 0.51   | 0.50      | 0.51     |
| RM.1.1 | 0.73   | 0.61      | 0.66     |
| RM.1.2 | 0.59   | 0.29      | 0.39     |
| MT.1.1 | 0.58   | 0.90      | 0.70     |
| MT.1.2 | 0.68   | 0.91      | 0.78     |
| MT.1.3 | 0.93   | 0.24      | 0.39     |

*Remark:* The overall performance scores are: Micro F1-score: 0.6029, Macro F1-score: 0.5668, Weighted F1-score: 0.6281.

by manually attributing a specific label to the text sequences in our dataset. Overall, our model obtains a micro F1 score of 0.60 and a macro F1 score of 0.57, which is satisfactory considering the presence of 14 classes. In addition, we observe that material financial impact of financial issues (ST.1.3) is the most challenging to identify (F1-score of 0.34) and the incorporation of climate-related performance metrics into remuneration policies (MT.1.2) the easiest (F1-score of 0.78). This discrepancy may be explained by the fact that financial material impact is a broader concept, and the task of identifying corresponding sentences may be more challenging, even for humans. We also observe that our governance labels exhibit a comparatively high precision. In contrast, the labels pertaining to transition risks (ST.1.1), the relationship between climate-related risks and financial risks (RM.1.2) and emissions-reduction targets (MT.1.3) display relatively lower precision, suggesting a higher number of false positives. Additionally, our

labels exhibit relatively high recalls, with the exception of material financial impact of financial issues (ST.1.3.) and financing and investment for carbon-intensive industries (ST.1.5).

Altogether, our zero-shot text classification does not appear to assign probabilities purely by chance. The TCFD recommendations appear to be intertwined, which is an argument for the multi-label approach we use. We also find that zero-shot classification yields better results when labels are based on well-delineated and precisely defined concepts.

## VI.5 Results

### VI.5.1 Climate-related disclosures by broad TCFD categories

The main objective of the TCFD recommendations is to guide companies in disclosing consistent and decision-useful information for key stakeholders (Bingler et al., 2022). These climate-related disclosures aim to reduce information asymmetry between reporting firms and stakeholders and demonstrate companies' awareness of climate-related issues (Krueger et al., 2020; Jung et al., 2018; Ding et al., 2023). In a first step, we examine the probability that corporate reporting addresses climate-related issues and relates to one of the four main TCFD pillars. Table VI.7 presents the probabilities associated with the general labels "Governance", "Strategy", "Risk Management", and "Metrics and Targets" as well as the probabilities for our labels "climate-related Governance" (GO.1), "climate-related Strategy" (ST.1), "climate-related Risk Management" (RM.1) and "climate-related Metrics and Targets" (MT.1), respectively. We intentionally include both types of labels to facilitate a comparison between disclosures on general topics and disclosures specifically related to climate-related matters.

Several observations can be made based on these results. First, the mean probabilities for the general labels, which do not specifically mention climate-related topics, are higher compared to the probabilities for the specific climate-related labels. For instance, the probability of reporting on "Governance" is consistently higher than the probability of reporting on "climate-related Governance" (GO.1) throughout the entire

Table VI.7: Mean of label probabilities at category level per financial year.

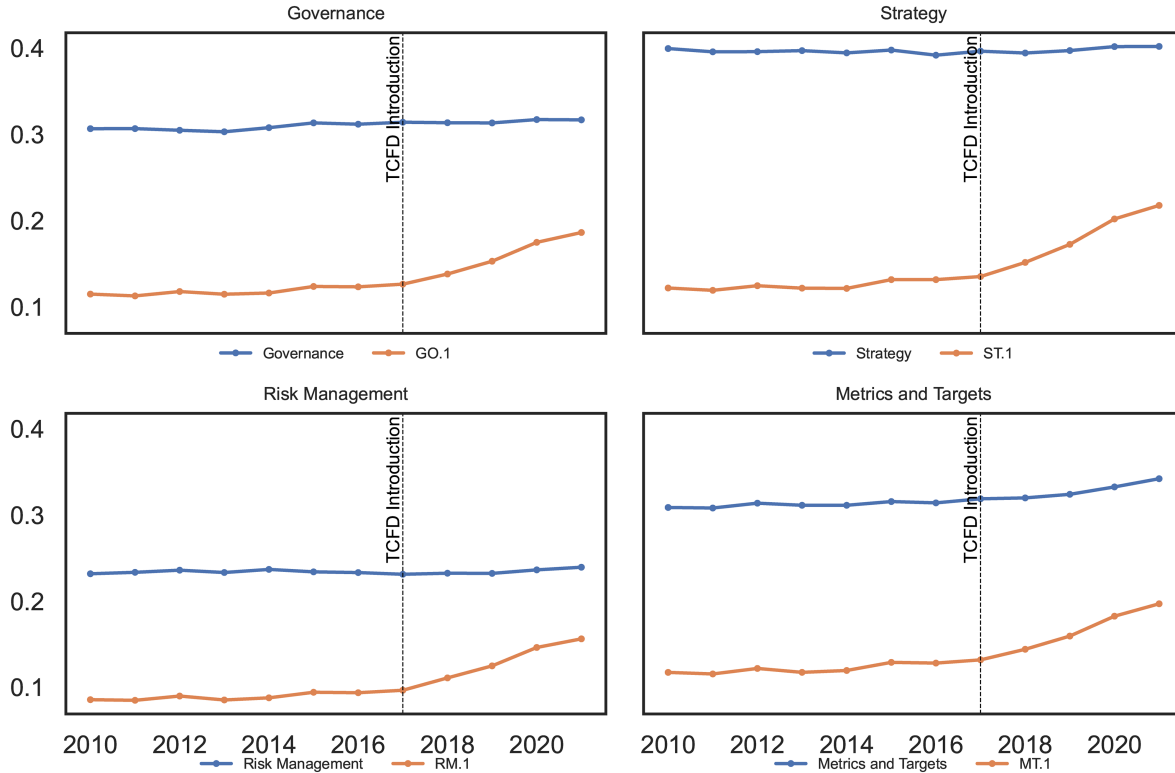
|                   | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Governance        | 0.31 | 0.31 | 0.30 | 0.30 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.32 | 0.32 |
| GO.1              | 0.11 | 0.11 | 0.12 | 0.11 | 0.12 | 0.12 | 0.12 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 |
| Strategy          | 0.40 | 0.40 | 0.40 | 0.40 | 0.39 | 0.40 | 0.39 | 0.40 | 0.39 | 0.40 | 0.40 | 0.40 |
| ST.1              | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.14 | 0.15 | 0.17 | 0.20 | 0.22 |
| Risk management   | 0.23 | 0.23 | 0.24 | 0.23 | 0.24 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.24 | 0.24 |
| RM.1              | 0.09 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 | 0.11 | 0.12 | 0.15 | 0.16 |
| Metrics & targets | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.32 | 0.31 | 0.32 | 0.32 | 0.32 | 0.33 | 0.34 |
| MT.1              | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.16 | 0.18 | 0.20 |

*Remark:* The table presents the mean of label probabilities (on a scale from 0 to 1) for the general and climate-related labels at category level based on the full sample of 3,355 reports.

sample period. The same result holds true for the other main categories. This result is reasonable considering that our text sequences are extracted from various reports, including corporate governance reports and annual reports that cover a wide range of governance-related topics, not solely focused on climate-related governance. Thus, the zero-shot text classification model appears to effectively distinguish between climate-related and non-climate-related textual data.

Second, we observe that the mean probabilities associated with the general labels (without explicit mention of climate) remain stable over the sample period from 2010 to 2021, while there is an increase in all probabilities for the climate-related labels after 2017. Among the general labels, “Strategy” exhibits the highest mean probability compared to the others, maintaining a consistent probability of around 40% over time. In contrast, the probability of “climate-related Strategy” shows a dynamic increase, growing from 12% in 2010 to 22% in 2021. This indicates that the probability of text sequences in our sample relating to “climate-related Strategy” was only 12% in reports from 2010 but reaches 22% for reports published in 2021. In addition, we find that the label “Metrics and Targets” has the second highest mean probability over the sample

Figure VI.3: Climate-related disclosures by broad TCFD categories.



*Remark:* This figure illustrates the results of the zero-shot text classification applied with the general and broad TCFD labels on the full sample of 3,355 reports.

period compared to the other labels with a mean probability between 31% and 34%. When examining the mean probability of “climate-related Metrics and Targets”, we find an increase from 12% in 2010 to 20% in 2021, surpassing the probabilities of “climate-related Governance” and “climate-related Risk Management” in 2021.

To further examine climate-related disclosures at the category level, we examine the trends in reporting before and after the publication of the TCFD recommendations in 2017. Fig VI.3 provides a visual representation of these trends for all four TCFD categories over the sample period. Specifically, the blue lines represent the label probabilities of the general labels, while the orange lines illustrate the probabilities of the climate-related category labels, denoted as GO.1, ST.1, RM.1 and MT.1 in Table VI.5. We observe an overall increase in all climate-related label probabilities, with a more pronounced change occurring around 2017.

## VI.5.2 Climate-related disclosures by fine-grained TCFD labels

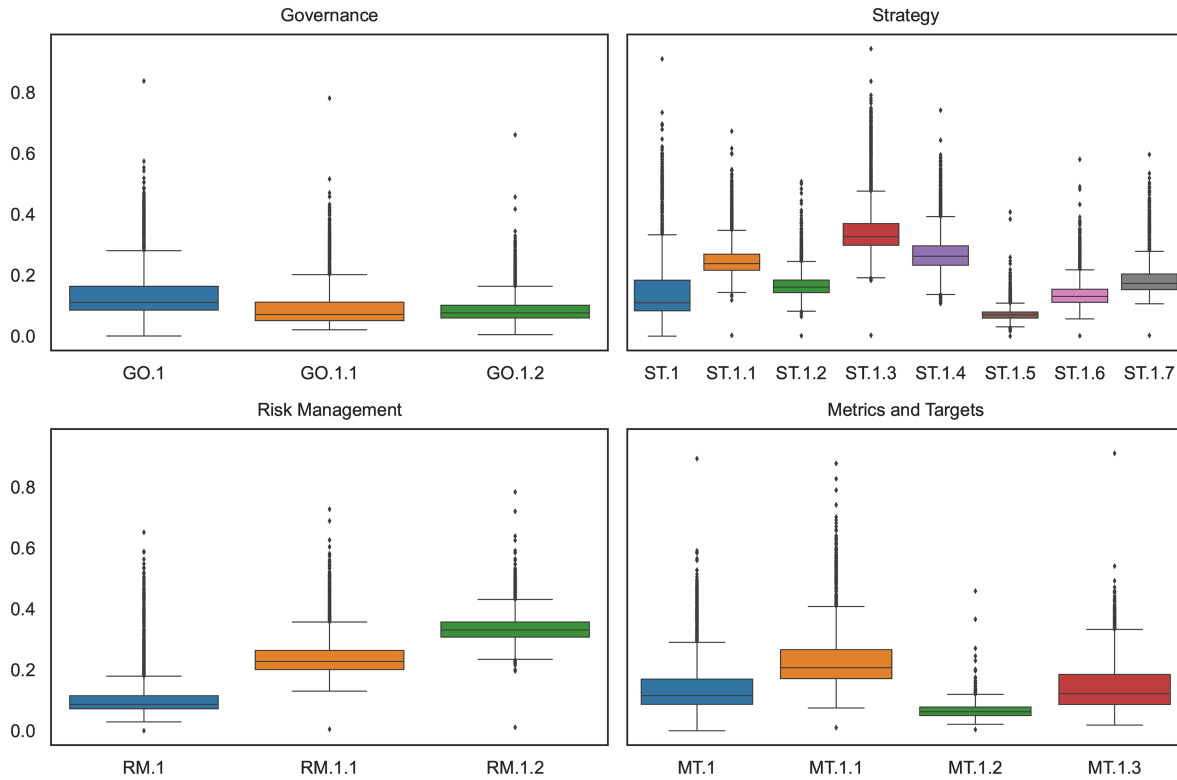
To more accurately assess the quality of climate-related disclosures, it is important to go beyond the quantity of reporting for each broad TCFD category and instead focus on examining corporate reporting on the specific recommended disclosures within each category. Therefore, as a next step, we consider the fine-grained labels that address specific topics related to the TCFD recommendations, rather than the climate-related category labels (GO.1, ST.1, RM.1, and MT.1). As highlighted earlier, the TCFD provides additional guidance for the financial sector, including banks, insurances, asset managers and asset owners (TCFD, 2017b). The additional guidance for banks particularly emphasizes disclosures related to strategy, risk management, and metrics and targets. We consider a higher label probability to serve as a proxy for disclosure quality. When a text sequence explicitly and accurately addresses a topic expressed in a label, it is associated with a higher label probability. A higher label probability also suggests a more comprehensive disclosure on a particular topic, as labeling is more likely to have a higher probability if a text sequence provides detailed information about the topic.

Fig VI.4 displays the results of the zero-shot text classification for the fine-grained labels applied to the entire sample of reports. As can be seen, there is considerable variation in the extent of disclosure within each TCFD category. The strategy category is the most comprehensive, encompassing several specific recommended disclosures for banks, which explains the presence of a greater number of labels compared to the other pillars. The reporting quality appears to be lower for disclosures related to financing and investment in carbon-intensive industries such as the fossil fuel industry (ST.1.5), as indicated by a probability of only 7%. This suggests that among all the text sequences extracted from our full sample of reports and classified by the zero-shot model, there is only a 7% probability of some of them matching the semantics of the ST.1.5 label. Similarly, TCFD-supporting banks seem to provide relatively limited disclosure on climate-related physical risks (ST.1.2) and the use of climate-related scenario models (ST.1.6), with both labels attaining probabilities of only 17% and 14%, respectively.

There could be several interpretations for these results. First, it is possible that the reports in our sample only address to a limited extent issues linked to the use of



Figure VI.4: Climate-related disclosures by fine-grained TCFD labels.



*Remark:* This figure illustrates the results of the zero-shot text classification applied with the fine-grained TCFD labels on the full sample of 3,355 reports.

scenario analyses or climate-related physical risks. This may be because some of the TCFD-supporting banks are still in the early stages of developing the necessary tools and expertise to conduct such analyses or identify such risks. This finding aligns with the study conducted by Binger et al. (2022), which highlights that only 10 out of 16 existing climate scenario tools allow for the assessment of climate-related physical risks. Similarly, Friederich et al. (2021) find that disclosures on transition risks have seen more significant growth compared to disclosures on physical risks.

The low label probability for disclosures related to the fossil fuel industry (ST.1.5), indicates that banks tend to provide limited information on this topic. Nevertheless, recent research highlights that financing for fossil fuel firms by international banks has not decreased since the Paris Agreement, and these banks continue to provide funding regardless of the associated stranded asset risk (Beyene et al., 2021). In fact, Beyene et al. (2021) specifically identified several TCFD-member banks, including JP Morgan

(TCFD-member since December 2017), BNP Paribas SA (TCFD-member since June 2017) and Wells Fargo & Co (TCFD-member since November 2019), as among the top lenders to fossil fuel firms between 2007 and 2018. This suggests that TCFD-supporting banks may engage in selective disclosure, as suggested by Bingler et al. (2022), potentially omitting certain information due to both reputational concerns and the absence of specific guidelines for measuring such exposures (Beyene et al., 2022). On the other hand, it is worth noting that banks appear to disclose more information regarding their credit exposure to carbon-related sectors. This is not surprising since this category encompasses a broader definition that includes sectors like transportation and utilities.

In the risk management area, we observe that banks tend to address processes for identifying, assessing, and managing climate-related risks and integrating them into overall risk management (RM.1.1) less frequently, on average, compared to the relationship between climate-related risks and financial risks (RM.1.2). The median value for RM.1.1 is also lower (23%) than in the case of RM.1.2 (33%). However, the probabilities provided by the zero-shot text classification could be slightly inflated compared to the actual reporting since the zero-shot performed less well for RM.1.2 (F1-score: 0.39). As shown previously, several sentence groups achieved a high probability of fitting into RM.1.1 and RM.1.2. Notably, several recommended disclosures within other pillars, such as the role of management in assessing and managing climate-related issues (GO.1.2), are also related to risk management topics.

In the metrics and targets category, we find that the incorporation of climate-related performance metrics into remuneration policies (MT.1.2) is associated with a lower label probability compared to metrics related to carbon footprints (MT.1.1) and emissions reduction targets (MT.1.3). The mean label probability for MT.1.2 is only 7%, while it is 24% for MT.1.1 and 15% for MT.1.3. This result aligns with our expectations, as financial institutions are less likely to align their compensation policies with climate-related performance metrics compared to making symbolic commitments to carbon neutrality goals, even if they may fail to meet these commitments (see e.g., Gibson Brandon et al., 2022; Bolton and Kacperczyk, 2021).

In the governance area, the TCFD-supporting banks appear to report at comparable levels on the board’s responsibility for overseeing climate-related issues (GO.1.1) and the management’s role in assessing and managing climate-related issues (GO.1.2). Both labels exhibit a relatively low average probability of 9%, with median values of approximately 7% for GO.1.1 and 8% for GO.1.2. However, the maximum values for GO.1.1 are higher, indicating more comprehensive disclosures on the role of the board in overseeing climate-related issues.

In order to better assess the evolution of reporting on the underlying recommended disclosures, we report in Table VI.8 the mean label probabilities of the fine-grained labels in each financial year. We observe that an increase in mean label probabilities can be observed for most labels between 2017 and 2018, and in particular between 2018 and 2019.

### **VI.5.3 Climate-related disclosures after individual TCFD support**

In the following step, we examine whether the observed increase in climate-related disclosures following the introduction of the TCFD recommendations is statistically significant for both the overall fine-grained labels and after individual banks declared their support. As the process of joining the official TCFD supporters was gradual, with banks joining at different times, we can investigate whether climate-related disclosures truly increased after banks individually began supporting the TCFD recommendations. Our approach builds upon the study of Bingler et al. (2022), but extends the analysis by focusing on the specific recommended disclosure topics rather than the broad category level.

Table VI.9 presents the results of a paired  $t$ -test (in percentage points), in which we compare the mean differences of label probabilities before and after the official TCFD introduction in 2017 (column 1), as well as before and after the year of individual TCFD support (columns 2 to 6). As a robustness check, we also performed permutation p-value tests using a Monte Carlo simulation and bootstrap confidence intervals, which yielded

Table VI.8: Mean of label probabilities for fine grained labels per financial year.

|        | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|
| GO.1.1 | 0,07 | 0,07 | 0,08 | 0,07 | 0,07 | 0,08 | 0,08 | 0,08 | 0,09 | 0,11 | 0,13 | 0,14 |
| GO.1.2 | 0,08 | 0,07 | 0,08 | 0,07 | 0,08 | 0,08 | 0,08 | 0,08 | 0,09 | 0,10 | 0,11 | 0,12 |
| ST.1.1 | 0,24 | 0,24 | 0,24 | 0,23 | 0,24 | 0,24 | 0,24 | 0,24 | 0,25 | 0,26 | 0,28 | 0,28 |
| ST.1.2 | 0,16 | 0,16 | 0,16 | 0,16 | 0,16 | 0,16 | 0,16 | 0,16 | 0,17 | 0,18 | 0,19 | 0,19 |
| ST.1.3 | 0,34 | 0,34 | 0,34 | 0,33 | 0,33 | 0,34 | 0,33 | 0,33 | 0,34 | 0,36 | 0,40 | 0,40 |
| ST.1.4 | 0,25 | 0,25 | 0,26 | 0,25 | 0,26 | 0,26 | 0,27 | 0,26 | 0,27 | 0,28 | 0,31 | 0,32 |
| ST.1.5 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,08 | 0,08 |
| ST.1.6 | 0,13 | 0,13 | 0,13 | 0,12 | 0,13 | 0,13 | 0,13 | 0,13 | 0,14 | 0,15 | 0,16 | 0,16 |
| ST.1.7 | 0,18 | 0,17 | 0,18 | 0,17 | 0,17 | 0,18 | 0,18 | 0,18 | 0,19 | 0,20 | 0,22 | 0,22 |
| RM.1.1 | 0,22 | 0,22 | 0,23 | 0,22 | 0,23 | 0,23 | 0,23 | 0,23 | 0,24 | 0,25 | 0,27 | 0,28 |
| RM.1.2 | 0,34 | 0,34 | 0,34 | 0,33 | 0,33 | 0,33 | 0,33 | 0,32 | 0,33 | 0,34 | 0,35 | 0,35 |
| MT.1.1 | 0,21 | 0,21 | 0,21 | 0,21 | 0,21 | 0,22 | 0,22 | 0,22 | 0,23 | 0,25 | 0,28 | 0,29 |
| MT.1.2 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 |
| MT.1.3 | 0,12 | 0,12 | 0,13 | 0,12 | 0,13 | 0,13 | 0,14 | 0,14 | 0,15 | 0,16 | 0,18 | 0,19 |

*Remark:* The table presents the descriptive statistics of label probabilities (on a scale from 0 to 1) for the fine-grained TCFD labels based on the full sample of 3,355 reports.

qualitatively similar results. As an illustration, if banks became TCFD supporters in 2018, we compare the mean of each label probability for all of these banks (26 in total) by taking the mean per bank from 2010 to 2017 and comparing it to the mean from 2018 to 2021 after the banks became supporters. For the full sample, in column 1, we compare the mean difference up to the publication of the official TCFD recommendations (mean of years 2010 to 2016) and after they were published (mean of years 2017 to 2021).

In column 1, we observe a small but statistically significant increase in climate-related reporting probabilities for the full sample following the official introduction of the TCFD in 2017. The mean differences are statistically significant at the 1% level, except for RM 1.2, which is significant at the 10% level. On average, we find a total increase of 2.72 percentage points across all labels, which aligns with the findings of

Table VI.9: Mean differences in percentage points of climate-related disclosures.

|        | Full sample<br>n = 188 | TCFD support since |         |         |         |         |
|--------|------------------------|--------------------|---------|---------|---------|---------|
|        |                        | 2017               | 2018    | 2019    | 2020    | 2021    |
|        |                        | n = 38             | n = 26  | n = 25  | n = 30  | n = 53  |
|        | (1)                    | (2)                | (3)     | (4)     | (5)     | (6)     |
| GO.1   | 3.59***                | 5.69***            | 4.72*** | 4.25*** | 4.51*** | 3.24*** |
| GO.1.1 | 3.29***                | 5.02***            | 4.43*** | 3.74*** | 4.34*** | 3.12*** |
| GO.1.2 | 2.21***                | 3.34***            | 2.88*** | 2.61*** | 2.98*** | 2.25*** |
| ST.1   | 4.80***                | 7.70***            | 6.51*** | 5.61*** | 6.16*** | 4.23*** |
| ST.1.1 | 2.41***                | 4.15***            | 3.41*** | 2.59*** | 3.22*** | 2.54*** |
| ST.1.2 | 1.47***                | 2.57***            | 1.89*** | 1.80*** | 2.10*** | 1.75*** |
| ST.1.3 | 2.74***                | 4.84***            | 5.36*** | 4.05*** | 4.52*** | 3.28*** |
| ST.1.4 | 2.45***                | 4.60***            | 3.98*** | 2.53*** | 3.25*** | 3.10*** |
| ST.1.5 | 0.50***                | 1.19***            | 0.96*** | 0.28    | 0.65*** | 0.71**  |
| ST.1.6 | 1.59***                | 3.24***            | 2.19*** | 1.77*** | 1.75*** | 1.93*** |
| ST.1.7 | 2.44***                | 4.13***            | 3.54*** | 3.02*** | 3.24*** | 2.45*** |
| RM.1   | 3.39***                | 5.76***            | 5.02*** | 3.42*** | 4.25*** | 3.09*** |
| RM.1.1 | 2.82***                | 4.72***            | 3.84*** | 3.11*** | 3.56*** | 2.74*** |
| RM.1.2 | 0.33*                  | 1.12**             | 2.20*** | 0.20    | 1.40**  | 1.29**  |
| MT.1   | 3.90***                | 6.22***            | 5.03*** | 4.57*** | 4.78*** | 3.62*** |
| MT.1.1 | 4.06***                | 6.43***            | 5.44*** | 5.28*** | 5.46*** | 3.75*** |
| MT.1.2 | 0.63***                | 1.06***            | 0.37*   | 1.03*** | 0.55**  | 0.86**  |
| MT.1.3 | 3.74***                | 5.34***            | 4.19*** | 4.94*** | 4.56*** | 3.38*** |

*Remark:* This table presents the mean differences (in percentage points) of climate-related disclosures and the significance of the corresponding paired  $t$ -test based on the full sample of 3,355 reports.  
 \*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

Bingler et al. (2022), who report an increase of approximately 2.2 percentage points. In columns 2 and 3, we report that the groups of banks that became supporters in 2017 and 2018 exhibit higher disclosure levels after their individual support, as illustrated by the relatively larger and statistically significant mean differences. For the group of banks who became official supporters in 2019, as shown in column 4, we do not find any significant change in mean label probabilities for two labels. This result is consistent with Bingler et al. (2022) who report the largest nominal effects for companies that supported the TCFD recommendations directly in 2017 and 2018 as compared to companies that supported the TCFD in 2019 and 2020.

In terms of magnitude, the greatest differences in reporting probabilities for banks that joined the TCFD in 2017 are found in the fine-grained labels MT.1.1 (carbon footprint, 6.43%), MT.1.3 (emissions reduction and carbon neutrality targets, 5.34%), and GO.1.1 (board oversight of climate-related issues, 5.02%). For the banks that joined in 2018, we find the largest mean differences for the labels MT.1.1 (carbon footprint, 5.44%), ST.1.3 (financial impact of climate-related issues, 5.36%) and GO.1.1 (board oversight of climate-related issues 4.43%). Similarly, for banks that joined in 2019, 2020, and 2021, the largest differences are found in the labels MT.1.1 (carbon footprint), MT.1.3 (emissions reduction and carbon neutrality targets), and ST.1.3 (financial impact of climate-related issues).

Altogether, the largest differences tend to be oftentimes observed in the Metrics and Targets category and pertain to carbon footprints as well as emissions reduction targets. Thus, TCFD-supporting banks appear to increase their level of disclosures related to these topics in the course of their official TCFD endorsement. One possible reason for this observation could be that the importance that stakeholders, including investors, place on carbon risk (Bolton and Kacperczyk, 2021). This is also consistent with Ding et al. (2023), who show that there is a positive relationship between carbon emissions and climate-related disclosures.

### VI.5.4 Climate-related disclosures by bank size

Finally, we examine the relationship between bank size and climate-related reporting, taking into consideration that larger firms generally have more resources and stronger corporate social responsibility profiles (Gillan et al., 2021). We anticipate that larger banks are more likely to produce climate-related reports that align with the TCFD recommendations, resulting in higher label probabilities compared to medium and small banks.

To examine TCFD reporting based on bank size, we employ a Tukey test, assessing the differences between the means of the different bank sizes. Table VI.10 summarizes the results of the Tukey test for the differences between the means and their adjusted p-values corrected for family-wise error rate. Consistent with our expectations, we report that mean scores for all TCFD recommendations significantly increase from medium to large banks and from small to large banks, suggesting that larger banks generally are more likely to produce reports that align with the TCFD recommendations. In contrast, the effects are nominally smaller between small and medium banks compared to the other groups.

In terms of magnitude of the results, we also observe differences across the labels. Notably, we find that the largest differences between large and small banks relate primarily to reporting on the financial impact of climate-related issues (ST.1.3), carbon footprint (MT.1.1) and emissions reduction targets (MT.1.3). These findings support our initial expectations, as larger banks possess greater capacities to measure and report their carbon footprints. Furthermore, they are more likely to consider the material financial impacts of climate change, given their larger portfolios and potential exposure to transition or physical climate risks.

## VI.6 Discussion and Conclusion

This paper examines the climate-related disclosures of TCFD-supporting banks using the zero-shot text classification as a novel computerized approach for textual analysis of climate-related disclosures. By combining the TCFD recommendations with additional

Table VI.10: Tukey difference-in-mean test of climate-related disclosures.

|        | Large - Medium | Large - Small | Medium - Small |
|--------|----------------|---------------|----------------|
| GO.1   | 2.06***        | 3.46***       | 1.40***        |
| GO.1.1 | 1.24***        | 2.23***       | 0.99***        |
| GO.1.2 | 0.93***        | 1.58***       | 0.65***        |
| ST.1   | 2.55***        | 4.68***       | 2.13***        |
| ST.1.1 | 1.64***        | 2.35***       | 0.71**         |
| ST.1.2 | 0.95***        | 0.96***       | 0.01           |
| ST.1.3 | 3.06***        | 4.15***       | 1.09**         |
| ST.1.4 | 2.67***        | 2.83***       | 0.16           |
| ST.1.5 | 0.73***        | 0.71***       | 0.01           |
| ST.1.6 | 1.76***        | 1.69***       | 0.07           |
| ST.1.7 | 1.48***        | 2.30***       | 0.83***        |
| RM.1   | 2.03***        | 2.91***       | 0.88***        |
| RM.1.1 | 1.87***        | 2.40***       | 0.54           |
| RM.1.2 | 1.40***        | 1.93***       | 0.54*          |
| MT.1   | 2.38***        | 3.83***       | 1.46***        |
| MT.1.1 | 2.39***        | 3.86***       | 1.48***        |
| MT.1.2 | 0.46***        | 0.67***       | 0.21           |
| MT.1.3 | 1.72***        | 3.46***       | 1.74***        |

*Remark:* This table presents the mean differences (in percentage points) of climate-related disclosures and the significance of the corresponding Tukey difference-in-mean test based on the full sample of 3,355 reports. \*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .



guidance specific to the financial sector, we create fine-grained labels that enable a more detailed examination of climate-related reporting. Our findings reveal significant variation in climate-related disclosures, not only across the broad TCFD categories but also within each category. Specifically, we observe that banks have a lower probability of reporting on topics such as climate-related physical risks, financing and investments in fossil fuel activities, the use of climate-related scenario models, and the integration of climate-related performance metrics into remuneration policies. These results indicate that the TCFD-supporting banks in our sample have not yet implemented all the recommendations to the same extent. Our research contributes to the expanding body of literature on voluntary climate-related corporate reporting (e.g., Friederich et al., 2021; Bingler et al., 2022; Ding et al., 2023).

Our study also entails some limitations, which warrant careful consideration and indicate potential areas for future research. First, although we observe an overall increase in climate-related reporting following the release of the TCFD recommendations, it is important to note that this does not necessarily imply that banks are taking more substantial internal actions to address the identified issues. Simply disclosing more information does not guarantee a corresponding increase in efforts to address climate-related challenges. This highlights the need for further research regarding the factors influencing reporting decisions. Additionally, there is a possibility that some banks intentionally do not disclose certain information and engage in selective disclosure (i.e., greenwashing) to improve their public image. This emphasizes the need to consider potential motivations and biases behind the disclosed information in the context of voluntary disclosures. Addressing these limitations and exploring these areas in future research can contribute to a deeper understanding of the relationship between climate-related reporting, internal actions, and the effectiveness of voluntary disclosure frameworks such as the TCFD. Furthermore, our research also reveals weaknesses in the TCFD recommendations, such as a lack of precise concepts and overlaps in recommended disclosures. Future research could therefore further investigate the determinants of high-quality climate-related disclosure frameworks and assess their impact in delivering material and decision-useful information.

Despite the limitations mentioned, our study has important practical implications. It underscores the necessity for precise and specific recommendations within climate-related disclosure frameworks. Without such consistent methodologies and explicit definitions for recommended disclosure topics, there is a potential for significant variation in the scope and depth of reporting. In the banking sector, while the TCFD recommendations are a positive step forward, the lack of concrete guidance hinders accurate assessment of banks' exposure to the fossil fuel sector and potential stranded assets. Addressing these issues can enhance the effectiveness and reliability of climate-related reporting frameworks, facilitating informed decision-making by stakeholders.

# Chapter VII

## Climate risk integration in bank risk management and capital requirements. An interview-based analysis of approaches and challenges

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# Climate risk integration in bank risk management and capital requirements. An interview-based analysis of approaches and challenges

## Abstract

This study explores the integration of climate risks into the risk management practices and capital requirements of large credit institutions, with a focus on 15 ECB-supervised entities. Recognizing that climate risks challenge traditional risk management, the study examines two key questions: (i) how are institutions integrating climate risks into their risk management frameworks, and what challenges are they encountering?; (ii) to what extent are climate risks being incorporated into capital considerations, and through which mechanisms are they influencing the determination of capital requirements? Via semi-structured interviews with 30 risk experts and a review of institutions' disclosure reports, the study sheds light on emerging approaches and discusses challenges. The focus areas include minimum capital requirements for credit risk, internal capital adequacy assessments (covering risk identification, quantification, stress testing and capital allocation), risk appetite frameworks, and supervisory review processes. Our findings provide insights into the evolving risk landscape, with a particular focus on the interplay between Pillar 1 and Pillar 2 of the Basel framework.

**JEL Classification:** E58, G28, Q54, Q58

**Keywords:** Climate change, climate risks, risk management, banking supervision

## VII.1 Introduction

If left unaddressed, today’s risks can easily turn into tomorrow’s losses. It is therefore vital for credit institutions<sup>1</sup> to have in place a robust and comprehensive risk management framework, including models and processes that ensure a clear understanding of risks and effective mitigation strategies. Nevertheless, even the most flawless risk management cannot fully eliminate the possibility of losses. Thus, a key imperative for these institutions is also to hold sufficient capital to be able to absorb losses exceeding expected levels (Holscher et al., 2022). This can be achieved by ensuring that capital requirements are met and that capital adequacy is maintained on an ongoing basis.<sup>2</sup> In addition, maintaining sufficient capital is essential for institutions to support their business models and pursue their strategic objectives (Gruenewald et al., 2023).<sup>3</sup>

The risks posed by climate change, including transition and physical risks, have in recent years contributed to reshaping the risk landscape known to credit institutions. Physical risks, such as acute and chronic weather events, and transition risks, including the economic impacts associated with the process of adjustment towards a lower-carbon economy, are receiving increasing attention from civil society, regulators and investors alike (Demekas and Grippa, 2022).<sup>4</sup> There are also concerns that such risks may change the distribution of losses that banks face (Holscher et al., 2022). In an evolving risk landscape, institutions need to adapt their risk management practices and continuously assess the robustness of their overall risk strategies (Buch, 2024). Climate risks, therefore, compel credit institutions to rethink their risk monitoring processes and to reassess their approach to capital adequacy from a new angle. However, as new (or “novel”) risks, for which historical data provides limited insight into future

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<sup>1</sup>In ECB (2020b), supervised credit institutions are commonly referred to as “institutions”. Throughout this study, we use the terms “credit institutions”, “banks” and “institutions” interchangeably.

<sup>2</sup>Capital adequacy refers to the degree to which risks are covered by capital (ECB, 2018).

<sup>3</sup>The weaker an institution’s capital base, the more difficult and costly it may be to pursue its strategy. For example, lower capital levels may lead investors and counterparties to demand higher risk premiums, thus reducing profitability (Gruenewald et al., 2023).

<sup>4</sup>Acute physical risks stem from extreme events such as droughts, floods and storms, while chronic physical risks result from gradual changes, such as rising temperatures and sea levels. Transition risks stem from shifts in climate-related policies, technological advancements or changes in market sentiment and preferences (ECB, 2020b).

developments, climate risks are, by definition, inherently uncertain (Buch, 2024; ECB, 2024c). Accounting for such risks therefore also poses significant conceptual, analytical and data challenges (Demekas and Grippa, 2024).

This study seeks to contribute to the discussion on climate risk integration by addressing two key broad questions. First, how are credit institutions integrating climate risks into their risk management frameworks, and what challenges are they encountering? (*“Question 1”*). Second, to what extent are climate risks being incorporated into capital considerations, and through which mechanisms are they influencing the determination of capital requirements? (*“Question 2”*).<sup>5</sup>

To address these questions, we examine institutions with total assets of more than EUR 30 billion, focusing particularly on 15 credit institutions directly supervised by the European Central Bank (ECB) and subject to the Capital Requirements Regulation (CRR) and the Capital Requirements Directive (CRD). In recent years, the ECB has been at the forefront of defining strategies to address climate risks in the banking sector (Gruenewald et al., 2023). In November 2020, it published 13 broad supervisory expectations regarding the management of climate-related and environmental risks (ECB, 2020b). These expectations are to be fully implemented by the end of 2024, making ECB-supervised institutions an ideal context for examining how banks are incorporating climate risks into their overall risk management practices. In 2022, the ECB conducted both a climate stress test and a thematic review of climate-related risk management practices. The ECB found that most institutions had implemented at least “basic practices” across most areas of the expectations, but also voiced “significant supervisory concern” about the institutions’ ability to achieve a higher level of implementation (p.2 & p.5, ECB 2022e).

Among these institutions, we conduct a series of semi-structured interviews with 30 respondents. Our interviewees have expertise in risk management, risk controlling, risk modeling, stress testing and related fields. Although the ECB has set out clear supervisory expectations, it does not prescribe specific approaches for their implementation.

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<sup>5</sup>“Capital requirements” refers, in this context, to the determination of capital needs in a broader sense, i.e., amount needed to cover risks, rather than compliance with minimum capital requirements in a regulatory sense.

Our interviews therefore allow us to gain in-depth insights into the various — and often heterogeneous — approaches for integrating climate risks, reflecting both current practices and ideas for future developments. In addition, in light of the concerns voiced by the ECB, it appears crucial to shed more light on the specific challenges at hand. This study therefore presents a structured discussion not only of the climate risk integration approaches and their underlying rationale, but also of the barriers identified by respondents. Finally, given that these respondents play a crucial role in implementing the ECB’s supervisory expectations, understanding their perspectives is particularly valuable. By better identifying and describing these challenges, we aim to contribute to a smoother, more effective integration of climate risks into banking practices.

We complement the semi-structured interviews by a review of the institutions’ disclosure reports (“Pillar 3” reports). An important development is that these reports are now required to include information on environmental, social and governance (ESG) risks,<sup>6</sup> with a particular focus on physical risks and transition risks (see Art. 449a of the CRR).<sup>7</sup> Specifically, qualitative disclosures are required to include information on risk management related to environmental risks, while quantitative disclosures cover exposures to transition risks, physical risks and mitigating actions. Even though these reports, particularly the qualitative sections, vary in their level of detail and do not directly highlight specific challenges, they provide a valuable overview of the climate-related risk management practices in place. The reports typically cover topics such as risk identification, materiality assessments, scenario analysis, stress testing, risk metrics, and integration into risk appetite. We therefore use the information from these reports to both inform our semi-structured interviews and complement interview findings.

Examining the integration of climate risks into risk management and capital considerations requires an understanding of the regulatory and supervisory frameworks governing financial institutions. These frameworks are shaped by a range of laws and

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<sup>6</sup>Climate risks are typically treated as a subset of ESG risks, which falls under the environmental pillar.

<sup>7</sup>For the technical standards, see Implementing Regulation (EU) 2022/2453 of 30 November 2022 amending the implementing technical standards laid down in Implementing Regulation (EU) 2021/637 as regards the disclosure of environmental, social and governance risks.

regulations, largely derived from the Basel Accords (“Basel framework”) (EBA, 2022b).<sup>8</sup> In the European Union (EU), the Basel framework is implemented through the CRR and the CRD, and is further supported by technical standards and guidelines issued by EU bodies, such as the European Banking Authority (EBA) and national supervisors, such as the BaFin and Bundesbank in Germany.<sup>9</sup> It is widely accepted that climate risks are not a stand-alone risk category but act as drivers of “conventional” (i.e., prudential) risk types, such as credit, market and operational risks (BIS, 2022b). As a result, it is useful to contextualize the integration of climate risks within the broader framework designed to manage these prudential risks.

To guide and structure our discussion, we therefore propose a conceptual framework aligned with core elements of the “Pillar 1” and “Pillar 2” of the Basel framework. Pillar 1, on the one hand, specifies standard rules for calculating minimum capital requirements relative to risk-weighted assets (RWA). In essence, riskier assets receive a higher risk weight, so that capital increases with risk (Holscher et al., 2022). These rules mainly apply to credit risk, market risk and operational risk. Examining the integration of climate risks within Pillar 1 is especially relevant for addressing *Question 2* on capital considerations. Nonetheless, since Pillar 1 defines minimum capital requirements, its outcomes also feed into broader capital considerations and risk management strategies under Pillar 2. Given the importance of climate risks primarily for credit risk, we focus on the standardized and internal ratings-based approaches — two credit risk-related methods for determining risk weights under Pillar 1 and capital requirements for credit risk (EBA, 2023).

Pillar 2, on the other hand, consists mainly of the Internal Capital Adequacy Assessment Process (ICAAP) and the Supervisory Review and Evaluation Process (SREP).<sup>10</sup> The ICAAP is the process by which institutions assess the adequacy of their capital

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<sup>8</sup>The Basel Committee on Banking Supervision sets standards for prudential regulation and serves as a forum for cooperation on banking supervision. It is composed of central banks and supervisory authorities. These standards are regularly updated, with the most recent series of reforms known as Basel III.

<sup>9</sup>For example, in Germany, even the MaRisk, referring to the minimum requirements for risk management, implement qualitative requirements derived from the Basel framework into German law.

<sup>10</sup>The Internal Liquidity Adequacy Assessment Process (ILAAP) is also part of Pillar 2, but is not covered in this study.



using their own internal methods and risk management processes (ECB, 2018). It considers not only the risk types covered under Pillar 1, but also all other material risks to which the institutions are exposed. In this context, the capital considerations under the ICAAP go beyond the minimum capital requirements set under Pillar 1. The ECB expects institutions to achieve full integration of climate risks into the ICAAP by the end of 2024 (ECB, 2022e). Examining such integration in the context of this study is therefore relevant for addressing both *Question 1* on risk management and *Question 2* on capital considerations. As the ICAAP is a multi-step process, we break down each of the key steps (e.g., risk identification and inventory, risk quantification, stress testing and capital allocation) and discuss the approaches and challenges involved in incorporating climate risks at each stage.

The ICAAP is reviewed by supervisors as part of the SREP, which is an annual process where supervisors evaluate, on a case-by-case basis, the risks institutions face and their ability to manage these risks in terms of risk management, capital, and liquidity (ECB, 2023g). One key outcome of the SREP is the Pillar 2 Requirement (P2R), a binding capital requirement set by supervisors (ECB, 2023f). This requirement can be applied, for example, if the ECB determines that an institution underestimates or inadequately manages certain material risks. As a result, the SREP process can shape institutions' risk management practices regarding climate risks and affect their capital requirements. Therefore, examining the role of climate risks within the SREP framework is also relevant for both *Question 1* and *Question 2*.

To structure our analysis, we categorize our results based on their main relevance to either Pillar 1 and/or Pillar 2. For example, the ICAAP is generally regarded as a process associated with Pillar 2 and, therefore, all results related to the ICAAP are classified under this pillar.<sup>11</sup> Within this conceptual framework of Pillars 1 and 2, our interview-based analysis delivers the following key takeaways and observations, which will be elaborated in more detail in the following sections:

- **Capital for credit risk – Internal ratings-based approach (Pillar 1):** A key

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<sup>11</sup>We note, however, that certain aspects of Pillar 1 are also relevant to the ICAAP and, by extension, to Pillar 2. For example, models developed for Pillar 1 may also find application in the context of Pillar 2.

development is that the ECB expects that where climate-related risks drivers are “found to be material, institutions should include such risk drivers in their internal models” approved for use for the calculation of capital requirements for credit risk (ECB, 2024a). The integration of climate risks into internal ratings-based models is still in its early stages, with a key challenge being the definition and assessment of materiality. While materiality assessments performed under the ICAAP are generally forward-looking, the quantitative integration of risk drivers into rating systems under Pillar 1 relies on statistical assessments and calibration requiring historical data. Short-term climate risks with financial impacts are considered by most respondents to be implicitly captured in the ratings, whereas medium- and long-term risks rely more heavily on ad hoc rating overrides and/or additional Margin of Conservatism (MoC). One institution quantitatively integrates climate risks into its ratings and Probability of Default (PD) estimates. Most institutions rely mainly on qualitative considerations, client engagement and apply rating overrides where necessary. The overrides are based on expert judgement derived from internal and highly heterogeneous climate-related scorecards, introduced by the institutions for risk management purposes. While overrides offer some flexibility and are based on a granular assessment of climate risks in the short term, they bear risks from a model validation perspective. They may also hinder a more systematic and consistent integration of climate risks into PD estimates.<sup>12</sup>

- **Capital for credit risk – Standardized approach (Pillar 1):** At present, the main method to integrate climate risks into this approach is through external credit ratings. Institutions primarily rely on the three major rating agencies — Moody’s, Standard & Poor’s and Fitch. The broad coverage provided by these agencies is a key reason for their selection. Consequently, the extent to which climate risks influence risk weights and capital requirements largely depends on how these agencies incorporate climate factors into their assessments, rather than on an active decision by the institutions themselves. With the “output floor” coming into effect in January

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<sup>12</sup>This study primarily focuses on PD considerations under Pillar 1. However, it is important to acknowledge that other credit risk parameters, including loss given default and the treatment of collateral values, also play a role in determining minimum capital requirements for credit risk.

2025, the standardized approach is expected to gain importance in the coming years and see even wider adoption. This shift is likely to let the role of external rating agencies and their methodologies become even more relevant in shaping minimum capital requirements in relation to climate risks.

- **ICAAP – Risk identification, materiality assessment and risk inventory (Pillar 2):** Institutions are increasingly incorporating climate risks into their internal risk identification process and annual risk inventory as part of the ICAAP. This involves identifying relevant climate-related risk drivers and determining their materiality. A key challenge in this process is the materiality assessment, which is multifaceted and requires detailed, granular data from both internal and external sources to evaluate how different climate-related risk drivers will affect various portfolios and risk types over short-, medium- and long-term horizons. Most institutions rely on qualitative approaches, such as expert judgement, while some further substantiate their materiality assessments with insights from quantitative methods, such as risk-type-specific scenario analyses and exploratory stress tests. Approaches to defining materiality as well as the types of materiality thresholds applied vary widely, highlighting the complexity of integrating climate risks based on materiality considerations.
- **ICAAP – Risk quantification methodologies and data collection (Pillar 2):** Institutions are increasingly using forward-looking simulation techniques to project changes in credit ratings based on climate scenarios. Some institutions are working to improve credit portfolio models by integrating climate risks, including through correlation factors. In addition, institutions are developing climate-related scorecards to quantify transition and physical risks at the individual client level. The scores resulting from these scorecards are also used in the context of rating overrides (see internal ratings-based approach under Pillar 1). The design of climate-related scorecards (e.g., criteria, weights) varies across institutions. Transition risks are assessed using criteria such as greenhouse gas emissions, technology risks and transition plans, while physical risks rely on criteria related to the regional or inter-

national nature of companies, geolocation and hazard-related data. Important data gaps remain, including on geolocation of corporate assets, production facilities and insurance coverage.

- **ICAAP – Risk quantification with climate stress tests (Pillar 2):** Institutions are gradually integrating climate stress tests into their broader stress testing frameworks. While many have introduced climate stress tests as a separate scenario class, others have also incorporated climate-related elements directly into their quarterly, institution-wide stress assessments. Most institutions rely on publicly available external climate scenarios, employing a diverse mix of short- and long-term scenarios, with considerable variation in scenario selection. Institutions make various adjustments to the scenarios, not only in terms of scenario expansion, but also by adding new assumptions, such as CO2 cost pass-through rates. A key challenge is the selection of an appropriate baseline scenario, with institutions adopting different approaches. Some institutions incorporate climate risks into the baseline macroeconomic forecast, while others use a dedicated climate scenario as the baseline. Modeling dynamic balance sheet assumptions is another major challenge. Finally, to achieve a comprehensive assessment and granular quantification of climate risks, institutions tend to combine top-down and bottom-up modeling approaches.
- **ICAAP – Internal capital adequacy and climate-related capital buffers (Pillar 2):** Several institutions use a combination of exploratory scenarios, which focus on specific risks such as credit or operational risk, and comprehensive scenarios, which encompass multiple risk types while considering macroeconomic impacts. Climate-related aspects, including CO2 prices, are increasingly incorporated into these comprehensive scenarios, supporting both capital adequacy assessments and capital planning efforts. Due to modeling uncertainties — particularly the limitations of traditional risk models in capturing medium- to long-term climate risks — some institutions have started to introduce climate-specific capital buffers. These instruments, often precautionary and based on expert judgement, vary in form, including general buffers, economic capital add-ons and adjustments to management

buffers. One institution combines an economic capital add-on for climate risks under the ICAAP with a management overlay for expected loss models.

- **Risk appetite, risk metrics and limit systems (Pillar 2):** Institutions are increasingly integrating climate risks into their risk appetite frameworks, including their credit risk appetite. Some institutions have formalized their climate objectives within their risk appetite statements, linking these objectives directly to risk metrics and limits. Institutions are also introducing a wide range of Key Risk Indicators (KRIs) specifically designed to track climate risk exposures and setting specific limits within their risk appetite frameworks. These limits vary in scope and focus, but typically target sectors and activities most exposed to transition and physical climate risks.
- **Integration of climate risks into loan pricing (Pillars 1 & 2):** Institutions are increasingly incorporating climate risks into loan pricing by factoring in credit risk costs, funding costs and capital costs. While climate risk-based pricing is still in its infancy, some institutions use innovative tools, such as green refinancing curves and margin premiums linked to internal ESG scores and loan maturities. Scenario analysis is also becoming increasingly used for loan pricing purposes, allowing institutions to develop default probabilities that are conditional on climate scenarios and determine credit provisions based on such scenarios. One institution includes climate risks into macroeconomic scenarios used for expected credit loss.
- **SREP, P2R and P2G (Pillar 2):** Climate risks are now integral to three critical SREP components: business model assessment, governance and risk management assessment and risks to capital assessment. The business model assessment holds particular importance, as supervisors increasingly evaluate institutions' strategic and operational plans, as well as their ability to assess climate risks from a business model perspective and to integrate them into broader business strategies. This qualitative integration of climate risks into the SREP framework influences SREP scores and is expected to more directly shape P2R levels over time. The Pillar 2 Guidance (P2G) is expected to play a greater role in the future as well and to further integrate climate

risks into capital recommendations.

Our study contributes to the growing body of literature on the role of climate risks in the banking sector, particularly in the context of banking supervision. To date, the ECB has published good practice reports on climate-related risk management and stress testing (ECB, 2022c,d). The EBA has also issued several reports on the integration of climate risks into Pillar 1 (EBA, 2022b, 2023). We add to this literature by providing a comprehensive analysis that highlights the interplay between Pillar 1 and Pillar 2. Furthermore, our study contributes to the growing empirical literature on both the relevance and the implications of climate risks for financial institutions. We discuss the existing empirical literature in more detail in Section VII.2.2.

The remainder of this study is organized as follows. Section VII.2 offers an overview of the latest regulatory and supervisory developments related to climate risks. Additionally, it reviews the literature and examines the relevance and implications of climate risks for financial institutions and supervisors. In Section VII.3, we describe our data and sample, and outline the conceptual framework used to structure our analysis. Section VII.4 presents our findings. Note that within the results section, each sub-section is designed to be largely self-explanatory. Section VII.5 discusses the limitations of our study and concludes.

## **VII.2 Theoretical background**

### **VII.2.1 Regulatory and supervisory developments**

The management of climate risks has received considerable attention from legislators and supervisors, especially in Europe. In particular, there has been growing interest and work by these actors on the extent to which climate risks are captured and addressed (or not) within the prudential framework.

The European legislator has issued several mandates related to the integration of climate risks into the three pillars of the Basel III framework, making these risks a key supervisory concern (Gruenewald et al., 2023). For example, the EBA has a man-

date under the CRD to issue guidelines to credit institutions in all EU member states on minimum standards for the identification, measurement and management of ESG risks.<sup>13</sup> Between 2021 and 2023, the EBA published, by exercising its mandate, various discussion papers and reports exploring the justification for a prudential, risk-based approach to ESG risks (EBA, 2021, 2022b, 2023). These reports address the integration of environmental risks, including transition and physical risks, into Pillar 1 (EBA, 2023) and into risk management practices under Pillar 2 (EBA, 2021). Similarly, the Basel Committee on Banking Supervision (BCBS) released a report in December 2022, outlining how climate risks may be more consistently incorporated into the existing Basel framework and reflected within existing Pillar 1 standards (BIS, 2022a). In the same year, the European Commission adopted new rules requiring additional disclosures under Pillar 3, including both qualitative information on ESG risk management and quantitative information on transition and physical risks.<sup>14</sup>

In line with these developments, the ECB has increasingly incorporated climate and environmental considerations into its supervisory practice. The ECB has made the management of climate and environmental risks one of its supervisory priorities for 2024-2026 (ECB, 2024f). Through its role in the Single Supervisory Mechanism (SSM), the ECB monitors how significant institutions in the euro area address climate risks (ECB, 2020b). To support this, the ECB published a guide setting out 13 supervisory expectations for the integration of climate and environmental risks (the “ECB Guide”). It also set staggered deadlines for supervised institutions to comply with these expectations by the end of 2024. In terms of content, these expectations focus primarily on Pillar 2 aspects, including risk management and internal capital adequacy assessment process. Specifically, institutions are expected to consider climate risks in their business strategies, risk appetite frameworks and credit processes, while assigning clear responsibilities for managing these risks (ECB, 2020b). They are also required to collect and report relevant data internally, incorporate climate risks into capital adequacy

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<sup>13</sup>See Directive 2013/36/EU on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms.

<sup>14</sup>See Implementing Regulation (EU) 2022/2453 of 30 November 2022 amending the implementing technical standards laid down in Implementing Regulation (EU) 2021/637 as regards the disclosure of environmental, social and governance risks.

considerations and conduct stress tests that include these risks. Finally, institutions are expected to consider the potential impact of climate risks on their liquidity position, business continuity and reputation (ECB, 2020b).

Another important supervisory development is the growing number of climate stress tests initiated by central banks, supervisors and regulators. In Europe, the ECB conducted one of the most comprehensive tests in 2022, building on earlier national-level efforts. De Nederlandsche Bank, the Dutch central bank, was among the first to introduce a mandatory stress test focused on transition risks in 2018, while the Banque de France launched a voluntary exercise in 2020 (Alogoskoufis et al., 2021). In 2021, the Bank of England followed with a stress test for major UK institutions, covering both transition and physical risks, and the EBA initiated an EU-wide pilot climate exercise that same year. Outside Europe, central banks in Canada (2020), Australia (2021), Singapore (2022) and the United States (2023) also conducted climate stress tests (AFME, 2023). Moreover, over the past few years, more than 100 central banks and financial supervisors have joined the Network for Greening the Financial System (NGFS), a forum aimed at enhancing supervisory practices for managing climate risks and developing climate scenarios (NGFS, 2024a).<sup>15</sup> This trend once again highlights the growing importance of climate risks for regulatory authorities and supervisors.

However, integrating climate risks into the broader risk management framework is particularly challenging because climate risks act as risk drivers for existing risks, rather than being a separate, stand-alone type of risk. For example, both physical and transition risks can impact institutions by reducing borrowers' ability to repay loans or by affecting the pricing of different asset classes (e.g., equities, bonds and commodities), thereby affecting loan books and trading books (Acharya et al., 2023). As illustrated in Figure VII.1, climate risks therefore materialize through “conventional” risk types such as credit, market and operational risks, and can affect both their likelihood and severity in different ways. As a result, incorporating climate considerations into risk management requires a nuanced, yet broad and comprehensive approach. This also requires a deep understanding of how climate risks interact with and amplify conventional risks,

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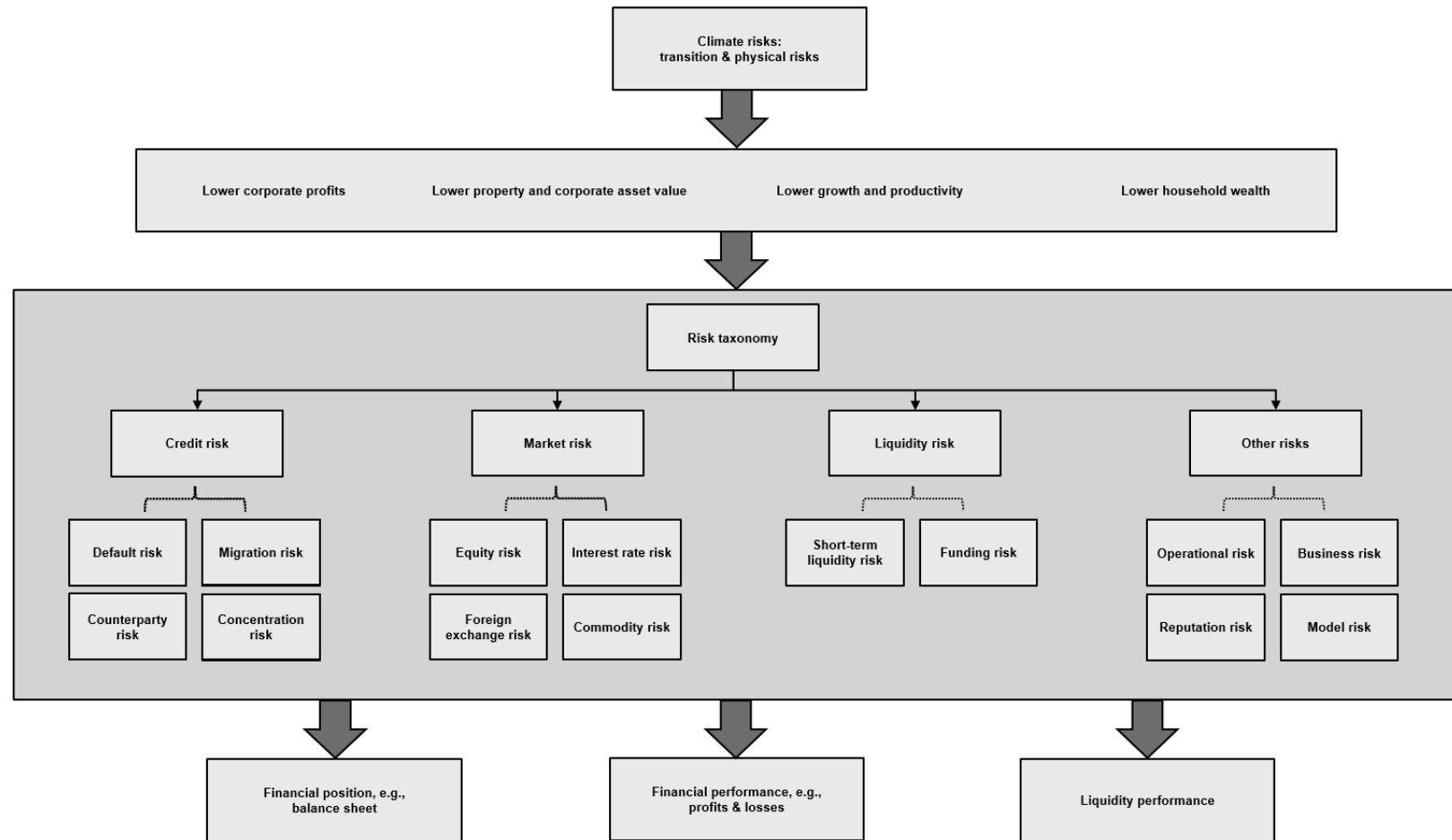
<sup>15</sup>We discuss some of the NGFS scenarios in Section VII.4.3.



as well as evaluating where climate-related factors may be inadequately addressed in current risk models and processes.

In this context, regulators and supervisors have emphasized that climate risk integration should focus on identifying and monitoring those risks that have, or may have, a material impact on institutions' financial health — i.e., their financial position (balance sheet and capital resources), financial performance (profits and losses) and liquidity position (BaFin, 2020; BIS, 2022b). In essence, the primary objective is to raise awareness among institutions about climate risks and their transmission channels, particularly those that manifest through conventional risk types and ultimately affect balance sheets, profitability and liquidity. In terms of conventional risks to focus on, the EBA has particularly stressed the relevance of credit risk in the context of climate risk integration for EU institutions (EBA, 2023). This emphasis stems from the fact that their activities and capital requirements are primarily driven by credit risk, as opposed to market or operational risks (EBA, 2023). As a result, this study pays particular attention to the relationship between credit and climate risks, especially when discussing Pillar 1 considerations.

Figure VII.1: Climate risk transmission channels.



*Remark:* The figure illustrates the channels through which climate risks may affect prudential risk types and, in turn, the financial position, financial performance and liquidity performance of institutions. It is based on BaFin (2020); EBA (2022b); BIS (2022b); Acharya et al. (2022). Note that the risks included in the taxonomy are not exhaustive.

## VII.2.2 Literature review

What are the motivations for supervisors and credit institutions to integrate climate risks into their prudential and risk management frameworks? In this section, we discuss the growing empirical literature on both the relevance and the implications of climate risks for these actors.<sup>16</sup>

While the scope of their involvement remains a subject of ongoing debate (see e.g., Hellwig, 2022; Demekas and Grippa, 2022, 2024), central banks are key actors in the discussion on climate-related risk management. Climate risks are becoming increasingly important to these institutions on two fronts: price stability and financial stability. In the euro area, the ECB has a primary mandate to pursue price stability by ensuring that inflation remains low, stable and predictable.<sup>17</sup> An emerging strand of literature shows that climate risks can contribute to inflationary pressures, making these developments relevant for the ECB to monitor and incorporate into its inflation forecasts. Thus, the ECB's price stability objective is seen as part of the justification for the climate-related policies it has introduced in the last years (Faccia et al., 2021; van 't Klooster and de Boer, 2022).<sup>18</sup>

On the one hand, climate change, in particular its physical manifestations, may disrupt supply chains and production processes and reduce agricultural yields, all of which have important implications for inflation dynamics and economic output (Acharya et al., 2023). For example, Pankratz and Schiller (2022) show that weather shocks (extreme heat and floods) negatively affect the financial performance of suppliers and that the financial impact of these shocks is transmitted to customers through existing supply chain links. Faccia et al. (2021) provide evidence for the impact of extreme temperatures on price development as captured by different measures of prices, including consumer and producer prices. Ciccarelli et al. (2024) assess the four largest euro area economies (Ger-

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<sup>16</sup>For extensive literature overviews on the effects of climate risks on financial market participants, see de Bandt et al. (2023), Eren et al. (2022) and Giglio et al. (2021).

<sup>17</sup>See Art. 127 (1) of the Treaty on the Functioning of the European Union (TFEU). Price stability is currently defined by a 2% inflation target over the medium term.

<sup>18</sup>The ECB's second mandate to support broader economic policies by and in the EU is also partly seen as an element of this justification, although we do not discuss this mandate in detail (van 't Klooster and de Boer, 2022).

many, France, Italy and Spain) and find that hotter summers lead to upward pressures in terms of food inflation and service inflation. De Winne and Peersman (2021) report that extreme weather events, such as droughts and heatwaves, influence fluctuations in global agricultural commodity prices and impact economic activity of both advanced and developing countries. Finally, Bilal and Känzig (2024) find that every additional 1°C rise in the average temperature on earth means a 12 percent hit to global Gross Domestic Product (GDP), arguing that the macroeconomic effects of climate change have so far been largely underestimated.

On the other hand, climate change may also pose a threat to the overall stability of the financial sector. As noted earlier, climate risks represent a new risk driver that can affect institutions' financial position (balance sheet), financial performance (income statement – P&L) and liquidity position.<sup>19</sup> In this context, these risks are not only of concern to central banks in their role as supervisors, but also a factor that institutions are increasingly required to take into account. In terms of mechanisms, there are three key channels through which climate risks are expected to affect institutions: the credit, market and liquidity risk channels (Acharya et al., 2023; de Bandt et al., 2023).

To illustrate the credit risk channel, climate risks may affect loan books, with both transition and physical risks reducing borrowers' ability to repay their outstanding loans and increasing their default rates (Acharya et al., 2023; Cepni et al., 2024). For example, this may hold for loan exposures to borrowers in sectors with high carbon emissions, facing higher operating costs as a result of regulatory interventions. Similarly, extreme weather events may lead to the destruction or depreciation of physical assets, resulting in higher default probabilities for corporate loans and mortgage loans (Cepni et al., 2024). Ultimately, this may potentially translate into increased loan losses for the banks (Brei et al., 2019).

Nevertheless, the empirical evidence on the credit risk channel is mixed. In par-

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<sup>19</sup>To understand the potential effects of climate risks on institutions' financial position and financial performance, it is useful to recall the structure of banks' balance sheets and the link with their P&L. On the asset side, institutions typically hold cash, loans (loan book) and trading assets (trading book). On the liabilities side, institutions typically have deposits, short-term and long-term debt (e.g., obligations and commitments related to derivatives contracts) and equity. Net income (from the P&L) increases equity, while a net loss decreases it.

ticular, while transition and physical risks are a source of financial risk for borrowers (see e.g., Ehlers et al., 2022; Seltzer et al., 2020), the effects on institutions' financial position and financial performance are contrasted. This may be due to factors such as composition and maturities of loan portfolios, but also to differences in the types of institutions (large, well-diversified institutions versus smaller and more local ones) and the wide range of climate risks considered (carbon taxes, heat, flood, etc.). So far, a large strand of the literature has focused on the link between physical risks and institutions' profitability. For example, Blickle et al. (2021) report that weather disasters in the last quarter century had limited effects on U.S. banks' performance. The authors find that loan losses tend to be offset by an increase in loan demand after the disasters, boosting profits at larger banks. On the contrary, Schubert (2021) reports that flood shocks negatively affect U.S. banks' performance, as measured by the return on assets (ROA). Ge et al. (2022) and Sastry et al. (2024) observe that the underlying assets of U.S. institutions with large real estate portfolios in climate-vulnerable regions (e.g., coastal areas prone to sea-level rise) are at risk of increased losses due to rising trends in insurance premiums, insurance company withdrawals and a decline in the quality of insurance quality. Vollmar and Wening (2023) analyze the effects of heat on regional institutions in Germany and find a negative impact in terms of profitability (ROA) for institutions servicing industries in heat-affected regions compared to institutions in less heat-affected regions. On the transition risks side, while there is evidence that institutions are managing these risks, including by adapting their lending, re-balancing their portfolios within borrower industries and adjusting their pricing (see e.g., Chava, 2014; Delis et al., 2019; Ivanov et al., 2023; Martini et al., 2023), their impact on bank performance is less evident. For example, Jung et al. (2023) find that the credit exposures of U.S. institutions to transition risks are modest and, on average, do not exceed 14% of their loan portfolios under several scenarios. Referring to an ECB study (Emambakhsh et al., 2023), the authors also underscore that "expected losses of European banks' credit portfolios are minimal, around 0.7% of the total loan exposure under both the accelerated and the delayed transition scenarios" (p. 5, Jung et al., 2023).

While the credit risk channel is widely regarded as the most relevant one for banks

(EBA, 2023), market risk is considered the second most critical. Market risk refers to the potential for losses arising from fluctuations in market prices, including the risk of losses from trading assets held in the trading book and the potential for losses due to foreign-exchange risk or commodity risk from assets in the banking book (EBA, 2023). Bonato et al. (2023a) analyze the role of climate risks in forecasting realized volatility of exchange rate returns of major fossil fuel exporters and find that climate risks (temperature, wind, precipitation) have incremental out-of-sample predictive value for exchange rate volatility. In a follow-up study, Bonato et al. (2023b) report that climate risks have predictive value for realized stock market volatility at the U.S. state-level. Bertolotti et al. (2019) analyze the impact of physical events on the stocks of U.S. electric utilities and find significant market price reactions after hurricanes. Additionally, since climate risks are anticipated to affect future cash flows, market risk also relates to the effects of such risks on the present-day values of financial assets Acharya et al. (2023). For example, if climate risks are considerably under-priced, changes in investor perception may lead to re-pricing of assets and, potentially, to losses for asset holders such as banks (Demekas and Grippa, 2024). A large strand of the literature therefore focuses on the extent to which climate risks explain stock market returns (see e.g., Bolton and Kacperczyk, 2021; Ardia et al., 2023; Aswani et al., 2023), are priced on stock and bond markets (see e.g., Huynh and Xia, 2020; Painter, 2020; Acharya et al., 2022) and affect investor beliefs (see e.g., Bakkensen and Barrage, 2021; Ceccarelli and Ramelli, 2024).

Finally, in addition to credit and market risks, there is also a potential liquidity risk channel to consider (Acharya et al., 2023). However, this channel appears not very well understood to date and research remains limited (de Bandt et al., 2023). So far, there is empirical evidence that climate risks may lead to both decreases and increases in deposit withdrawals after major disasters. For example, Choi et al. (2022) find that institutions with a poor environmental reputation are more likely to face a decline in their branch deposits in regions exposed to severe physical risks. In some cases, climate risks, particularly physical risks, are shown to increase loan demand, which offsets losses but puts pressure on liquidity buffers. Brei et al. (2019) report that following natural

catastrophes (hurricanes) institutions face large deposit withdrawals and experience a negative funding shock to which they respond by reducing their loan supply and drawing on their liquid assets. Koetter et al. (2020) study the role of German local banks in the context of natural disasters (flooding) and find that local banks that are domiciled in unaffected counties but are exposed to disaster-ridden firms in affected counties lend 3% more in the post-flood period compared with unexposed local banks. Cortés and Strahan (2017) find that institutions are incentivized to cut lending from markets unaffected by natural disasters in order to have enough liquidity to support disaster-affected markets facing increased credit demand.

## VII.3 Research method and sample

### VII.3.1 Semi-structured interviews

We adopt an empirical approach based on semi-structured interviews with risk experts, combined with insights from archival data, primarily from Pillar 3 reports. This approach allows us to gather information on both the climate-related risk management practices of institutions and the experiences and views of practitioners. We also use data from the Pillar 3 reports to guide and refine our interviews. This data proved particularly helpful in gaining an overview of the climate-related risk management processes in place. Finally, we analyze supervisory and regulatory guidelines to gain a deeper understanding of the expectations and recommendations set by supervisors and regulators.

We conducted semi-structured interviews with risk experts mainly from significant institutions that are directly supervised by the ECB and subject to the CRR. The ECB maintains and regularly updates a public list of these institutions (ECB, 2024d). For our study, we used the list as of January 1, 2023 and selected institutions classified as “credit institutions”. We particularly focused on institutions established in Germany due to our geographical proximity and personal contacts, which contributed to a higher response rate. As of January 1, 2023, the ECB’s list of supervised entities included 18 SIs established in Germany. Our sample covers experts from 12 of these institutions

(approximately 67%). Furthermore, we also targeted experts of large credit institutions established in France and the Netherlands. Our sample covers three of these institutions. In addition, our sample includes one expert from a Less Significant Institution (LSI) in Germany that is preparing for ECB supervision and thus actively integrating climate-related risks.<sup>20</sup> Finally, we conducted one interview with an expert in PD modeling and stress testing from a large German institution that is exempt from the scope of the CRR, but is subject to key banking regulations and supervised by the German banking supervisory authorities. To sum up, our sample includes 17 institutions, of which 15 are credit institutions currently directly supervised by the ECB.

We identified respondents through LinkedIn and via personal recommendations. Employees of relevant institutions were screened on LinkedIn using keywords such as “climate risk”, “ESG risk”, “credit risk”, “credit risk modeling”, “risk controlling”, “risk management”, “stress testing”, “scenario analysis”, “IRB”, “rating”, “PD model”, “environmental risk”. This process led to 62 potential respondents being contacted. Overall, 30 risk experts participated, which corresponds to a high response rate of 48%. The breakdown of respondents is presented in Table VII.1. To maintain full anonymity, the names of the respondents and their institutions are not disclosed. Furthermore, we deliberately use the pronoun “they” instead of “she” or “he”. Each respondent is assigned a “respondent ID”, and each institution receives an “institution ID”, which are used to present our findings. As can be seen, our sample includes experts from various risk-related functions, offering different perspectives on climate risk integration, covering both Pillar 1 and Pillar 2 aspects. Furthermore, our sample includes a wide range of large private commercial institutions (53%), public institutions (35%) and cooperative institutions (12%), with total assets ranging from EUR 30 billion to over EUR 1,000 billion.

The decision to use semi-structured interviews, rather than a traditional survey with a set of pre-defined answers, provided several important advantages for our research.

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<sup>20</sup>LSIs have been explicitly invited by the ECB to apply its climate-related expectations in a manner that is proportionate to the nature, scale and complexity of their activities (ECB, 2020b). Furthermore, 79 LSI participated in the 2022 thematic review on climate-related and environmental risks (ECB, 2022e).



First, this approach allowed us to ask detailed questions about climate risk integration and thus better capture the complexity of the topic at hand. In addition, by allowing respondents to freely express their thoughts and views, we encouraged a more open and nuanced discussion, shedding light on the challenges currently faced. Second, the flexibility of the interviews enabled us to tailor questions to each respondent's specific background, responsibilities and expertise. While we adhered to a core set of questions, some respondents had specific expertise in areas such as stress testing, while others had broader risk management roles, allowing us to explore certain topics in more depth in individual interviews. Importantly, we carefully selected respondents to ensure they had substantial expertise in their respective fields. Third, the interviews allowed respondents to introduce additional topics or concerns. This approach enabled us to incorporate insights from earlier interviews into subsequent ones, integrating emerging themes as they arose (Hummel and Bauernhofer, 2024).

The interviews were conducted in German or French and structured around open-ended questions. Each interview lasted approximately 60 minutes. The interviews were conducted between February and November 2024. Prior to the interviews, respondents were asked for their consent to be recorded using an audio recorder. We transcribed the interviews verbatim, resulting in about 500 pages of text. Key excerpts from the interviews were later translated into English. Thematic analysis was undertaken based on the interview transcripts (Braun and Clarke, 2006). Using the software program MAXQDA Plus 2020, we carefully examined each interview transcript to perform qualitative data coding. This process allowed us to identify significant themes and refine our conceptual framework, presented in Section VII.3.3. This framework serves as the foundation for the structure of this study.

Table VII.1: Sample composition.

| Respondent ID | Respondent expertise and/or role                                    | Institution ID | Total assets     | Country     |
|---------------|---------------------------------------------------------------------|----------------|------------------|-------------|
| A1            | Director Regulatory Policy, Capital & Liquidity                     | A              | EUR 30-50 bn     | Germany     |
| A2            | Senior Stress Testing Expert                                        | A              | EUR 30-50 bn     | Germany     |
| A3            | Risk Expert Stress Testing Expert                                   | A              | EUR 30-50 bn     | Germany     |
| B1            | Director Risk Methods, Risk Controlling                             | B              | EUR 30-50 bn     | Germany     |
| B2            | Manager Risk Management                                             | B              | EUR 30-50 bn     | Germany     |
| C1            | Executive Director, Climate Risk                                    | C              | EUR 50-75 bn     | Germany     |
| C2            | Expert Credit Risk and Market Capital                               | C              | EUR 50-75 bn     | Germany     |
| D1            | Senior Project Manager, Group Credit Risk Management                | D              | EUR 300-500 bn   | Germany     |
| D2            | Expert Risk Management                                              | D              | EUR 300-500 bn   | Germany     |
| E1            | Head of Department, Overall Bank Risk                               | E              | EUR 50-75 bn     | Germany     |
| F1            | Director Strategic Analytics                                        | F              | >EUR 1,000 bn    | Germany     |
| G1            | Head of Stress Testing Methodologies and Models                     | G              | >EUR 1,000 bn    | France      |
| G2            | Senior Risk Manager, Physical Risk Lead                             | G              | >EUR 1,000 bn    | France      |
| H1            | Expert ESG Risks                                                    | H              | EUR 500-1,000 bn | Germany     |
| H2            | Risk Manager Group Risk Controlling                                 | H              | EUR 500-1,000 bn | Germany     |
| H3            | Head of Department Stress Tests and Scenario Analysis               | H              | EUR 500-1,000 bn | Germany     |
| H4            | Stress Testing Expert                                               | H              | EUR 500-1,000 bn | Germany     |
| H5            | Expert Risk Controlling, ICAAP, ESG Risk Management                 | H              | EUR 500-1,000 bn | Germany     |
| I1            | Expert Rating Methodology, Risk Controlling & ESG Risk              | I              | EUR 150-300 bn   | Germany     |
| I2            | Group Manager Risk Controlling                                      | I              | EUR 150-300 bn   | Germany     |
| J1            | Head of Strategic Risk Control                                      | J              | EUR 30-50 bn     | Germany     |
| J2            | Director ESG Risk                                                   | J              | EUR 30-50 bn     | Germany     |
| K1            | Head of Model Risk Management and Validation                        | K              | EUR 75-100 bn    | Germany     |
| K2            | Expert Risk Controlling, Non-Financial Risk and Sustainability Risk | K              | EUR 75-100 bn    | Germany     |
| L1            | ESG Stress Testing Expert                                           | L              | EUR 30-50 bn     | Germany     |
| M1            | Expert Risk Controlling, Credit Risk Stress Test and PD Modeling    | M              | EUR 500-1,000 bn | Germany     |
| N1            | Managing Director Risk Controlling                                  | N              | EUR 150-300 bn   | Germany     |
| O1            | Global Head Risk Control                                            | O              | EUR 100-150 bn   | Germany     |
| P1            | Team Lead ESG Risk Management                                       | P              | EUR 500-1,000 bn | Netherlands |
| Q1            | Expert ESG Risk and Climate Risk                                    | Q              | EUR 150-300 bn   | Netherlands |

### VII.3.2 Archival data

We reviewed the 2023 Pillar 3 reports from the institutions in our sample. Although Pillar 3 reports (also known as regulatory disclosure reports)<sup>21</sup> were not the focus of specific interview questions (e.g., we did not ask the respondents to discuss the preparation of these reports or the challenges their institutions face in disclosing climate-related information), we used the content of these disclosures to gain insights into the institutions' climate-related risk management practices and to guide our interview questions. In addition, we used the qualitative information from the disclosures to complement our interview findings and offer a more comprehensive perspective of the risk management approaches employed by the institutions in our sample.

Under the CRR, Pillar 3 disclosures are mandatory disclosures for significant institutions (see Art. 431 of the CRR) and must be published at least annually (see Art. 433 of the CRR). The content of the disclosures is also largely determined by the CRR, which specifies technical criteria for the disclosure of risk management objectives and policies (see Art. 435 of the CRR), own funds (see Art. 437 of the CRR), capital requirements (see Art. 438 of the CRR), capital buffers (see Art. 440 of the CRR) and leverage (see Art. 451 of the CRR), among others. Thus, Pillar 3 reports contain important information on both Pillar 1 and Pillar 2 aspects. In addition to the above, these reports are typically organized by risk type (e.g., credit risk, market risk, operational risk, liquidity risk, reputational risk, model risk, etc.) and provide specific information on the institutions' exposure to and management of each risk type.

An important development is the requirement for Pillar 3 reports to include detailed information on ESG risks,<sup>22</sup> with a particular focus on physical risks and transition risks. Institutions whose securities are admitted to trading on a regulated market in the EU have to comply with the disclosure requirements pursuant to Art. 449a of the CRR.<sup>23</sup> In January 2022, the EBA published the final Implementing Technical Standard (ITS)

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<sup>21</sup>Pillar 3 of the Basel framework focuses on market discipline through prescribed public disclosures.

<sup>22</sup>Climate risks are typically treated as a subset of ESG risks and fall under the environmental pillar.

<sup>23</sup>While Art. 449a of the CRR itself does not specify the content of the ESG risk disclosures, it refers to Art. 98 (8) of the CRD, which, in conjunction with Art. 434a of the CRR, gives the EBA a mandate to develop an Implementing Technical Standard (ITS).

(EBA ITS 2022/01) on prudential disclosures on ESG risks, which defines the nature of these disclosure requirements and forms the basis for Implementing Regulation (EU) 2022/2453.

In particular, this ITS specifies the set of qualitative and quantitative information to be disclosed by institutions regarding ESG risks. Qualitative disclosures include information on business strategy, governance and risk management related to environmental risks, while quantitative disclosures cover exposures to transition risks (templates 1 to 4), exposures to physical risks (template 5) and mitigating actions (templates 6 to 10).<sup>24</sup>

### VII.3.3 Conceptual framework

Analyzing the interaction between climate risks and conventional risk types, as well as the integration of climate-related considerations, requires an understanding of the theoretical foundations of institutions' capital requirements and risk management. This brings the banking prudential framework (the “Basel framework”) into focus (Redondo and Aracil, 2024; EBA, 2021; Gruenewald et al., 2023).<sup>25</sup>

The Basel framework, developed by the BCBS, is an internationally agreed set of measures and standards for prudential regulation. The EBA participates as an observer in the Basel Committee and plays a crucial role in implementing the Basel standards within the EU (EBA, 2024). Far from being a set of loose guidelines, the Basel framework is directly applied in the EU through the CRR and the CRD.<sup>26</sup> The institutions in our sample operate under both the CRR and the CRD, making the Basel framework applicable to them. The framework itself is structured around three

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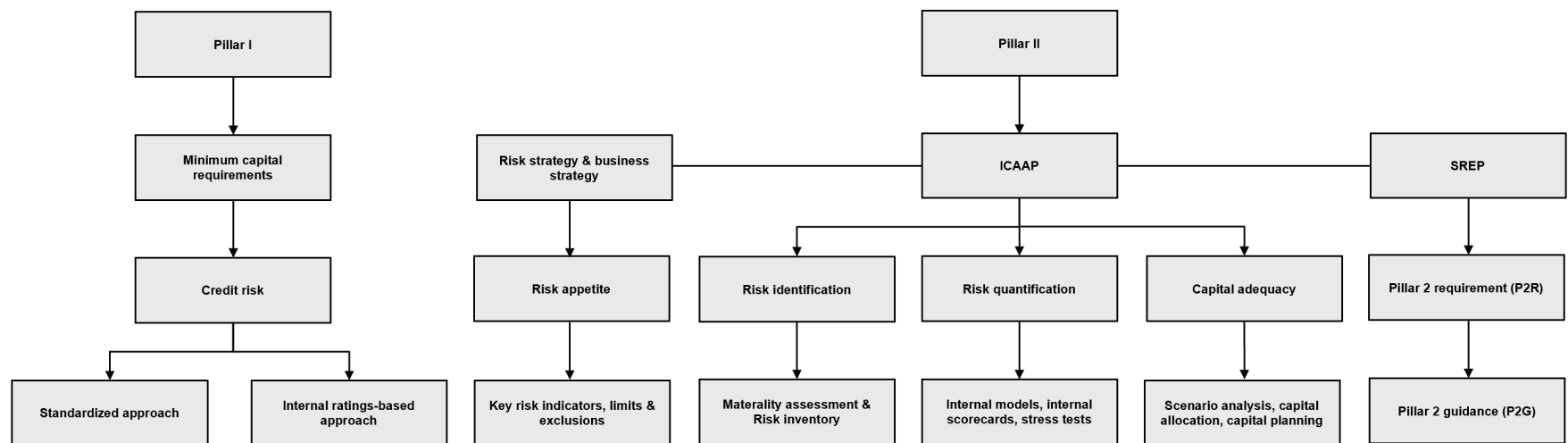
<sup>24</sup>See Implementing Regulation (EU) 2022/2453 of 30 November 2022 amending the implementing technical standards laid down in Implementing Regulation (EU) 2021/637 as regards the disclosure of environmental, social and governance risks.

<sup>25</sup>The Basel I Accord, introduced in 1988, established a framework for minimum capital requirements based on risk-weighted assets to ensure institutions held adequate capital to cover credit and market risks. In 2004, the Basel II Accord expanded this framework by adding operational risk alongside credit and market risks, introducing three pillars: minimum capital requirements (Pillar 1), the supervisory review process (Pillar 2), and market discipline through transparency (Pillar 3). The Basel III reforms, developed in response to the 2007-2008 financial crisis, aim to enhance institutions' resilience to financial and economic shocks by further strengthening risk management and addressing liquidity and funding risks.

<sup>26</sup>See Regulation (EU) No 575/2013 on prudential requirements for credit institutions and investment firms and Directive 2013/36/EU on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms.

fundamental pillars, which we explore further in this study. Specifically, we use key elements of Pillar 1 and Pillar 2 to guide our discussion of climate risk integration, as illustrated in Figure VII.2.

Figure VII.2: Conceptual framework.



*Remark:* The figure illustrates the conceptual framework of this study and outlines its main areas of focus within Pillar 1 and Pillar 2 of the Basel framework.

There are important differences between the two pillars, leading to different approaches, but also challenges, in integrating climate risks. Pillar 1 of the Basel framework focuses on minimum capital requirements for credit, market and operational risks. Capital requirements are determined as fixed percentages of RWA. The RWA is a measure of an institution's assets adjusted for the level of risk inherent to those assets. This level of risk is partly determined by a risk weight. The key idea is therefore to capture the relative riskiness of various assets on an institution's balance sheet (Holscher et al., 2022). The calculation of RWA is governed by a set of rules applied uniformly across institutions, aiming to establish consistent regulatory standards for risk-based capital requirements. An important metric under Pillar 1 is the Common Equity Tier 1 (CET1) ratio, which compares an institution's CET1 capital to its total RWA (i.e., the sum of credit RWA, market RWA and operational RWA). The primary goal of minimum capital requirements, along with regulatory buffers, is to ensure that institutions can absorb losses beyond expected levels and thus maintain an amount of capital necessary to be regarded as a viable going concern by creditors and counterparties (Holscher et al., 2022). Expected losses are typically covered ex-ante by risk-based pricing and through loss provisioning under International Financial Reporting Standard 9 (IFRS 9). Expected credit loss provisions are deducted from capital (Krüger et al., 2018).<sup>27</sup>

In recent years, both the BCBS and the EBA have published discussion papers on incorporating climate risks into the Pillar 1 framework (EBA, 2022b; BIS, 2022a). However, unlike credit, market and operational risks — where clear rules for calculating RWA are already well-established — neither the BCBS nor the EBA have proposed new, specific capital requirements, such as dedicated risk weightings, for assets exposed (or less exposed) to climate risks under this pillar.<sup>28</sup> Instead, the emphasis has been on how these risks can be more consistently integrated into the existing frameworks and

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<sup>27</sup>More specifically, expected credit losses are deducted from accounting equity, which is the starting point for regulatory capital, e.g., CET1. Provisions are not covered in detail in this study, but we touch upon some aspects in Section VII.4.3 and Section VII.4.5.

<sup>28</sup>For example, the EBA has so far ruled out the introduction of a green supporting factor, which would lower capital requirements for environmentally sustainable exposures by reducing risk weights or adjusting the RWA calculation (EBA, 2023). A similar instrument already exists under Pillar 1, however for small and medium-sized enterprises and infrastructure projects, allowing institutions to apply a discount factor, resulting in a downward adjustment in risk weights for SME and infrastructure-related exposures meeting certain eligibility criteria (EBA, 2023).

models, with a focus on credit risk and, to a lesser extent, market risk. For example, the ECB issued in 2024 an updated guidance on internal models, requiring institutions to incorporate material climate-related risk drivers into their existing Pillar 1 models for credit and market risks (ECB, 2024a).

Integrating climate risks into the existing Pillar 1 framework presents challenges due to several factors, including the framework’s rigidity, its short-term focus and its reliance on historical data for calculations (Gruenewald et al., 2023). In addition, a less explored issue in the literature is the potential for double counting. For example, internal models under Pillar 1, which are designed to quantify the specific risk of an exposure, already incorporate various risk factors that may implicitly account for some climate-related risks (EBA, 2022b). This broader context raises important questions about where climate risks may already be captured implicitly and where a more explicit approach is necessary.

In contrast, Pillar 2 of the Basel framework encourages institutions to implement individual risk management strategies for identifying, measuring and monitoring their risks beyond minimum regulatory requirements. Key components of this pillar include the ICAAP and the SREP. The ICAAP is characterized by an internal capital adequacy concept comprising an internal capital adequacy calculation, stress tests and capital planning processes (BaFin, 2018). It is closely linked to the development of both business and risk strategies, as well as risk management processes (BaFin, 2018). Supervisors evaluate the soundness of an institution’s ICAAP and overall risk management framework through the SREP. Based on their assessment, supervisors may prescribe or recommend the institution to hold additional capital (e.g., via the Pillar 2 Requirement or Pillar 2 Guidance) or take other corrective actions.

Compared to Pillar 1, the treatment of climate risk integration is more concrete for Pillar 2 (Smoleńska and van ’t Klooster, 2022; Gruenewald et al., 2023). The ECB’s 13 supervisory expectations regarding the integration of climate risks into risk management practices have placed significant emphasis on Pillar 2, particularly on the integration of these risks into the ICAAP. Notably, the ECB highlighted that the Guide on climate-related and environmental risks should be considered alongside the ECB guide to the



ICAAP, indicating that these two guides are complementary (ECB, 2018, 2020b). As the ICAAP is an internal and individual process, this also suggests that the integration of climate risks requires tailored approaches across institutions. Finally, the treatment of climate risk under Pillar 2 is also influenced by the integration of climate risks into the SREP, where the ECB now plays a critical role in reviewing how institutions manage these risks (Gruenewald et al., 2023).

What does the combined consideration of Pillar 1 and Pillar 2 imply for the integration of climate risks? Standardizing the treatment of such risks under Pillar 1 would likely contribute to establishment of consistent regulatory standards across all institutions, potentially resulting in higher minimum capital requirements for institutions exposed to climate risks. As Pillar 1 capital calculations often serve as the basis for further risk assessments under Pillar 2 (BaFin, 2018), a more systematic integration of climate risks into Pillar 1 may indirectly raise the baseline requirements and also impact capital considerations under Pillar 2.

The current guidelines and expectations for both Pillar 1 and Pillar 2 provide institutions with large flexibility in terms of implementation. This highlights the need to examine how individual institutions are integrating climate risks and the specific challenges they face in doing so. Furthermore, where climate risks act as drivers of other risk types, an important question emerges: to what extent, and how, are climate risks being factored into institutions' risk management and capital considerations? If climate risks are (or are to be) incorporated, it is crucial to understand the mechanisms through which this integration occurs, as well as how institutions and supervisors determine the capital resources needed. To support this analysis, Figure VII.2 illustrates the conceptual framework of our study and outlines the key areas that were the focus of our interviews.

## VII.4 Results

### VII.4.1 Pillar I: Integrating climate risks into the standardized approach (SA)

#### Background and rationale

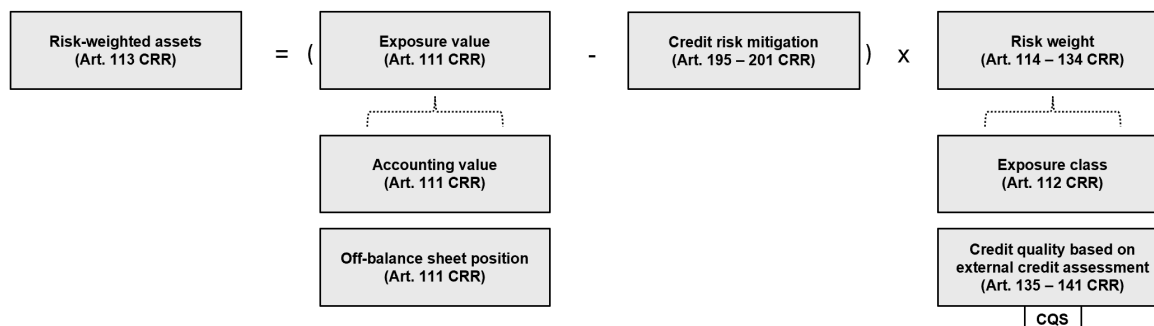
We start by discussing important features of Pillar 1 and explore both potential and existing approaches for integrating climate risks. As noted in Section VII.3.3, Pillar 1 focuses on the establishment of minimum capital requirements for three primary types of risk: credit risk, market risk and operational risk. Under this framework, capital requirements are calculated as fixed percentages of RWA based on these risk types (Holscher et al., 2022).<sup>29</sup> The EBA describes climate risks as a particularly relevant driver of credit risk, which in turn accounts for the largest share of institutions' total capital requirements (compared to the capital requirements resulting from market and operational risks) (EBA, 2022b).<sup>30</sup> As a result, our analysis of Pillar 1 focuses primarily on the interaction between climate and credit risks.

In this section, we delve into a key approach to credit risk: the standardized approach. Given its importance in determining capital requirements for credit risk under Pillar 1, we explore the main channel for integrating climate risks into this approach and address the challenges involved. As of June 2023, the standardized approach represented on average 54% of all credit risk-weighted exposure amounts in the EU (EBA, 2023). Several participants (A1, B1) pointed out the increasing regulatory shift towards this approach over internal models (further discussed in Section VII.4.2). A notable example of this shift is the introduction of an “output floor”, applicable as of January 2025, designed to prevent institutions from using internal models to significantly lower their capital requirements compared to the standardized approach (Smoleńska and van 't Klooster, 2022). Specifically, with the introduction of the output floor, the RWA calculated using internal models will not be allowed to fall below 72.5% of those calculated by

<sup>29</sup>For example, all institutions must hold capital equivalent to at least 8% of total RWA.

<sup>30</sup>The EBA notes that “credit risk is considered the most relevant part of the prudential framework, with RWAs attributable to credit risk accounting for over 80% of total RWAs” of credit institutions in the EU (see p.24, EBA 2022b).

Figure VII.3: Calculation of risk-weighted assets (RWA) under the standardized approach for credit risk.



*Remark:* This figure is based on Regulation (EU) No 575/2013 on prudential requirements for credit institutions and investment firms (CRR).

the standardized approach, limiting the potential capital benefit from internal models to 27.5%. The respondents observed that this restriction makes using internal models more challenging, which is likely to drive wider adoption of the standardized approach in the coming years.

Under the standardized approach, the RWA resulting from credit risk are calculated as the product of the exposure value (net of credit risk mitigation instruments) and a specific risk weight, as illustrated in Figure VII.3. A key feature of this approach is the reliance on external credit assessments (i.e., external credit ratings) to determine the risk weight (see Art. 135 of the CRR). These external credit assessments reflect an agency's opinion about the issuer's (i.e., the borrower's) ability to meet its financial obligations on time and in full. Each external credit assessment is assigned to a Credit Quality Step (CQS). The CQS, together with the exposure class, determine the risk weight. The exposure class depends on the type of issuer, such as corporate, retail or public sector entities (see Art. 112 of the CRR).

Only credit assessments from external credit rating agencies explicitly approved by the regulator are permitted.<sup>31</sup> Under the standardized approach, institutions have to formally nominate a rating agency whose credit ratings they will use. Consequently, the degree to which climate risks are integrated into the standardized approach —

<sup>31</sup>A list of such rating agencies is published by the EBA and regularly updated (see Art. 135 of the CRR).

and thus into the calculation of the risk weight and, indirectly, the minimum capital requirements for credit risk — largely depends on the selected agency, its methodologies and its approach to incorporating climate-related factors into credit risk assessments.

The EBA has already extensively discussed this issue, identifying two primary challenges in this context (EBA, 2022b, 2023). First, the degree to which credit rating agencies incorporate climate risks into their credit assessments varies significantly from one to the other, leading to an inconsistent treatment of such risks across the industry. Second, the EBA also pointed to a lack of transparency in the methodologies used by credit rating agencies. In particular, the specific ways in which these agencies incorporate climate risks into their ratings are often unclear, making it difficult for institutions to fully understand whether and how climate-related factors influence their final rating decision.

### **Credit ratings and dialogue with rating agencies**

In our sample, all but one institution (A) rely on internal models to calculate capital requirements for credit risk. In this section, we build on the EBA’s earlier observations by adding two key insights shared by a respondent (A1) from this institution and exploring the challenges that were highlighted.

First, the respondent stressed that large, globally operating institutions heavily rely on the three major credit rating agencies — Moody’s, Standard & Poor’s and Fitch. This expert noted that their institution uses ratings from all three, rather than opting for smaller, less established agencies that have more limited coverage. Currently, the broad coverage provided by these agencies is considered to outweigh concerns about their treatment of climate risks. Therefore, the extent to which climate risks are integrated largely depends on how these three leading agencies, in particular, incorporate such factors into their ratings:

*“If you are a globally operating bank, then there is a certain expectation in the market that you will use these rating agencies [Moody’s, Standard & Poor’s and Fitch]. But if you are a specialized bank, such as the Umweltbank, where sustain-*

*ability is part of the core strategy, then I could imagine that you might try to take a closer look at the sustainability criteria applied by the rating agencies and their coverage of climate risks. In this case, you might also select a smaller agency with a stronger sustainability focus.” (A1)*

At this stage, it is also important to note that the European Securities and Markets Authority (ESMA), which oversees the rating approval process, conducted an assessment in 2019 of the extent to which credit ratings take into account ESG factors (ESMA, 2019). The ESMA concluded that such factors, including climate-related factors, are taken into account in credit ratings, but that their importance and incorporation varies across asset classes. In addition, the ESMA advised against amending the regulation governing credit rating agencies to more explicitly account for ESG-related factors in credit risk assessments (ESMA, 2019).

Our respondent also pointed out that direct dialogue between institutions and rating agencies regarding their methodologies is rather rare. In practice, external ratings are imported into internal systems that assign the appropriate risk weights. As a result, this respondent believed it is unlikely that an institution could influence a rating agency’s methodology to better incorporate climate risks unless the agency is already doing so.

An exception to this may arise with the implementation of the CRR III, which is due to take effect in January 2025. Specifically, the CRR III amends Article 138 of the CRR, restricting the use of credit ratings that include assumptions of implicit government support. While this regulation applies to credit ratings for certain financial institutions rather than corporates, the respondent viewed it as an opportunity for institutions to re-examine rating methodologies more broadly:

*“New regulations could drive a broader discussion on rating methodologies. A clear example is the implementation of CRR III, where institutions, when assessing other institutions as counterparties, will only be allowed to use ratings that exclude embedded government support. This is likely to prompt institutions to engage with their credit rating agencies and take a closer look at the underlying methodologies,*

*as such ratings are currently quite limited.” (A1)*

## VII.4.2 Pillar I: Integrating climate risks into internal models (IRB)

### Background and rationale

Most institutions in our sample use internal models under Pillar 1 to calculate RWA from credit exposures. This section outlines the key features of these internal models for credit risk, while the following sections consider approaches to integrating climate risks and discuss the main challenges highlighted by our respondents.

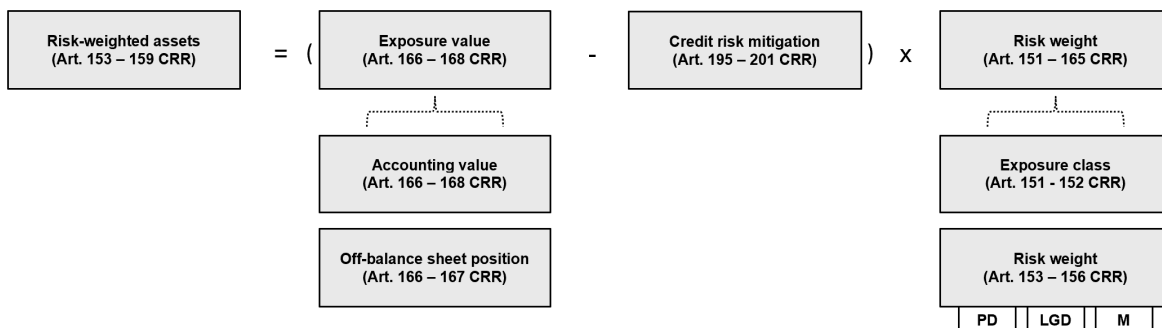
With internal models and the Internal Ratings-Based Approach (IRB), institutions use their own modeling techniques and internal data to estimate key credit risk parameters. There are two types of internal models for credit risk: the Foundation Internal Ratings-Based Approach (F-IRB) and the Advanced Internal Ratings-Based Approach (A-IRB). Under the F-IRB, institutions model only the PD using their internal approach. In contrast, under the A-IRB, institutions can also estimate their own Loss Given Default (LGD) and Exposure at Default (EAD). Both approaches share the common feature that institutions develop their own PD models for credit risk exposures based on internal ratings, which help categorize borrowers by their risk of default. These models are subject to supervisory approval and have to fulfill a set of requirements set forth in the CRR.

Figure VII.4 illustrates the calculation of RWA under the internal ratings-based approach. As shown, the credit risk parameters associated with the internal rating play a key role. The input parameters PD, LGD and Maturity (M) influence the risk weight and ultimately determine the RWA.<sup>32</sup>

An important development introduced in the latest revision of the ECB guide to internal models is the expectation that institutions incorporate material climate risks

<sup>32</sup>Note that several parameters, including PD, LGD, M and Credit Conversion Factors (CCFs), are involved in credit risk modeling (see EBA, 2023). This study focuses on the integration of climate risks into internal ratings, particularly in relation to PD considerations.

Figure VII.4: Calculation of risk-weighted assets (RWA) under the internal ratings-based approach (IRB) for credit risk.



*Remark:* This figure is based on Regulation (EU) No 575/2013 on prudential requirements for credit institutions and investment firms (CRR).

in their internal models for credit risk (ECB, 2024a). Specifically, the ECB stated that “where climate-related and environmental risks drivers are found to be relevant and material, institutions should include such risk drivers in their internal models approved for use for the calculation of own funds requirements for credit and market risk” (p.13, ECB 2024a). In addition, the EBA also commented on the integration of climate risks into internal models for credit risk and formulated specific recommendations (EBA, 2023). In particular, the EBA noted that as the “impact of climate risks on defaults and loss rates becomes available, institutions should reflect these risks in their PD and LGD estimates through a re-development or recalibration of their rating systems in the long term” (p.58, EBA 2023).

Overall, these expectations and recommendations have important implications, both in terms of Pillar 1 and Pillar 2 aspects. The direct implication is that institutions are required to test and evaluate whether climate-related risk drivers are a material predictor of credit risk within their portfolios.<sup>33</sup> If they are, the ECB guide to internal models suggests that climate risks should be incorporated into internal ratings-based models and thus into PD modeling (and LGD modeling, depending on whether F-IRB or A-IRB is in place), requiring a comprehensive review of the modeling process. In addition, it also raises important questions about how climate risks are to be incorpo-

<sup>33</sup>For example, univariate analysis is commonly applied to assess the discriminatory power of risk drivers, after which relevant data is integrated as independent risk drivers in regression models (e.g., logistic regressions) aimed at predicting the default target variable.

rated, e.g., by adding risk factors quantitatively into the models or indirectly through the use of overrides and additional margins of conservatism.

Institutions face further implications. For example, testing whether climate risks are a material predictor of credit risk requires access to comprehensive, high-quality data on relevant risk drivers integrated into a reference data set (EBA, 2023). In cases where such quantitative data is lacking, institutions have to establish processes and implement tools to collect the necessary climate-related information. These tools and processes are essential components of the risk identification, risk inventory and risk quantification processes under Pillar 2, as discussed in Section VII.4.3. While the ECB stresses the importance of integrating “material” climate risks into the models, it does not prescribe specific approaches for assessing materiality. As shown in Section VII.4.3, institutions have adopted different approaches to evaluate the materiality of climate risks.

Finally, another important consideration, raised by several respondents, is that while institutions may use internal models for credit risk, the models themselves may not always be developed in-house, but rather provided by external vendors. For example, they noted that many German “Landesbanken”, which are supervised by the ECB, rely on a rating tool developed by Rating Service Unit GmbH & Co. KG (RSU). Similarly, German savings institutions (“Sparkassen”) commonly rely on a tool developed by Sparkassen Rating und Risikosysteme GmbH (SR) for their rating systems. To ensure that these institutions integrate material climate risks into their capital considerations under Pillar 1, it is therefore essential to also assess the methodologies of these external model providers.

In the following sections, we examine the approaches described by the respondents for integrating climate risks into internal ratings-based models and discuss the associated challenges and implications, with a primary focus on PD considerations. Figure VII.5 provides a simplified representation of the rating process in the context of internal ratings-based approaches, illustrating the link between the rating and the final PD (see EBA (2017) for a detailed explanation of the PD estimation process). Ratings are typically based on a combination of quantitative and qualitative rating criteria or



risk drivers, which we discuss in Section VII.4.2. One approach to integrating climate risks is to incorporate climate-related factors quantitatively, either as new risk drivers or through adjustments to existing rating criteria. Institutions may also apply overrides in the rating process when “individual circumstances, related to a given obligor or exposures, cannot be reasonably captured by the model” (p.12, EBA 2017). These overrides offer an indirect way of accounting for climate risks. In addition, model recalibration may be necessary, meaning that the weights assigned to certain risk drivers may need to be adjusted to better account for climate risks as reflected in historical data. The final PD typically includes a MoC to account for uncertainties in the best estimate of the risk parameter (EBA, 2017). This margin may also be applied to address data limitations, such as inadequate or incomplete climate-related data, and other sources of uncertainty (BIS, 2022a).

### Materiality

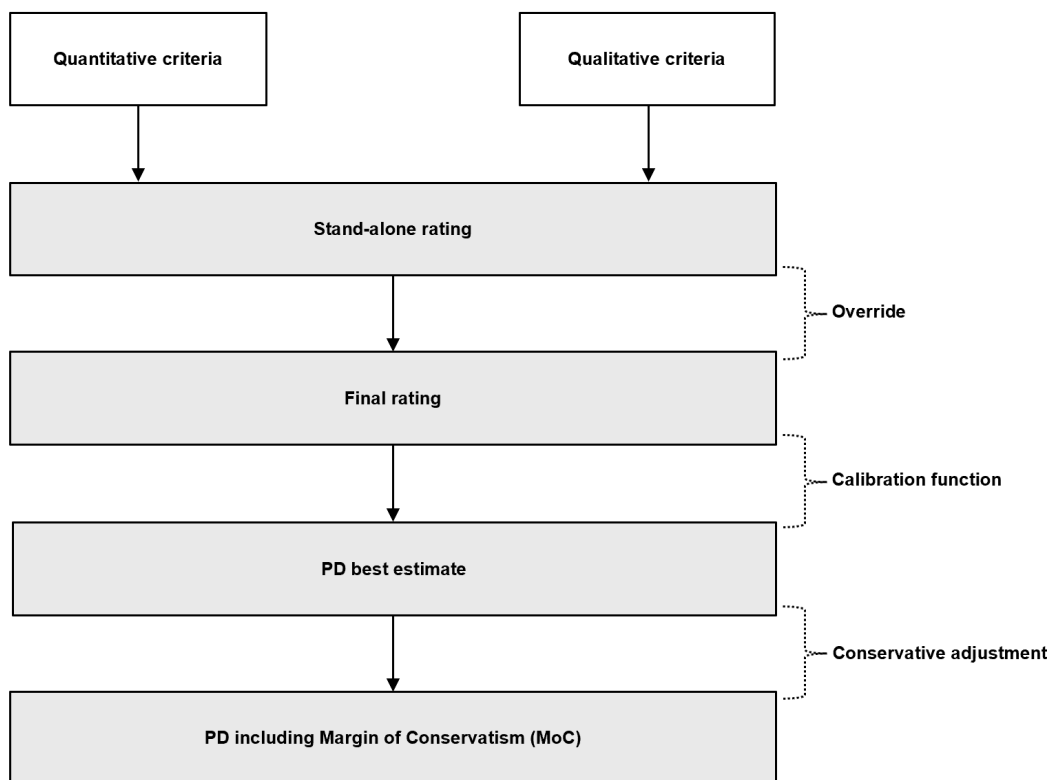
As outlined in Section VII.4.2, the ECB expects internal ratings-based models to incorporate climate risks when they are identified as material risk drivers (ECB, 2024a). This expectation brings the concept of materiality into focus and calls for a discussion of its interpretation in the context of the Pillar 1 framework. Our analysis shows that nine institutions in our sample report in their Pillar 3 disclosures that climate risks are considered to be material for credit risk exposures. Of these, one institution (C) quantitatively integrates climate risks into its PD models (for corporates) under Pillar 1. One of the respondents (C1) from this institution explained:

*“We incorporate climate risk into our ratings. The assessment feeds into the models. The corporate rating model/PD including a climate risk assessment is used for capital calculations under the foundation IRB approach approved by the ECB. Therefore, we consider a climate risks assessment to calculate capital.” (C1)*

The remaining institutions adopt a more indirect approach, primarily through the use of rating overrides,<sup>34</sup> as discussed in Section VII.4.2. At present, although all

<sup>34</sup>An override is a manual upgrade or downgrade of a stand-alone rating. See Figure VII.5 for an

Figure VII.5: From stand-alone rating to PD estimation under the internal ratings-based (IRB) approach.



*Remark:* This figure illustrates the steps from stand-alone rating to final PD estimation under the IRB approach. It is based on a framework from Prof. Dr. Stefan Reitz and EBA (2017).

institutions in our sample have developed some form of internal climate (or ESG) scoring methodology, these scores are generally not quantitatively integrated into PD models under Pillar 1. Some institutions (e.g., D) indicate in their disclosure reports that climate risks only become material over a period of at least five to ten years. However, even among those institutions (e.g., I) that find a material effect of climate risks over a shorter time horizon of one to five years, these risks are not directly integrated into the models as a distinct risk factor. For example, one of the institutions (B) states in its Pillar 3 report that both physical and transition risks exhibit “relevant impact correlations” for credit risk. An expert (B1) from this institution offered a counter-argument regarding the quantitative integration of climate-related risks in the Pillar 1 framework:

illustration.

*“If a supervisor were to question our model and ask why climate risk is not considered material, I would argue that we have not observed climate-related defaults in the past. It doesn’t show up significantly in our historical data, and so from a statistical perspective, I can’t incorporate it into the model as a material risk driver (...). What we are doing now is looking at the defaults that occurred last year, for example, and also looking at whether they were driven by climate risk. In this way, we can practically build a dataset step by step that we can use as a basis for modeling purposes in the future. However, this process will take time, likely more than a year or two, because we still lack sufficient default rates and empirical data to produce statistically reliable results. It is a gradual process.” (B1)*

Similarly, another institution (H) highlights in its disclosure report that the impact of transition and physical climate risks on credit risk is considered material over the short, medium and long term. A risk expert (H1) from the institution stressed the need to distinguish between a “forward-looking” and a more “backward-looking” definition of materiality. Most materiality assessments — and the corresponding statements — focus on future impacts and forward-looking assessments.<sup>35</sup> In contrast, the definition of materiality under Pillar 1 is one that is more grounded on historical data and thus based on backward-looking assessments:

*“We are not including the ESG scorecard in our PD model as it stands today. In other words, we say it is not material at this point. I am aware that we have written in another document that climate and environmental risks are material to us. Let me clarify this contradiction. In PD models, you have to look at which risk drivers explain which aspects in the past. In particular, which risk factors help to distinguish clients who have not defaulted from clients who have defaulted in your historical data. All of the aspects that help explain this distinction are essential and have to be included in the models (...). Again, it is based on historical data. However, we believe that climate risk is a phenomenon of the future. It is not a*

<sup>35</sup>See Section VII.4.3 for a discussion of current approaches to materiality assessments.

*phenomenon of the past. And this line of reasoning leads us to say that climate-related credit risks are not a material aspect in terms of Pillar 1 and in terms of historical time series. Therefore, we do not think it is appropriate to include them in our models today. So why do we talk about material risks in this risk inventory? It is explicitly about forward-looking risks. And we definitely see climate risks as a material risk driver in the future.” (H1)*

Overall, the materiality debate highlights a discrepancy between the forward-looking and backward-looking perspectives. The absence of significant climate-related defaults in historical data sets makes it difficult for some institutions to justify the inclusion of these risks into current models, even though their materiality is expected to increase in the future. This discrepancy may diminish over time as climate risks become more apparent in the data. Furthermore, the fact that one institution has already begun to quantitatively integrate climate risks into its PD models shows that such integration is possible and is likely to become more widespread in the future.

### **Rating criteria and climate-related scores**

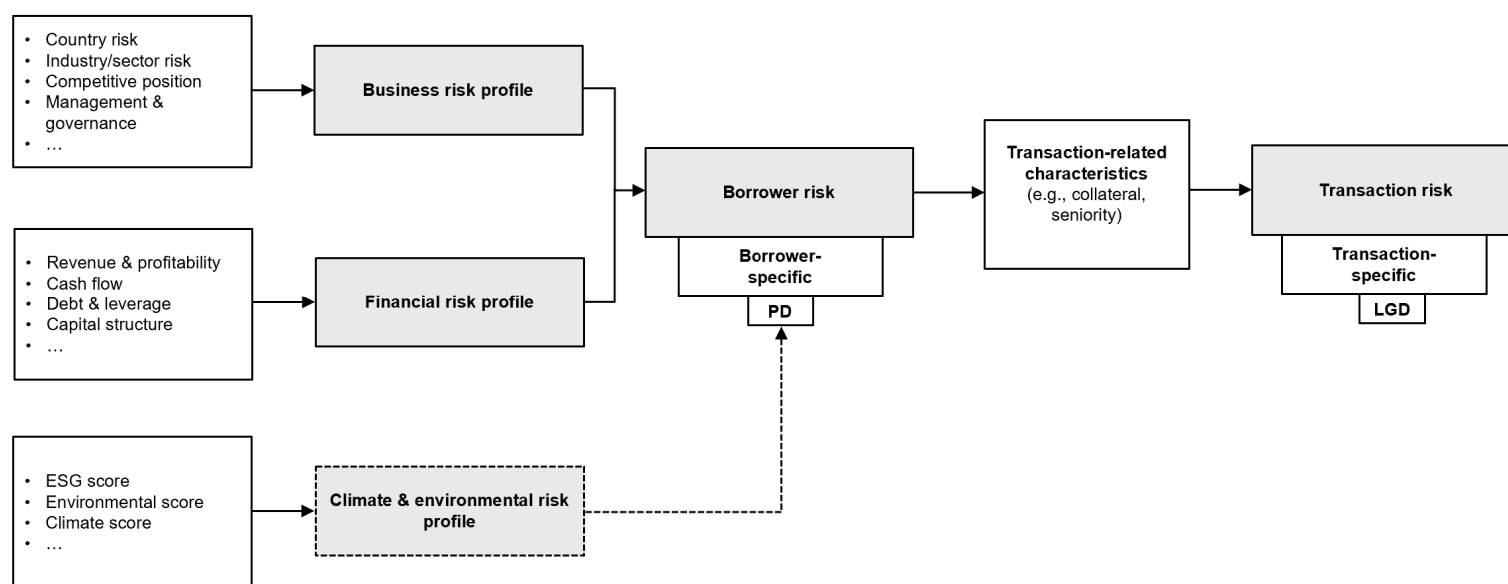
As shown in Figure VII.5, institutions using the internal ratings-based approach rely on their own rating systems and data to estimate a client’s PD. In addition to these rating systems, all institutions in our sample have developed and implemented internal ESG scoring methodologies, including climate-related scores, to assess and quantify climate risks. These climate-related scores are generally evaluated alongside credit ratings. In this section, we explore key considerations related to these climate scoring methodologies and discuss some of the challenges they present from a Pillar 1 perspective.

Institutions’ internal rating systems have to ensure a meaningful assessment of client and transaction characteristics, a clear differentiation of risk levels and consistent quantitative estimates of risk (see Art. 144 of the CRR) (ECB, 2024a). At the PD model level, this requires an appropriate selection and calibration of relevant risk drivers. In particular, the selected risk drivers have to contribute to the discriminatory power of the rating system, ensuring that such system is able to consistently and accurately

distinguish between defaulted and non-defaulted obligors (ECB, 2024a). As of today, there is no mandatory list of specific risk drivers to be incorporated into internal rating systems. However, risk drivers are expected to capture relevant information on financial and non-financial characteristics of clients that are indicative of their creditworthiness.

Figure VII.6 provides a simplified illustration of key risk drivers for PD estimation, including quantitative and qualitative factors, such as financial ratios and competitive positioning (ECB, 2024a). For PD models targeting exposures to large corporates, key risk drivers also include the industry, the country (or global region), and company size (e.g., total turnover) (ECB, 2024a). Institutions are also required to take into account “significant changes in the economic, legal or business environment within the historical observation period” (p.69, EBA 2017). Typically, the business and financial risk profiles are quantitatively integrated into the internal rating process, directly impacting stand-alone ratings and PD estimates.

Figure VII.6: Risk drivers for PD and LGD estimation.



*Remark:* This figure provides a simplified illustration of key risk drivers for estimating borrower and transaction risk. It is based on EBA (2017) and ECB (2024a).

Several respondents (B1, D1, I1, O1) argued that climate risks are already captured by existing quantitative and qualitative rating criteria within current rating systems. Internal ratings typically take into account factors such as a client's financial performance, industry risk, business model and competitive positioning, as illustrated in Figure VII.6. As a result, climate risks that are financially material in the short term are implicitly incorporated into PD estimates. For example:

*“Our internal rating procedures under Pillar 1 follow the foundation IRB approach. Climate risks are implicitly accounted for, as these procedures include an evaluation of the client's business model. This allows for the identification of clients operating in industries that are exposed to significant transition risks.” (O1)*

*“It is essential to incorporate all material factors influencing PD into the models — this is non-negotiable. The central question becomes whether there is any factor that is not yet in the model or implicitly included. For example, is there anything additional beyond what is already captured by financial ratios like operating profitability or current financial liabilities, or by qualitative factors such as market position? These aspects are already part of the rating process (...). Elements that affect sales, earnings and the financial structure are already embedded in our model.” (I1)*

*“Climate risks are reflected in the PD when they are quantifiable through other financial parameters. For example, if a client is known to need investments of a specific amount in the next year, this is a concrete, tangible factor — not a hypothetical scenario — which is included in the PD. Additionally, climate risks, especially transition risks, are highly sector-specific. The sector is also an element that is already part of the ratings.” (D1)*

In addition to this “implicit” integration, the institutions in our sample have all developed internal ESG scoring systems, where transition and physical risks are typically evaluated and scored as part of the environmental pillar at the individual client

level. We refer to such scores as “climate-related scores”.<sup>36</sup> As shown in Figure VII.6, climate-related scores (i.e., the climate and environmental risk profile) are generally derived from a separate evaluation and do not directly serve as quantitative risk drivers or rating criteria that directly feed into the PD estimates.

Specifically, all but one of the institutions in our sample incorporate climate risks into their risk classification through qualitative considerations derived from the climate-related scores and by applying rating overrides (see Section VII.4.2). Several respondents (D1, E1, K1) described the climate-related scores as a valuable approach for conducting a granular and structured analysis of climate risks at the client level, despite some overlap with several rating criteria (e.g., sector/industry) already included in the rating system:

*“Some factors are fundamentally already incorporated into existing risk models. However, I see a difference in the level of granularity. There is a difference between broadly assessing whether a company has appropriate management practices and, alternatively, examining 15 specific detailed questions explicitly related to ESG and climate issues.” (E1)*

*“The scorecard allows us to assess each borrower in a structured and individual way, identifying the physical and transition risks that might arise over different time horizons and are potentially not captured in the quantitative data. This provides a complementary perspective.” (K1)*

Climate-related scores are typically aligned with the internal rating process and are subject to internal review and approval. In addition, they are updated annually or more frequently if important changes occur. For example, one institution in our sample (J) indicates in its Pillar 3 report that ESG scoring is mandatory for all new business transactions. For existing clients, the score has to be updated at least once a year. The ESG scoring process is aligned with the rating process by having the second line of defence approve the results. The overall ESG score ranges from 1 to 6, with 1 being the

<sup>36</sup>The design of these climate-related scores is further discussed in Section VII.4.3.



highest grade. A new business opportunity with a score of 5 or 6 leads to a deal rejection unless mitigating factors are presented and explicitly approved by the voting members of the credit committee. Consistent with the previous observations, a respondent (J2) from this institution noted that the current ESG scoring system provides a score that is currently separate from the internal rating, but updated annually. Furthermore, another respondent (D1) described a similar approach:

*“We developed a proprietary scoring tool to effectively capture ESG information. Our intention was to explore whether this information could become relevant to default risk in the medium to long term. Currently, the ESG scoring tool produces a score that is not equivalent to a probability of default and is not directly incorporated into our PD or LGD models (...). Going forward, our goal is to collect as much data as possible and continuously assess the relevance to default risk.” (J2)*

*“The climate risk score is updated annually alongside the internal rating for two reasons. First, because we recognize a certain connection with the probability of default, at least in theory. Second, because adjustments to the score may become necessary over time. Like the rating methodology, the climate score methodology is reviewed annually and modified if needed.” (D1)*

Several respondents (D1, I1) pointed out that the climate-related scores are considered in transaction decisions and therefore influence the outcomes. For example, a below-average climate score may prompt a more detailed review of a transaction, even if the quantitative client’s PD is deemed acceptable. In such cases, the transaction may be escalated to higher decision-making bodies, such as credit committees or even the board of directors. In addition, some institutions in our sample have reviewed their competence level systems so that the hierarchical level required to review and approve transactions increases if a client receives a poor climate-related score. For example:

*“Our climate risk score complements the internal rating to reflect long-term climate risks that are not yet tangible. This score may not have a direct impact on the PD, but it does influence certain process requirements. For example, if the short-term PD is acceptable but the climate risk score is particularly poor, climate risks may need to be addressed more extensively in the credit analysis. In certain cases, the transaction may also have to be decided at a higher competence level, e.g., credit committee. For high-volume transactions, this could be discussed all the way up to the board of directors.” (D1)*

*“We have a formalized competence level system. Above a certain threshold of the ESG-score, certain hierarchical levels or committees have to review the transaction. For clients with a poor ESG score, the competence level increases by one level.” (I1)*

The quantitative integration of climate-related scores into rating systems represents a key challenge and is, for most institutions, still in its early stages. Several respondents (B1, H1, H2, J2, K1, M1, N1, O1, P1) argued that integrating climate-related scores into ratings is premature due to scarce historical data, poor data quality and modeling uncertainties. Furthermore, one expert (K1) stressed the importance of keeping internal ratings and climate-related scores separate for now to maintain a more robust and transparent model validation process:

*“From a validation perspective, I believe the best approach currently is not to automatically incorporate the ESG scorecard into the rating. This approach allows me to clearly separate the rating from the ESG scorecard and still understand why the analyst rated the borrower a certain way and applied a weighting within the scorecard that may or may not have led to an override. Separating these two steps makes a lot of sense from a validation perspective.” (K1)*

*“In our view, our ESG score is nowhere near the level of the Pillar 1 models due to modeling uncertainty and lack of data quality. Therefore, it is appropriate to assess such scores separately and not integrate them into PDs. I think it will happen eventually. But it makes sense that it hasn’t happened yet because the ESG score is not that advanced in terms of data and also in terms of modeling.”*

**(H1)**

However, the use of separate climate-related assessments also has its limitations. For example, one expert (D1) highlighted that while such scores are currently useful for integrating climate-related considerations into new business assessments, the long-term priority should be to simplify the process and integrate all measurable and relevant factors into rating systems. In particular, this respondent cautioned against the trend of creating multiple separate scores:

*“Why do we need the climate score? It has an important training effect for credit analysts. As an analyst, I need to understand how climate risk affects sector risk, sector by sector (...). My personal view is that a tool like the climate score is the right thing to have at the moment, because it helps the credit analysts and also our corporate relationship managers to think about these questions (...). At the end, we should aim to remove complexity. Anything that can be quantified should, in my view, ultimately be captured by our established models and made relevant to PD assessment. At the moment, the trend is the other way round. There is a tendency to have more and more scores. One for social, one for governance, one for biodiversity and so on. We are critical of this because, as risk managers, we obviously want to end up with one metric, one probability of default, that incorporates all these aspects, rather than ending up with 15 different scores.”*

**(D1)**

### Override framework and margin of conservatism (MoC)

A key challenge related to the integration of climate risks into the Pillar 1 framework is the issue of time horizon. To comply with the Basel requirements, internal models for the parameters PD, LGD and CCF have to be developed using long-run average realized one-year default rates (PD), realized loss rates (LGD) and realized conversion rates (CCF) (EBA, 2017). As a result, PD estimates not only rely on historical data, but also have a one-year time horizon, which is shorter than what is typically considered relevant for assessing climate risks. This creates a misalignment between the short-term focus of credit ratings and the longer-term nature of climate risk assessments (NGFS, 2022; Gruenewald et al., 2023).

To address this challenge, the institutions in our sample use overrides as an additional approach to incorporate climate risks. An override is a manual upgrade or downgrade of a stand-alone rating (see Figure VII.5). Overrides may be applied when the stand-alone rating is considered inadequate, particularly when the predefined rating criteria fail to capture risks expected to materialize in the medium to long term. This issue often arises when certain risks, such as climate risks, are not adequately reflected in historical data.

*“One possible approach is to adopt an expert-based, forward-looking perspective by applying upward or downward notching. In such way, the model generates an initial PD, and adjustments are then made if it is determined that certain factors are not adequately reflected in the historical data.”(N1)*

For example, the EBA considers that “an override would typically be appropriate if there are individual circumstances, related to a given obligor or exposures, which the model reasonably cannot take into account. Such adjusted risk parameters are then used for the purpose of calculating own funds requirements (...) which influences the level of own funds included in the calculation of capital adequacy ratio” (p.13, EBA 2017). Thus, overrides directly impact PD estimates, which in turn affect the risk weight of an exposure and, by extension, the capital requirements under Pillar 1 (see Sections VII.4.1

and VII.4.2 for a more detailed discussion of Pillar 1 capital requirements).

Institutions typically have internal override frameworks that provide guidance to rating analysts on when and how to effectively apply overrides. Several institutions in our sample have reviewed and refined their override frameworks to ensure that climate-related risks are addressed in such frameworks and that the associated requirements are well described (e.g., policies and criteria, scale and rationale, list of justifications, documentation, monitoring, etc.).<sup>37</sup> In this context, one respondent (K1) noted that overrides are gaining importance as a tool for integrating climate risks. They provide a way for institutions to address future risks that may not be captured in historical data, though the respondent also cautioned against excessive reliance on this practice:

*“The option to apply an override is already available, allowing a rating analyst to make adjustments for various reasons, including ESG-related factors. In the current environment, I think overrides are taking on a new relevance in a way that they may not have had before (...). The result of such an override is a final rating that takes into account factors that might otherwise have been overlooked. However, it is important to note that this also has an impact on the PD best estimate.”(K1)*

In the same vein, one respondent (B2) expressed skepticism regarding the use of overrides, questioning whether this practice aligns with regulators’ expectations from a Pillar 1 perspective. In particular, this respondent stressed that overrides, which directly affect the PD best estimate, may introduce elements of subjectivity and arbitrariness. In addition, this respondent highlighted the growing regulatory focus on enhancing the comparability of models results (and, by extension, of capital ratios) under Pillar 1. Similarly, another respondent (J2) stressed their understanding that overrides should be used sparingly, even in the context of climate risks:

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<sup>37</sup>See guidelines on human judgement in the application of risk parameters defined in EBA (2017).

*“What you want is objective evidence that your model’s results are statistically sound. When you introduce expert-based elements that can’t be empirically shown to improve the model’s discriminatory power, you enter a gray area of arbitrariness or model manipulation. Historically, as far as I know, supervisors have been hesitant to allow this. There is also growing pressure under the new Basel reforms to move away from internal models, particularly for portfolios with limited data. Take the example of so-called ‘low default portfolios’. It is becoming increasingly difficult to get internal models approved under Pillar 1, and institutions are being encouraged to adopt the standardized or foundation approaches.” (B2)*

*“This can be done in exceptional cases, but it should remain the exception. If overrides occur too frequently, the supervisors will likely raise concerns that the models are not properly designed (...).” (J2)*

The respondents also mentioned the use of a MoC as another approach to account for climate risks in PD estimates. Given the potential for unpredictable errors in PD estimates, institutions are required to incorporate an MoC to reflect a likely range of errors (BIS, 2022a). This conservative adjustment is shown in Figure VII.5. The EBA defines several categories of MoC to address distinct sources of uncertainty in the estimated parameters. Category A covers uncertainty related to the data and methodology deficiencies; category B covers the uncertainty related to changes in risk appetite and internal processes; while category C covers the statistical uncertainty from the estimated parameter (EBA, 2017). This MoC is added to the PD best estimate, thus influencing the calculation of risk weights for exposures and, consequently, the capital requirements under Pillar 1.

In terms of climate risk integration, gaps in climate-related data may necessitate an additional MoC, particularly in Category A. Although none of the institutions in our sample currently apply an MoC specifically for climate risks, one respondent (K1) identified it as a potentially valuable approach for addressing climate-related uncertainties in PD estimates in the future:

*“Another approach could involve addressing these uncertainties within the margin of conservatism. For example, one might argue that specific uncertainties, like the CO2 pathway, should be treated as model uncertainties and incorporated into the MoC. This would allow quantitative uncertainties to be managed within the MoC. These would then be factored into the capital requirements, even if they are not part of the PD best estimate. However, this is not a practice currently adopted in our organization. We typically conduct a qualitative assessment through the scorecard, which might lead to a downgrade via a rating override. That said, I do think the MoC approach is a good option. The ECB, naturally, is focused on ensuring the survival of institutions and therefore a strong focus on sufficient capitalization. I believe this approach could be a very good solution to propose to the ECB. One could highlight the uncertainties around future pathways — whether 1.5 degrees, 2 degrees, or other outcomes — and incorporate them into the MoC, since they are not captured in historical data. This approach could help to effectively meet regulatory requirements. But for now, this is something that we do not do internally.” (K1)*

In contrast, another expert (E1) stressed the strategic implications of incorporating climate risks into the MoC, pointing out that such conservative adjustment would have an effect on loan pricing (discussed further in Section VII.4.5) and potentially place an institution at a competitive disadvantage:

*“When it comes to the future integration into Pillar 1, we as an institution are still at the very beginning. We haven’t conducted any quantitative analyses yet, nor have we developed our internal models to the point where we can say that we are explicitly considering climate-related risks through specific factors in the modeling. A lot of foundational work is required first, and there are also business strategy implications. If I were to integrate such risk factors into my PD today, even if only through conservative add-ons, it would immediately impact the client, in particular the client’s conditions. This creates a risk if we implement additional*

*risk surcharges that our competitors have not yet adopted. This is, of course, a strategic business aspect that always needs to be taken into account.” (E1)*

### Model calibration

One approach, and simultaneously a challenge, in integrating climate risks into ratings-based models is through the redevelopment or recalibration of these models. As noted earlier, internal models for the parameters PD, LGD and CCF have to be developed using long-run average realized one-year default rates (PD calibration), realized loss rates (LGD calibration) and realized conversion rates (CCF calibration) to comply with Basel requirements (EBA, 2017). The calibration function for PD parameters is illustrated in Figure VII.5.

As climate risks start to impact defaults and loss rates, model recalibration may become necessary. A challenge is that the calibration of PD models has to be based on a “through-the-cycle” PD, which accounts for defaults over an entire business cycle, smoothing out short-term economic fluctuations. This approach is considered more stable and less sensitive to changes in economic conditions than a “point-in-time” PD (EBA, 2017). A priority in this context is therefore to analyze available data, collected both via climate-related scoring tools and internal rating systems. Since both ratings and climate-related scores are updated annually, each new data point can potentially be used for further model recalibration, as one of the respondents (B1) explained:

*“Every year we have another year of observation that we add to our empirical data. What we do is look at the model on a regular basis and recalibrate it (...). For example, adjusting the weights in terms of the ratio of qualitative to quantitative factors or, within the quantitative factors, looking at which ones should have more weight (...).” (B1)*

The fact that PD models have to be calibrated based on a through-the-cycle PD, particularly due to the number of observations required, represents a challenge when it comes to climate risk integration, as noted by several respondents (B1, I1, K1, M1,



N1). For example:

*“The issue is that IRB models require a data history that spans an entire economic cycle. Typically, data goes back at least to 2007 or 2008, sometimes to 2010. The minimum requirement is generally around seven years. Currently, we are simply facing a lack of historical data related to climate risks.” (N1)*

*“We have to develop statistically-based models. One challenge is that we have data that goes back 10 or 20 years, and the issue of climate risk was not as virulent then as it is now or as it will be in the next 5 to 10 years. So it is difficult to find many cases in the historical default data where we can say with confidence that they were driven by climate-related events (...). From a Pillar 1 perspective, we have the requirement to calibrate our models against long-term realized defaults and losses.” (B1)*

*“Ratings are trained on historical data including several business cycles. It is an open question whether the sustainable transformation of huge parts of the the economy in a relatively short period of time will follow a pattern similar to historical business cycles.” (I1)*

In addition, several respondents (B1, C1, C2, I1, K1, M1) expressed uncertainty as to whether supervisors would approve an internal ratings-based model incorporating climate-related drivers without sufficient historical data. While acknowledging the ECB’s expectation that material climate-related risk drivers should be incorporated into internal models (see ECB 2024a), they pointed out that the ECB has historically maintained strict standards on data quality and the use of historical data. Furthermore, while a number of institutions are already developing PDs conditional on climate scenarios<sup>38</sup> in other contexts (under Pillar 2), the respondents expressed uncertainty as to whether the ECB would allow PD models calibrated on the basis of forward-looking scenarios rather than historical data in the context of Pillar 1. For example:

<sup>38</sup>We discuss these approaches in Sections VII.4.3 and VII.4.5.

*“The ECB requires extensive historical data, and we have already undergone numerous ECB audits, each time with a strong emphasis on data requirements. After each audit, it is natural to anticipate the next one and to start thinking about how to address new issues, especially with regard to climate risks. Based on this experience, one would not try to incorporate climate risks in a quantitative way at all costs, but rather focus on qualitative aspects (...). Regarding Pillar 1, my impression is that convincing the ECB requires a great deal of effort, particularly when it comes to persuading them that we are moving beyond historical data. It is possible to do so in Pillar 2 and we already do a great deal there, but not in Pillar 1. In addition, the ECB is a large organization with many stakeholders involved. Ultimately, what matters to us is what the auditor on site observes and what they write in the audit report about what we need to change. So far we experienced limited flexibility to such topics.” (K1)*

*“It is very difficult, in particular for European institutions, because the ECB is so keen on having historical data. In contrast, other supervisors are somewhat more flexible (...).” (C1)*

For example, one respondent (G1) explained that their institution developed a methodology for credit risk provisions<sup>39</sup> that relies on default probabilities conditional on climate scenario:

*“By the end of this year, we plan to integrate the impact of climate scenarios into the calculation of credit risk provisions. This will have pricing implications, as the effects of these scenarios will be felt from the moment a transaction is originated, and even for existing transactions in their internal billing. To implement this, we are developing default probabilities that are conditional on climate scenarios (...).” (G1)*

<sup>39</sup>This point is briefly addressed in Section VII.4.5 on loan pricing. However, credit risk provisions under IFRS 9 are not covered in detail in this study.

### VII.4.3 Pillar II: Integrating climate risks into the ICAAP and broader risk management

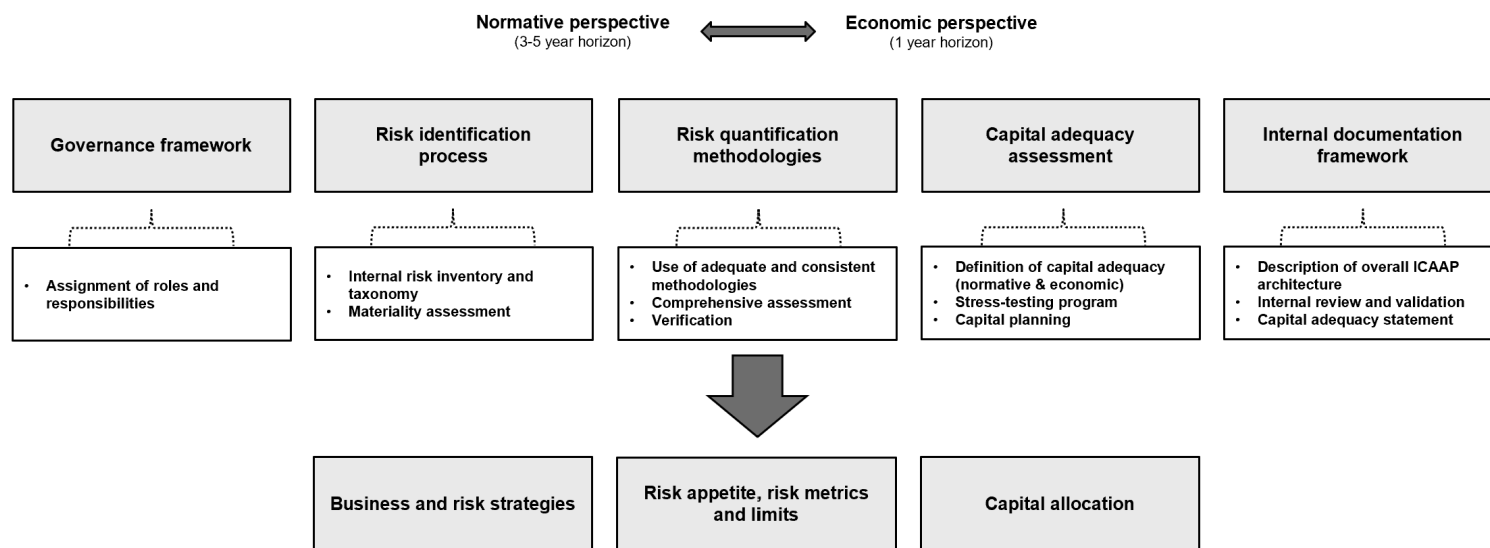
#### Background and rationale

We now turn to Pillar 2 of the Basel framework. A key aspect of Pillar 2 is the ICAAP. In accordance with Article 73 of the CRD, institutions are required to implement effective and comprehensive strategies for assessing and maintaining adequate capital amounts to cover both current and potential risks (ECB, 2018). Consequently, the ICAAP represents a key internal process aimed at ensuring that institutions have sufficient capital to meet regulatory requirements and address other capital needs on an ongoing basis, including under stress scenarios (ECB, 2018).

The key components of the ICAAP are illustrated in Figure VII.7. Alongside a governance and internal documentation framework, the ICAAP involves the development of processes for risk identification, methodologies for risk quantification and the evaluation of capital adequacy through stress testing. Additionally, the ICAAP is intended to serve as a foundation for other key risk management processes and outputs, such as defining risk appetite, establishing risk metrics, setting exposure limits and allocating capital internally (ECB, 2018). While being an internal process, the ICAAP also plays a key role in the dialogue with supervisors, as part of the SREP. The SREP is discussed in Section VII.4.6.

The ECB stressed that its guide on climate-related and environmental risks (described in Section VII.2.1) should be read in conjunction with the ECB guide to the ICAAP (ECB, 2018, 2020b). The ECB guide to the ICAAP includes seven principles that promote a forward-looking, comprehensive approach to capital adequacy, focusing on risk identification, stress testing as well as governance and management frameworks (ECB, 2018). Unlike the prescriptive nature of Pillar 1, Pillar 2 provides institutions with considerable flexibility in designing their ICAAP and selecting models and methodologies. This flexibility extends to how climate risks are integrated, resulting in a variety of approaches among the institutions in our sample.

Figure VII.7: Key components and main outcomes of the Internal Capital Adequacy Assessment Process (ICAAP).



*Remark:* This figure describes key features of the ICAAP and is based on ECB (2018).

Another key feature of the ICAAP is the concept of “capital adequacy”, which corresponds to the “degree to which risks are covered by capital” and is aimed at “maintaining adequate capitalization” on an ongoing basis (p.39, ECB 2018). It is informed by two distinct perspectives: a normative (regulatory) perspective and an economic perspective (ECB, 2018). Institutions are required to ensure capital adequacy through both lenses, with each perspective complementing and informing the other (see also Section VII.4.3). The ECB also expects institutions to incorporate climate risks into both perspectives. Specifically, the ECB expects institutions to account for the potential impact of climate risks on economic value within the economic perspective (ECB, 2020b). This involves quantifying the potential losses from material risks to capital based on value at risk approaches and comparing them with measures of internal capital. In addition, the normative perspective should consider the potential impact of climate risks on future regulatory and supervisory capital ratios, based on assessments of baseline and adverse scenarios (ECB, 2020b). The integration of climate risks into the normative and economic perspectives is discussed in Section VII.4.3.

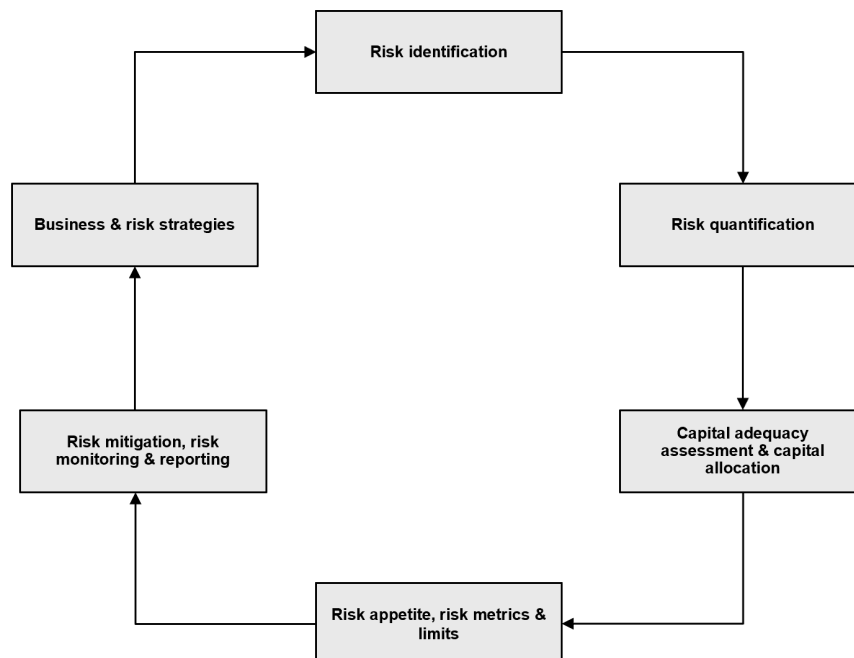
In the following sections, we discuss approaches to account for climate risks in the ICAAP. Given their critical importance in the climate context, we focus on three ICAAP components: risk identification, risk quantification and capital adequacy assessment. These components are closely interconnected and form a sequential process as part of the risk management cycle, as shown in Figure VII.8. Additionally, we discuss the risk appetite and risk management processes that result from these core elements.

### **Risk identification, materiality assessment & risk inventory**

We begin with the first key component of the ICAAP: risk identification. In this section, we highlight key features of this process (independently of climate risks), followed by a more detailed examination of how climate risks are integrated into this process in the subsequent sections.

As part of their ICAAP, all institutions in our sample conduct a regular, at least annual, process to identify all material risks to which they are exposed. This process not only includes climate risks, but more generally serves as a standard procedure

Figure VII.8: Risk management cycle.



*Remark:* This figure shows key steps of the risk management cycle and is based on ECB (2018) and ECB (2020b).

for identifying material risks and their underlying drivers (ECB, 2018). This process typically focuses on the short and medium term, covering at least the next three years. In practice, institutions rely on a time horizon of 3 to 5 years for non-climate risks, while for climate risks they are encouraged to consider potential developments over a longer period, extending up to ten years (EBA, 2021).

The ECB defines a risk as material if “its materialization, omission or misstatement would significantly change or influence the capital adequacy, profitability, or continuity of the institution from an economic perspective” (p.27, ECB 2018). From a normative perspective, a risk is regarded as material if it significantly affects “relevant regulatory ratios, including own funds and risk exposure amounts over the planning period” (p.14, ECB 2018).

The risk identification process typically combines both qualitative and quantitative methods. In the initial step, it involves developing a comprehensive understanding of relevant risk drivers and assessing the channels through which the risks may materialize (ECB, 2022d). In the next step, this process relies on the use of qualitative techniques,

such as expert judgement, together with quantitative approaches, such as sensitivity analysis and stress testing, to assess risk levels against predefined materiality thresholds. This process is then expected to result in a comprehensive risk inventory outlining the identified risks and their characteristics (ECB, 2018). These steps form the basis for determining the institution’s risk appetite, which is further discussed in Section VII.4.4.

**Identification of risk drivers and relevance assessment** In line with the ECB guide to the ICAAP (ECB, 2018), the ECB expects institutions to develop a well-defined description of climate risks in their risk inventory (see expectation 4.1 of the ECB Guide, ECB 2020b), to have a holistic and well-documented view of the impact of climate risks on existing risk categories (see expectation 7.1 of the ECB Guide, ECB 2020b) and to include climate risks in their materiality assessments (see expectation 7.2 of the the ECB Guide, ECB 2020b). All institutions in our sample already have a risk identification process as part of their ICAAP and have taken steps to define climate risks internally, identify relevant risk drivers, and assess how these risks could materialize and impact existing risk types. We therefore outline key steps of this process, providing examples of approaches and discussing challenges highlighted by our respondents.

To integrate climate risks into the regular risk identification process, several respondents (E1, H5, K2) noted that a key first step is to define and create a comprehensive list of potential climate-related risk drivers. This list typically distinguishes between transition risks and physical risks, along with their respective drivers. For example, one respondent (K2) stressed the importance of creating an internal taxonomy and definition of climate risks:

*“First, we developed a taxonomy that clearly defines climate and environmental risks, along with the risk drivers associated with them. Our current framework categorizes these risks into ‘physical’, ‘transition’, and ‘other’, each with specific sub-drivers. This classification is essential for establishing a shared understanding, which forms the basis for analyzing our risk types and conducting associated stress tests. This step is crucial to ensuring a consistent understanding within our*

*institution.” (K2)*

The respondents noted that a common approach is to rely on external sources to establish an initial list of potential risk drivers. For example, sources mentioned by the respondents include the EBA report on the management and supervision of ESG risks (EBA, 2021) and the ECB guide on climate-related and environmental risks (ECB, 2020b), which provide information on various risk drivers, their transmission channels and their potential impact on prudential risk types.<sup>40</sup> In most cases, institutions classify climate risks as a subset of ESG risks, with the environmental dimension split into transition and physical risk drivers. These risk drivers, in turn, may affect the likelihood and severity of existing risk types (e.g., credit risk, market risk, operational risk).

Several institutions disclose key climate-related risk drivers in their disclosure reports, identified through their risk identification process. Overall, the list of climate-related risk drivers considered is typically quite standard and uniform across institutions. For example, one institution (J) notes that it considers physical risk drivers, comprising both acute (e.g., natural disasters) and chronic (e.g., temperature changes) physical risks. In terms of transition risks, this institution considers several drivers, including political and legal pressures on EU banks’ business models, green regulations (e.g., stricter environmental standards in sectors such as real estate, transport and energy), green technologies (e.g., the displacement of non-sustainable products and services, decarbonization), market sentiment and demand changes, ESG reputation (e.g., public boycotts due to ESG concerns), ecological protectionism (e.g., international trade conflicts triggered by environmental regulations) as well as biodiversity and ecosystem protection. Similarly, another institution (P) considers both physical (acute and chronic) and transition risk drivers, including climate-related policy changes (e.g., energy efficiency mandates, carbon pricing), technological shifts and market sentiment

<sup>40</sup>For example, the EBA recommends considering the following risk drivers for transition risks: policy risks (e.g., due to energy efficiency requirements, carbon pricing), legal risks (e.g., due to litigation), technology risks (e.g., innovation, new technologies replacing others), market risks (e.g., shifts in consumer choice) and reputational risks (e.g., difficulty in attracting or retaining customers). For physical risks, the main underlying risk drivers to be considered are acute physical impacts (e.g., storms, floods, fires) and chronic physical impacts (e.g., temperature changes, rising sea levels, reduced water availability).



changes.

An institution's business model and portfolio exposures may also influence the initial scope of relevant risk drivers. For example, institutions with a regional focus may be able to narrow down the list to a smaller set of climate-related risk drivers, while those with global portfolios and activities are more likely to consider a wider range. Overall, the institutions in our sample exhibit a relatively high number of climate-related risk drivers. For example, one respondent (H5) reported that their institution had identified 26 risk drivers related to the climate dimension, as well as 13 additional risk drivers for the environmental and nature dimensions. Another respondent (E1) noted that his institution had so far compiled a list of about 110 risk drivers covering the environmental, social and governance dimensions, including at least 36 risk drivers related to environmental and climate aspects. Finally, another institution (P) has identified 26 risk drivers for physical risks (both chronic and acute) and other environmental factors, including water stress, pollution and waste, alone. The list of risk drivers is typically reviewed annually and adjusted if necessary:

*“Various regulatory authorities have established standards in recent years. We have used these as a minimum benchmark and assessed whether any risk drivers might be missing from our perspective. Our comprehensive list of risk drivers is regularly reviewed. If all of your clients are only in Germany, you might not be so interested in analyzing tsunami risk as a potential risk driver. Although we have a strong focus on Germany, parts of our portfolio are globally diversified. We cover virtually all sectors and countries, even if only to a small degree. This means that, initially, we were able to filter out very few risk drivers. During the annual update, we review and discuss these risk drivers with internal experts, and a materiality assessment is also conducted annually.” (H5)*

Institutions commonly further refine their list of relevant risk drivers by conducting a relevance assessment in collaboration with internal risk expert teams. For example, one institution (H) undertakes this analysis by breaking down its portfolio by sector and country, and assessing the exposure to various risk drivers within these segments.

A respondent (H5) from this institution explained the approach as follows:

*“We started with a large list of risk drivers and sought to identify the most relevant ones. Our approach involves assessing the relative portion of our portfolio potentially affected by each specific risk driver. We first ask ourselves: How large is this portion? We are able to segment our portfolio by industry and country across all risk types. For example, in the case of credit risk, we know the counterparty for each credit exposure, the industry it operates in, and the country where it is located. In parallel, we also collect information on which regions and industries may be impacted by specific risk drivers or remain unaffected. If the portion of our portfolio that is identified as potentially affected by both industry and country exceeds a specific threshold, we consider the risk driver as potentially relevant — though this is only a preliminary assessment. For example, if a certain threshold of the portfolio falls within a scenario where both industry and country could be potentially affected, the risk driver is considered potentially relevant. In the context of credit risk, we particularly focus on credit volumes. A more detailed evaluation may then follow, for example, as part of the bank-wide climate and environmental stress test.” (H5)*

The relevance assessment also contributes to determining the amount of exposures in the banking book that is exposed to physical or transition risks on an annual basis (exposure analysis). For example, one institution (P) uses a physical risk heatmap and a transition risk heatmap, which are both based on a sector assessment (classified by the NACE economic sector). For the latest physical risk heatmap, ten relevant climate-related risk drivers were taken into consideration and mapped to the various sectors present in the institution’s banking book. For each of the risk drivers, a low, medium or high score was attributed based on a qualitative assessment of expected severity (e.g., expert judgement by sector specialists). Any sector exposure at medium or high risk is considered sensitive to physical risk. For transition risk, a similar approach was adopted. The heatmap is based on seven relevant risk drivers related to policy changes, technological developments and shifts in market sentiment. For each of the

relevant drivers, a low, medium or high score is attributed based on a qualitative assessment. The heatmaps then aggregate the results, providing an overview of the amount per sector exposed to medium, and high transition or physical risk. These relevance assessments and heatmapping exercises serve as the foundation for subsequent actions in terms of measuring the materiality of the risks and implementing effective risk management strategies.

**Materiality assessment** Materiality assessments are an important part of the risk identification process in the context of the ICAAP and build on the identification of relevant risk drivers discussed in the previous section (ECB, 2018). In 2020, the ECB noted that institutions’ methodologies for evaluating the materiality of climate risks were “limited in terms of depth and sophistication” (p.14, ECB 2020b). Furthermore, the ECB argued that most institutions lacked adequate tools to assess the impact of climate risks on their balance sheets. In this section, we discuss examples of materiality assessment approaches and examine key challenges reported by our respondents.

In its guide on climate-related and environmental risks, the ECB set the expectation that institutions explicitly integrate climate risks into their materiality assessments across all business areas, considering short-, medium-, and long-term horizons (see expectation 7.2 of the ECB Guide, ECB 2020b). In light of these developments, the institutions in our sample have implemented a variety of approaches to assessing the materiality of climate risks. A key observation is that institutions typically assess the materiality of climate risks by considering multiple climate-related risk drivers across various categories of prudential risk types. Since climate risks may increase the probability and severity of existing risk types, the materiality assessments generally focus on evaluating the potential effects of individual climate-related drivers from different angles.

#### **Internal and external data points:**

Given the wide range of risk drivers (e.g., floods, temperature changes, market sentiment, CO2 pricing, and energy efficiency) and their influence on different risk types

(such as credit, market, operational or reputation risk), the respondents stressed that materiality assessments regarding climate risks require a highly granular and detailed approach. Such assessments typically involve analyzing different business lines, portfolios and incorporating different internal and external data points to capture the full range of potential risk drivers and risk effects. Some institutions disclose detailed information in their Pillar 3 reports on the data points used in their materiality assessments. For example, one institution (K) provides a table that highlights specific data points related to physical and transition risk drivers, such as client location data (to evaluate the link between physical and credit risks) and greenhouse gas emissions data (to assess the effect of transition risk to credit and market risks). Similarly, another institution (I) uses both internal data, such as greenhouse gas intensities, and publicly available data from sources (e.g., World Bank hazard maps) to assess transition and physical risk effects. Several respondents (E1, J2, O1, P1) described this process and highlighted its complexity, for example:

*“When assessing credit risk, we examine, for example, our shipping and real estate portfolios. For instance, we have been collecting data on energy efficiency labels from a very early stage, and when these labels are not available, we derive them ourselves. This allows us to categorize our real estate portfolio according to energy efficiency classes. We can analyze the extent to which properties with lower energy efficiency are more exposed to transition risks compared to those with higher efficiency. In the case of our shipping portfolio, we proactively acquired external data early on, allowing us to assess how a particular ship aligns with the net zero trajectory. In addition, we have two specific ESG scenarios and also incorporate ESG factors into other scenarios. For example, our standard downside scenario includes long-term shipping forecasts, which take into account the potential decline in demand for certain ship classes. This scenario also provides us with quantitative results that we use in our materiality assessments.” (J2)*

*“For us, climate is not a separate risk category but rather a risk driver within the various types of risk. Therefore, we always need to assess how material a driver is for credit risk, market risk, liquidity risk, and so on. Within climate risks, we distinguish between physical and transition risks, and for environmental risks there are further subcategories, such as biodiversity. Even with physical risks, we delve deeper into aspects like storms, river floods, sea-level rise. This creates multiple dimensions that need to be considered, making the process quite complex. As a result, our methodology document is over 50 pages long.” (O1)*

*“In a first step, we conduct an assessment to identify potential risks that could be relevant to the bank. In the second step, a financial impact analysis is typically carried out, based either on expert judgement or on quantitative analyses. We interpret climate risk according to supervisory understanding, i.e., not as a separate risk type but as risk drivers that can impact existing risk types. For example, for flood risk, we assess whether floods may be material to credit risk, market risk and operational risk (...). We assess the quantitative impact, and if it exceeds a certain threshold, the risk driver is considered material. The outcome of this process is a materiality heatmap, which we produce annually. This is something we repeat every year. We currently perform this materiality assessment on a gross basis, without taking into account potential or existing risk mitigation measures, which are also technically relevant to credit risk, for example natural hazard insurance.” (E1)*

### **Qualitative and quantitative approaches:**

In addition to a wide range of data points, the institutions in our sample use heterogeneous approaches and methodologies to assess the materiality of climate-related risk drivers. Some of these approaches are purely qualitative, while others rely on quantitative assessments. The respondents noted that the choice of methodology largely depends on the time horizon considered (short, medium or long term), as well as the availability and quality of data. Overall, most institutions in our sample primarily rely

on qualitative approaches and complement them with insights from stress tests and scenario analyses. A common qualitative approach involves relying on expert judgement. For example:

*“As part of the risk inventory process, we conduct an annual review of individual risk drivers with the portfolio managers. The focus is primarily on a qualitative assessment of which risks are material and to what extent. The assessment is based on a scale of low, medium and high. This classification as low, medium or high is purely qualitative. At this stage, we do not estimate an RWA impact of X or a potential loss of Y, but rather make a qualitative assessment. We also take into account the findings of the ECB’s climate stress test, in which we participated, which indicated a medium level of impact on credit risk. However, these are separate assessments and different components of the overall materiality assessment process.” (N1)*

*“We conduct an expert-based, qualitative assessment, primarily because our historical data does not allow for reliable quantification. However, we can make forward-looking assumptions. To support this, our colleagues are asked to evaluate specific risk drivers based on two dimensions: probability and severity, in terms of potential loss amounts. We provide them with predefined thresholds to guide their evaluations (...). Typically, we interview one individual from each risk department, usually the head of department.” (B1)*

*“In our materiality assessment, we also make a statement about different time horizons: Short, medium and long term. This is mostly based on expert judgement in our case.” (H5)*

In terms of quantitative assessments, the most commonly used approaches for assessing materiality are sensitivity analysis and scenario analysis. In essence, sensitivity analysis, also known as a univariate stress test, assesses the isolated impact of an extreme change in a specific risk factor on a particular risk type (Gruber et al., 2010;

Müller and Schöning, 2012). In the context of climate risks, some institutions use this approach to assess portfolio sensitivity to climate-related risk drivers, such as CO2 prices. For example, institutions seek to estimate potential credit losses for specific corporate portfolios if the price of CO2 were to increase by a given amount per ton. The main advantage of sensitivity analysis is its simplicity, as it does not require assumptions about how risk factors interact under stress (Müller and Schöning, 2012). However, its limitations include reduced explanatory power and the potential to overlook certain risk effects, making it primarily suitable for short- to medium-term assessments. In contrast, scenario analysis, also known as a multivariate stress test, examines the impact of changes in multiple risk factors simultaneously on one or more risk types. This approach offers a more comprehensive and realistic view of risks and portfolio behavior under stress conditions, allowing for longer time horizons to be considered (Müller and Schöning, 2012). The challenge, however, lies in designing the scenarios and accurately mapping transmission channels (Gruber et al., 2010). We discuss scenario analysis and stress tests in detail in Section VII.4.3.

Several respondents (E1, H3, J2, K2) explained incorporating insights from sensitivity or scenario analysis into their materiality assessments. For example, one respondent (K2) highlighted the complementary use of a risk-type-specific approach and a scenario-based approach (through macroeconomic stress testing) in the context of materiality assessments. Another respondent (H3) also reported using insights from exploratory climate scenario analysis for risk identification purposes:

*“The materiality analysis is conducted using two complementary components: a risk-type-specific approach and scenario-based analysis through macroeconomic stress testing. These two methods are considered across different time horizons. In the short and medium term, risk types (e.g., credit and market risks) are analyzed through various methods, including location analyses, sensitivity analyses and risk-type-specific scenario analyses. For each risk type, specific methods are applied within a defined observation period to assess which risk drivers could have a material impact. Quantitative thresholds help determine the materiality of these*

*impacts. Our macroeconomic stress testing, which also takes into account second-round effects, provides insights for the medium to long term. In macroeconomic stress testing, we heavily rely on NGFS to derive our climate scenarios. In contrast, when it comes to risk-type-specific approaches, we also develop very individualized methodologies tailored to each risk type. For example, PD shifts represent one such approach for credit risk. For market price risk, we consider changes in volatility. This approach focuses specifically on individual risk types, whereas the climate scenarios within the framework of macroeconomic stress testing take a broader, economy-wide perspective (...).” (K2)*

*“We differentiate between two types of stress tests. The first type is what we call ‘exploratory climate scenario analysis’. This approach focuses on analyzing individual climate risk drivers to derive a materiality assessment. Although such exploratory analyses are climate stress tests, they differ from our typical stress tests, which usually try to encompass all effects, simulate the entire P&L and balance sheet, and produce a capital ratio result at the end. Instead, exploratory climate scenario analysis targets specific considerations (...). Essentially, with this approach, we assess capital losses from both normative and economic perspectives, compare them with thresholds and derive a materiality statement. The second type of stress test involves holistic scenarios. These are similar to our standard stress scenarios, but include climate aspects. However, this approach is still under development in our bank.” (H3)*

### **Materiality thresholds:**

Materiality thresholds are critical to determining the materiality of climate risks and making a final judgement (ECB, 2022d). However, there is significant variation in how such thresholds are defined and applied across institutions. More generally, the EBA has acknowledged the absence of standardized materiality thresholds, noting that materiality is not a one-size-fits-all concept, but rather depends on institution-specific factors, such as its specific circumstances, risks and risk profile (EBA, 2014). Conse-



quently, what one institution considers material may differ from another, including in the context of climate risks. Materiality thresholds are generally set and defined in the risk appetite framework, which we discuss in Section VII.4.4. As noted by two respondents (K2, O1), assessing the materiality of climate risks involves evaluating different risk dimensions, with thresholds varying by risk type. This highlights the complexity of integrating climate risks based on materiality considerations:

*“Materiality assessment approaches can differ significantly among institutions, and even within a single institution, there can be considerable variation depending on the type of risk. For example, in the context of operational risks with a short-term focus, the approach typically involves a detailed examination of key service locations, identifying associated physical risks, and assessing the mitigation measures in place. In operational risk management, this process often results in a color-coded system that categorizes severity based on potential damage and likelihood of occurrence. This method contrasts with the metrics and logic used for other types of risk, such as evaluating changes in CVaR for credit risk. In other words, different types of risk within the same institution require distinct approaches, metrics and thresholds. Consequently, a wide array of methods is employed across the risk spectrum.” (K2)*

*“We conduct a comprehensive climate stress test every two years, and the results are integrated into our risk inventory. We use multiple techniques to assess materiality and therefore we do not rely on a single threshold.” (O1)*

As noted above, the institutions in our sample typically assess climate-related risk drivers in the context of specific risk types. As a result, materiality thresholds are sometimes aligned with the thresholds defined for those risk types. Particularly in the context of quantitative risk assessments, such as scenario analysis, these thresholds typically include an assessment of the overall impact on capital metrics and liquidity buffer:

*“I am essentially just adding another risk driver to my risk assessment. However, I am not changing the point at which something becomes material for me. That doesn’t change just because I am incorporating climate-related risk drivers. Of course, it is possible that an additional climate-related risk driver may push the total risk above the threshold. But if it stays below, it won’t have any impact. I am not changing the risk thresholds because of that.” (D2)*

*“We define materiality based on risk-specific thresholds. The logic is quite simple. Let’s take address risk and a medium-term perspective as an example. We have identified certain sectors that are particularly vulnerable to climate and environmental risks. We would assign a specific rating shift to the addresses (i.e., the business partners operating in these sectors), and then observe how our CVaR changes in this scenario analysis. Depending on the magnitude of the change, we determine whether the driver is material or not. These thresholds are not arbitrary; they generally align with established thresholds we already know from our risk inventory, typically around 5% of the risk metric. Sometimes, other metrics are used, so it is not always 5%, but this gives a rough idea of the scale.”(K2)*

*“Our materiality threshold for risk assessment is defined by a CVaR threshold, which we review annually. We leverage our stress testing infrastructure for materiality assessments, analyzing different portfolios individually.” (D1)*

One respondent (C1) mentioned that their institution evaluates the materiality of climate risks using quantitative thresholds related to credit and market stress losses as well as liquidity outflows:

*“To assess materiality, we use our established materiality assessment methodology. We have defined climate and environmental risks as risk drivers of existing risks, and therefore we have incorporated them into our risk taxonomy. We quantify stress losses for existing risks and compare them to our materiality thresholds.*

*The metrics that we use are stress losses [for credit and market risk] and liquidity outflows [with respect to the liquidity position]. These metrics are anchoring the capital of our entity. This approach is consistent with our standard materiality assessment procedure.”(C1)*

One respondent (H3) highlighted that the materiality threshold is typically expressed as a capital figure (CET1) and also depends on the probability of a scenario:

*“Our materiality threshold is a € figure, which is of course specific to our bank, based on the capitalization and our CET1 ratio that we have as a bank. It is about 2% of our Common Equity Tier 1 capital. We also take into account the probability of occurrence of a particular scenario in our materiality assessment.”*  
(H3)

For institutions that rely more on qualitative approaches in their materiality assessments, the thresholds and criteria for determining materiality tend to differ. For example, one expert (J2) described an alternative approach that does not rely on materiality thresholds based on capital or liquidity figures. Instead, this approach involves analyzing EAD within specific segments, using NACE codes, and determining whether these segments are exposed to transition risks based on analyses from regulatory authorities or reports from the International Energy Agency (IEA). The institution then assesses which portion of the total EAD has a medium to high transition risk score. A score is calculated and subsequently monitored. This method is also employed by institution (P). While this approach provides an initial assessment of the potential materiality of climate risks in relation to credit risk, it is relatively similar to the exposure analysis described in Section VII.4.3.

*“We apply different materiality thresholds for climate risks compared to those used for specific risk types. When assessing risk types independently of climate, we rely on materiality thresholds based on changes in the CET1 ratio or liquidity. These thresholds are appropriate at the risk type level. However, we do not consider*

*this approach suitable for climate risks. If we were to use the same thresholds for climate, I believe very little would be considered material. For this reason, we have a separate methodology for climate.” (J2)*

**Risk inventory** The risk identification process is a standard procedure for all institutions and forms a core part of the ICAAP. The purpose of this process is to produce a comprehensive risk inventory. A risk inventory is defined by the ECB as a “list of identified risks and their characteristics” and “the result of the risk identification process” (p.43, ECB 2018). The ECB expects institutions to ensure that such risk inventory is kept up to date (at least annually) using the “internal definition of materiality” (p.25, ECB 2018). This section discusses some of the challenges and implications related to the risk inventory highlighted by our respondents.

In essence, the risk inventory is a comprehensive list of all risk categories and sub-categories that are material to the institution and warrant ongoing monitoring. Such inventory typically includes the main risk types (such as credit risk, market risk and operational risk) as well as sub-categories of risks (such as concentration risk, country risk, credit spread risk, model risk etc.). The ECB also requires institutions to incorporate climate risks, including descriptions of these risks and their underlying drivers, into their risk inventory (see expectation 4.1 of the ECB Guide, ECB 2020b). Consequently, the institutions in our sample have either already integrated or are in the process of integrating climate risks into their risk inventories. One respondent (E1) noted that the traditional risk inventory process has typically been separate from the materiality assessment of climate risks. Therefore, a key objective of the institution (E) is to integrate this assessment into the overall risk inventory:

*“The risk inventory is an annual process within our organization. Our goal is to incorporate the materiality assessment for ESG risks within the framework of the risk inventory. Until now, we have approached this assessments more on a project basis. For example, last year, we conducted a materiality assessment specifically for ESG risk drivers for the third time. The approach was similar*

*to the traditional risk inventory: we first identified potential ESG risk drivers based on supervisory publications. Then, using this as a foundation, we conducted a materiality assessment for the material risk types, analogous to the traditional risk inventory. Up until now, this has been a separate process, but looking forward, our aim is to integrate it into the existing risk inventory.” (E1)*

The risk inventory serves as the foundation for the formulation of the risk appetite framework, which is further discussed in Section VII.4.4. As such, it plays a crucial role in shaping the institution’s overall risk strategy, as well as the strategies for specific sub-risks. One key implication of the risk inventory is that risks identified as material have to be managed through appropriate governance, monitoring and reporting mechanisms, as highlighted by two respondents (D1, K2):

*“It becomes part of the overall risk strategy. If climate risk is material for credit risk, then the corresponding risk strategies, such as for credit risk, must address this issue. The next step is to operationalize the credit risk strategy through concrete guidelines, processes and documents that also explicitly address climate risk.” (D1)*

*“The central question is what are the implications of such a materiality assessment and risk inventory? This leads to two main considerations: Do we need to allocate capital and is our existing risk management approach adequate? In other words, are our risk frameworks, e.g., guidelines, exclusion lists, or other processes sufficient? It might also involve establishing new types of limits. All of these questions are related to risk management, with the primary concern being whether we are effectively managing these key risk drivers.” (K2)*

## **Risk quantification approaches**

We now turn to the second key element of the ICAAP: risk quantification. This section outlines the core aspects of the risk quantification process (irrespective of climate risks),

followed by a more detailed discussion on the integration of climate risks into this element in the sections that follow.

As part of the ICAAP, institutions use different risk quantification methodologies tailored to their specific characteristics, such as their business model, risk profile and size (ECB, 2018). Unlike Pillar 1, which, for example, specifies rules for the calculation of RWA, Pillar 2 does not prescribe specific risk quantification methodologies for the ICAAP, provided that such methodologies ensure an adequate quantification of material risks (ECB, 2018). In a report on ICAAP practices, the ECB noted that institutions typically use a variety of approaches to quantify their risks, including amended Pillar 1 approaches, scenario analysis and stress testing as well as internal statistical models, such as credit portfolio models and other models based on value at risk methods (ECB, 2020a).<sup>41</sup>

One respondent (F1) described the risk quantification models under Pillar 2 as “adjustment models”, explaining that they build on the outputs of Pillar 1 models. For example, as described in Section VII.4.2, some institutions use internal models under Pillar 1 to calculate credit risk parameters such as PD and LGD for every credit risk position. These outputs serve as the basis for forward-looking or hypothetical analyses under Pillar 2, such as scenario analysis and stress testing. For example, in the context of their stress tests, institutions assess the impact of adverse scenarios on key performance indicators of their credit portfolios (e.g., value at risk, risk-weighted assets and provisions). In this process, the potential effects of scenarios are translated into negative changes in existing key credit risk parameters in the relevant portfolios. Rather than competing with Pillar 1 approaches, the risk quantification models under Pillar 2 therefore refine and adapt the outputs to specific contexts, as one respondent (K1) pointed out:

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<sup>41</sup> A value at risk measure represents the maximum level of potential loss over a specified time horizon and associated with a given confidence level (e.g., 99.9%). Credit portfolio models are typically used to quantify the credit value at risk, taking into account losses from credit defaults and rating migrations at the portfolio level. Such models provide a measure of the magnitude of potential credit risk losses above expected levels and therefore help quantify capital requirements in the context of the ICAAP.

*“Pillar 1 serves as a foundation for the credit portfolio models in Pillar 2. The ratings provide a starting point, but in Pillar 2, we have the opportunity to take a much more forward-looking approach, rather than relying solely on retrospective analysis.” (K1)*

While Pillar 1 focuses on the amount of “regulatory” capital that institutions are required to hold in relation to RWA, Pillar 2 comprises assessments of capital adequacy not only in terms of regulatory capital, but also in terms of “economic capital”. Economic capital is a key metric for internal risk measurement and management. It is the amount of capital that should be set aside in order to mitigate potential unexpected losses from all material risk types identified in the course of the risk inventory process (e.g., including business and reputation risks). Internal risk models, such as value at risk models, are used to calculate the economic capital within a given confidence level and time horizon.

These risk quantification estimates are subsequently used in daily risk management processes, including assessing the institution’s risk-bearing capacity, refining its risk appetite, setting key risk indicators and limits (see Section VII.4.4), and allocating capital. Another important aspect of ICAAP risk quantification methodologies is independent validation. In particular, these methodologies are expected to be reviewed on a regular basis and the results of such review are expected to be reported to senior management (ECB, 2018).

**Credit rating simulations and credit portfolio models** Scenario analysis and stress testing are among the most widely used and essential risk quantification methodologies in the context of climate risks. A detailed examination of these methodologies is provided in Section VII.4.3. Some respondents (I1, G1, O1), however, noted an emerging trend within their institutions. On the one hand, there is a growing use of forward-looking simulation techniques to project and evaluate corporate credit ratings in response to climate-related risk drivers derived from climate scenarios. On the other hand, efforts are underway to enhance existing credit portfolio models to better capture

climate-related risk factors. Both approaches are therefore addressed in this section.

Given that climate risks have the potential to alter future credit conditions, projecting credit risk parameters is crucial for improving risk quantification. For example, one respondent (G1) mentioned that their institution had developed an in-house risk quantification methodology based on a “forward-looking adjustment of internal ratings”. This solution allows the institution to simulate changes in credit ratings and rating migration parameters in line with climate scenarios:

*“There are two ways to influence PDs. One way is to use historical data on macroeconomic and sectoral activity variables and run them through our regression models. We are familiar with this approach. Unfortunately, this approach doesn’t allow to fully take into account all climate-related issues because there are many transformation aspects that don’t necessarily have a significant macroeconomic impact (...). Therefore, we also incorporate more direct climate-related effects linked to the fact that, for example, certain companies may have to invest more, that the cost structure of companies may change, that the price of raw materials may be higher and so on. This approach is more complex because we lack clear historical data to draw from. As a result, we use our credit scoring models. We know that, for example, the more debt a client has, the higher their credit risk, all else being equal. So, what we do is almost a classic customer-by-customer financial analysis. We take their financial ratios, their whole balance sheet and income structure, and we change them according to specific climate scenarios. We change their financial ratios and recalculate their credit rating.” (G1)*

Another respondent (I1) also noted a growing trend toward simulating future credit ratings by incorporating climate-related risk drivers. While these simulations provide valuable forward-looking insights, the expert stressed the challenges associated with communicating the results to management and supervisors. Unlike ratings based on historical data, simulated ratings are less reliable because their accuracy can be quickly affected by new information or changing conditions:



*“I believe we’re beginning to see a shift toward simulating credit ratings. For example, if the portfolio contains a property with a poor energy classification, what will happen to its market value? What will the credit rating be in five or ten years from now? There’s a growing trend in using simulation techniques for internal ratings (...). The challenge with these simulations is that their results are difficult to communicate to management and supervisors. While we can make predictions, the actual outcomes may not align with our forecasts. Unlike ratings based on historical data, which are more precise, these simulations are not an exact science, making the results harder to convey (...). A rating is essentially a statistical measure calibrated with historical default data, but simulating future ratings is much harder to calibrate. One reason is that within a year, we could have new information, or the environment could have shifted dramatically. So the predictive power of the simulated rating may, in retrospect, be very limited. This creates challenges in the communication, particularly with supervisors.” (I1)*

One respondent (P1) described a different approach that focuses on assessing the impact of carbon pricing at the client level. By incorporating a carbon price sensitivity analysis into financial models, this method allows the institution to evaluate how shifts in CO<sub>2</sub>-related costs may affect a company’s financial position. These financials, in turn, directly feed into internal models, as discussed in Section VII.4.2. Finally, one respondent (O1) elaborated on the use of credit portfolio models and current efforts to better integrate climate risks into such models, for example by using correlation factors:

*“For companies, we take a carbon price sensitivity into account and incorporate it into our financial models. These financials are also ultimately an important input factor in our internal models.” (P1)*

*“In the credit portfolio model, one option is to adjust PDs. Another approach is to work with correlation factors. For example, it could be assumed that certain sectors are collectively impacted by the climate crisis, leading to stronger corre-*

*lation effects, which can be integrated into the model. This is something we are currently exploring.” (O1)*

**Climate-related scoring methodologies** The ECB expects institutions to quantify the climate-related and environmental risks to which they are exposed (see expectation 7.3 of the ECB Guide, ECB 2020b). In addition, the EBA requires institutions to assess a “borrower’s exposure to ESG factors, in particular environmental factors and the impact on climate change, and the appropriateness of the mitigating strategies, as set out by the borrower” (p.39, EBA 2020). The EBA further specifies that this assessment should be carried out on an individual borrower basis (EBA, 2020). In this section, we explore client-level approaches for quantifying climate-related risks and discuss key challenges identified by our respondents.

All institutions in our sample have developed and implemented internal approaches for quantifying climate risks using dedicated scoring systems at the individual client level. Climate risks are typically considered a subset of ESG risks, with both transition and physical risks evaluated under the environmental pillar. As discussed in Section VII.4.2, these climate-related scores generally complement internal credit rating assessments and systematically incorporate an evaluation of climate-related risk factors into a distinct score. The exact climate-related criteria and methodologies are generally not disclosed by institutions, with the exception of one institution (J), which provides a table outlining the main question categories and their weighting.

Another observation is that despite the existence of ESG ratings (e.g., MSCI ESG ratings, Sustainalytics ratings), our respondents expressed a preference not to rely on such external ratings for risk quantification purposes. For example, one respondent (I1) stressed the importance of conducting individual assessments using institution-specific criteria or more tailored solutions. Several institutions developed their own climate-related scoring methodology, while others rely on specialized tool providers (e.g., CredaRate). In addition, two respondents (D1, H2) explained that internal scoring systems allow for a more tailored analysis of climate risks and encourage risk analysts to pay more attention to these issues. For example:

*“We looked at external ESG ratings. In the end, we decided to develop our own score to do justice to our portfolios and our clients. External ratings are very dependent on the questions asked. External ratings also rely heavily on industry averages. We are trying to work more closely with our clients. We have risk managers and loan originators who know the clients well and try to assess them on a more individualized basis.” (I1)*

*“Why do we need the climate score? It has an important training effect for analysts. As an analyst, I need to understand how climate risk affects sector risk, sector by sector. Climate is not that simple because the challenges in the automotive sector are very different from those in steel or cement, for example. Is the technology I need to switch to already available? When will the technology be cost competitive? When can I use it efficiently? When is the right time to invest? This is very complex. My personal view is that a tool like the climate score is the right thing to have at the moment because it helps the analysts and also our corporate client advisors to think about these questions.” (D1)*

As a result of these individual scoring frameworks, the climate-related criteria and methodologies used to quantify climate risks at the client level differ between institutions. Additionally, even within the same institution, these methodologies often differ depending on the type of portfolio or segment (e.g., corporate, real estate etc.), as explained by two respondents (I1, K2):

*“We have different scores depending on the segment. For example, we have a lot of corporates in our portfolio, but also real estate. The climate challenges are very different depending on the segment. Thus, we have decided to build this score differently. But, basically, we always have two main building blocks. One focuses on the physical risks and the other on the transition risks.” (I1)*

*“The questions of the scorecard are segment-specific. These questions are also guided by data availability. For each segment, we have a set of different questions that need to be answered, with predefined ranges.” (K2)*

### **Transition risks:**

We provide five examples of scoring approaches to quantify transition risks at the individual client level. One respondent (H1) reported having developed an internal “ESG credit risk score” for the corporate portfolio. This expert explained that the transition score is primarily based on two factors: the client’s greenhouse gas emissions and its transformation efforts.

*“How do we measure the transition score? Basically we have two components in this sub-score. One is an emissions score. This is based on the company’s most recently reported emissions data and assesses the current exposure to changes in CO2 pricing and allowance allocation. This allows us to assess how exposed a client is based on current emissions. We look at all three scopes of emissions and consider emissions in relation to the company’s sales. This emissions score represents the status quo. We calculate it for all of our clients (...). The second component is a transformation score. It is based on qualitative questions that assess how far-reaching and ambitious the company’s transformation plan is, for example how fast and by how much a company plans to reduce its emissions over the next 5 to 10 years, and how binding it is, for example how much investment has already been made. Another important aspect of the transformation score is the extent to which a company plans to change its product mix in the future, i.e., the extent to which it wants to adapt its product portfolio towards less CO2-intensive products. Finally, we have a question on water consumption and a question on waste generation to assess the efforts made in these areas (...). This score is calculated for large clients in focus industries, i.e., industries with high CO2 emissions, where the bank has a larger portfolio volume (...). We have*

*some very small clients that are not handled manually by our market and credit departments. For these clients, we do not calculate a transformation score, so the transition dimension is equal to the emissions score (...). The emissions score and the transformation score are equally weighted, so that each accounts for 50% of the transition dimension. The main reason for this is the lack of a real target figure. This is an entirely expert-based model. We have no historical data on which to train the model. This is why we have started with a very simple equal weighting.” (H1)*

One respondent (J) described another climate-related scoring approach. The score consists of 18 questions related to climate and environmental issues, which account for 50% of the overall ESG score. The score components include five questions on greenhouse gas emissions, energy consumption and energy efficiency; four questions on climate-related issues such as technology risk; and nine questions on specific environmental areas such as water and marine resource protection. The final result is an overall ESG score ranging from 1 to 6, with 1 being the highest score:

*“For transition risks, the analyst needs to assess the technological risks faced by the client. For example, is the client’s production technology at risk? Have the necessary investments been made to stay technologically up-to-date and avoid being impacted by future regulations? Additionally, we have a bonus-malus system for specific climate-related topics. For example, there are positive incentives for certain certifications in the real estate sector, while we apply penalties within this score, for example for unsustainable land use (...). In the environmental category, we assess factors such as the carbon footprint, reporting on emission reduction targets, energy consumption, energy efficiency, share of renewable energy, sustainable use and protection of water and marine resources and the transition to a circular economy. We also examine efforts to reduce pollution. There is a set of questions that are identical for everyone. However, there are also sector-specific questions, such as those for the shipping industry. The main questions remain the*

*same, but the sub-questions and responses vary based on the sector.” (J2)*

An additional respondent (O1) elaborated on the use of a scoring system provided by the external provider RSU, where the environmental dimension constitutes 60% of the total ESG score. This dimension focuses primarily on transition risks, including greenhouse gas emissions, waste and water-related factors:

*“Strictly speaking, we use the tools from RSU and S Rating, depending on whether we are operating in the wholesale or retail sector. With RSU, the environmental dimension currently accounts for 60% of the total score, with 20% allocated to both the social and governance dimensions. Within the environmental dimension, the score is split between physical risks and transition risks, with a somewhat greater weight given to transition risks. Within transition risks, the assessment focuses mainly on Scope 1, 2 and 3 CO2 emissions. Waste generation and water consumption are also considered, with equal weight given to each.” (O1)*

One respondent (D1) explained that their institution uses a “climate risk score”, which incorporates both sector analysis and client-specific qualitative questions. Finally, another expert (P1) described a similar approach that assesses clients based on their alignment with sector transition pathways, the robustness of their transition plans, and the potential financial impact of the transition:

*“We use the results of an external tool that we use for economic / risk analysis to create a climate risk score. This score is based on a sector analysis and is supplemented by qualitative questions asked in the individual credit analysis. With the tool, for example, we get a climate risk indication that is sector-specific. This tells us whether the client is active in a sector where climate risks do not play a role, or vice versa. In the individual analysis, we then use qualitative questions to gain a more detailed understanding of whether the specific client is more or less affected by these risks. The results are aggregated into a climate risk score.” (D1)*

*“We evaluate clients on an individual basis, with the aim of assigning a score to all of them. For transition risks, we consider a range of criteria, with a key focus on a company’s emission intensity, specifically physical emissions rather than economic ones. For example, in the automotive sector, we assess the CO2 intensity of the vehicle fleet. This data is then compared to climate pathways, which we derive from the IEA transition pathways. We analyze whether these emission intensities are above or below the transition pathways, considering both the current status and a five-year outlook. Based on this analysis, we assign clients a risk grade of high, medium, or low. We also evaluate the quality of the client’s transition plan, though this assessment is more qualitative. We examine whether the plan is credible, includes a detailed action plan. Additionally, we apply a set of ten questions to assess factors like scope 1, 2, and 3 emissions, whether the client has a net-zero target and whether management is actively engaged. We also consider financial resilience. To do so, we use a model-based approach to apply transition risk pathways from integrated climate models. This allows us to estimate potential changes in CapEx and OpEx, helping us gauge the impact on cost structures and other financial metrics.” (P1)*

### **Physical risks:**

Next, we provide three examples of scoring approaches to quantify physical risks. Overall, we observe that the scoring methodologies developed by the institutions in our sample have a stronger focus on transition risks than on physical risks at the client level. One possible explanation for this could be that quantifying physical risks heavily depends on the location and nature of assets. Such an assessment may not be systematically relevant or feasible at the client level. In addition, some climate-related factors may already be reflected in collateral values. For example, one respondent (K2) highlighted that their institution currently sees a potential risk of double counting in this respect (e.g., environmental factors already influence the valuation of real estate collateral, see EBA 2023). The respondent (K2) explained:

*“Currently, physical risks are still being assessed in a fairly general manner. The focus is primarily on overall vulnerability to physical risks. However, these risks are not yet factored into our internal scorecard to avoid the possibility of double counting. Physical risks are already accounted for in the collateral valuation, and including them in the scorecard as well could lead to the same factors being considered twice.” (K2)*

One of the respondents (H1) described how their institution calculates a physical risk score by analyzing company locations using geolocation data and hazard maps. The model assesses physical damage and business interruption risks, considering factors such as asset type and diversification, and is fully automated:

*“To calculate the physical risk score, we examine the company’s locations. We convert addresses into geolocation data and estimate the risk for each location using hazard maps from the World Bank and other leading organizations, aggregating a score based on various natural hazards. In practice, we often have only one location per client in our database, usually the headquarters. So far, we haven’t gathered data on other sites. However, to accurately assess physical risk, looking only at the main location is often insufficient. As a result, we now purchase data from an external provider, though this mainly covers large corporates. For small clients with only two or three other sites, we don’t currently have a way of recording them manually, and we don’t buy the data either (...). At the moment, we treat all of a company’s locations as equally important. We attempted to gather information on the share of sales for each site to determine which are most critical, but the external provider couldn’t deliver this. However, we do know the type of asset, such as whether it’s a factory, office building, or power station (...). When assessing physical risks, we consider two impact channels: the first is physical damage, assessing how severely buildings could be affected by river floods, droughts, and similar events. The second is business interruption, where we examine the climate hazards that could disrupt operations. In the case of business*



*interruption, the sector of the client and the type of asset also play a role. We also assess asset diversification, such as whether all factories are in the same location (...). Our model aggregates data from hazard maps and runs fully automatically.”*  
**(H1)**

Another respondent (I1) described their institution’s tool, which focuses on analyzing physical hazards, particularly flood risk and makes a distinction between regional and international corporate clients. Lastly, a third respondent (O1) explained using a scoring system developed by RSU, which includes criteria for assessing physical risks, such as floods and heat waves, at the client level:

*“We have a physical risk tool application (...). We distinguish between regional and international companies. For regional companies, we look at the extent to which a region is exposed to physical hazards. For example, we look at a city and say that if more than 10% of it is at risk of flooding, then the entire city is flagged as being at risk. In turn, we mark companies that operate regionally in that city as potentially exposed to flooding. For international companies, we simply look at the sector. This is because large companies are generally able to replace certain assets. A flood may cause damage, but it may not lead to credit defaults of these companies. Therefore, we tend to perform a sectoral analysis and flag sectors that are particularly exposed to physical risks. There are certain sectors that are significantly more affected by physical risks, agriculture or tourism for example, and we take that into account.”* **(I1)**

*“With RSU, the E dimension accounts for 60% of the total score, with 20% allocated to both the S and G dimensions. Within the E dimension, 30% relates to physical risks and 70% to transition risks (...). For physical risks, the focus is on extreme weather events, such as coastal flooding, river flooding and heat waves (...). When financing a corporate client in a region prone to flooding, for example, we have to consider the potential impacts if the client’s premises are flooded*

*or if employees cannot reach work due to flood conditions. These are physical risks that cannot be fully addressed through collateral alone.” (O1)*

### Challenges:

While these scoring approaches are valuable for quantifying risk and collecting client-level data, several respondents (B1, H1, I1, J2) highlighted challenges posed by modeling uncertainties and data quality issues. For example, one respondent (H1) highlighted the difficulty of tailoring questions to specific industries and acknowledged the potential subjectivity in some scoring climate-related criteria:

*“One question asks how fast and by how much a company plans to reduce its emissions over the next 5 to 10 years. Based on this, we created percentage buckets on a three-tier scale. Anything below 10% is considered ‘unambitious’, up to 20% is considered ‘average’ and anything above that is considered ‘above average’. We recognize that there is a high degree of subjectivity in these aspects (...). We have also created 25 industry clusters and then, for so-called ‘focus industries’, we have discussed again with experts from the credit and loan origination departments how the questions need to be adjusted for specific industries. So far, we only did this for two sectors: automotive and energy. In the automotive sector, for example, the question is along the lines of ‘How much does the company rely on the classic combustion engine?’. But, in essence, what we have done is to build an overarching model and then make only a few selective adjustments in individual sectors.” (H1)*

Consequently, and as discussed in Section VII.4.2, climate-related scores are typically not quantitatively integrated into rating systems but remain a separate assessment considered alongside credit ratings. To illustrate, the respondent (H1) considered the integration of climate-related scores into PD models to be premature:

*“For now, the PD remains unaffected by our ESG score. If we included it directly in our PD models, then it would be included everywhere. We don’t want that.”*

*In our view, the ESG score is nowhere near the level of the Pillar 1 models due to modeling uncertainty and lack of data quality. Therefore, it is appropriate to assess such scores separately and not integrate them into PDs. I think it will happen eventually. But it makes sense that it hasn't happened yet because the ESG score is not that advanced in terms of data and also in terms of modeling.”*

**(H1)**

**Climate-related data and data collection** In order to quantify climate risks, the ECB expects institutions to be able to generate aggregated and up-to-date climate-related data in a timely manner. Furthermore, it requires institutions to develop a holistic approach to data governance and to collect the necessary data to assess their exposures to climate risks (see expectations 6.1, 6.2 and 6.3 of the ECB Guide, ECB 2020b). This section provides examples of key data-related considerations and discusses the challenges involved.

In addition to the climate-related scoring methodologies discussed in Section VII.4.3, the institutions in our sample have implemented processes to overhaul their credit process and collect climate-related data in a more systematic way, including during due diligence and loan origination. For example, one respondent (H5) reported that their institution conducted a comprehensive review of the credit process and made adjustments to internal IT systems to aggregate climate-related data into relevant metrics:

*“The entire credit process has been reviewed, from data collection to the systems in which we store data to the metrics we calculate around credit risk. We have also set up a new internal reporting on this topic.”* **(H5)**

### **Corporate Sustainability Reporting Directive (CSRD):**

Several respondents (I1, L1, D2) highlighted the challenges their institutions face in quantifying climate risks due to important data gaps. In this context, some noted the crucial role of the Corporate Sustainability Reporting Directive (CSRD) in facilitating

data collection, despite some limitations.<sup>42</sup> For example, one respondent (I1) explained that beyond improving data quality, the CSRD is expected to simplify data collection for institutions in several ways, including by putting a greater focus on material issues. The involvement of auditors, who will have to audit the reported data and validate the analytical processes used, was also seen as a positive development. Another respondent (L1) echoed the relevance of the CSRD, but pointed out that important data gaps are likely to remain, in particular for small and medium-sized companies as well as companies headquartered outside the EU, to which the CSRD will apply at a later stage (reporting years 2026-2028):

*“In addition to standard balance sheet reporting, we will integrate data from the CSRD. We expect our clients to report on material aspects, which we will then process internally. If a company reports that physical risks are not material, we will accept this information (...). If you compare this process with the way we process balance sheet data, we also do not question every single piece of information. We would need extreme insider knowledge. Instead, there are auditors who certify the reported data and verify the analytical process. Therefore, relying on audited and certified reports is the best approach going forward, and we will continue to do so with the CSRD.” (I1)*

*“In terms of data, everyone is waiting for the CSRD. However, we should keep in mind that this is only for the EU and, at least in the first step, mostly for large companies. It will be broken down further over the next few years (...).” (L1)*

### **Geolocation of financed assets, including corporate assets, facilities and sites:**

Several respondents (I2, G2, L1, O1) highlighted the challenge of obtaining comprehensive data on the geolocation of company assets, facilities and sites, particularly in order to assess corporate exposures to physical risks. For example, one respondent (L1) highlighted the need for more detailed information on production and logistics sites,

<sup>42</sup>See Directive (EU) 2022/2464. Large companies will have to implement the CSRD for the first time with the publication of reports in 2025 for the financial year 2024.

especially regarding their strategic importance and resilience to physical risks. Another respondent (O1) mentioned that their institution uses geolocation data from an external provider to evaluate exposure to physical risks. However, this data mainly covers real estate collateral and the headquarters of corporate clients, leaving out production sites. Finally, one expert (P1) explained that their institution currently has precise address-level data, including on critical company sites, for approximately 15% to 20% of the portfolio. For the remaining sites, the locations are approximated:

*“We need more location data, not just about the headquarters, but also about where the main production or logistics facilities are located. For example, if a company relies on a few large logistics centres, it would be important to know whether they could be affected by physical risks (...). We also need to look at the impact of potential production downtime, e.g., because the surrounding infrastructure is broken or the company’s infrastructure is broken. What is the impact of one month, two months, three months of production downtime on the company’s turnover? It is important to analyze these second-round effects. This should not be limited to the damage caused. The analysis should also look at how the company will be able to resume full production, when it will be back to normal and how much revenue it will have lost by then.” (L1)*

*“We acquire data from Munich Re to quantitatively evaluate the exposure to various physical risks. This data helps us assess the risk levels for specific properties, such as the likelihood of flooding, storms, and other hazards. Additionally, we take into account protective measures, such as whether a location is “defended” or “undefended”, for instance, whether it has dike protection. We map this data onto the locations within our portfolio, particularly for real estate used as collateral. In general, we have extensive data for real estate collateral and agricultural land. We also use this approach for corporate clients, at least for certain business locations that we can already assess. However, we currently do not have data on production sites. For example, we can obtain the address of Volkswagen’s headquarters in*

*Wolfsburg, but this doesn't cover all relevant locations. The issue of production sites, particularly for large multinational companies, is complex, and we currently lack the necessary data to analyze them comprehensively.” (O1)*

*“We analyze what percentage of a company's locations could potentially be affected. Based on this, we can then make a physical risk assessment. Typically, we know how many locations a company has, but we don't always have the exact details of where they are. For about 15% to 20% of the portfolio, we have clean data, but for the rest, the information is insufficient. Where we do have the exact locations, we use them. Internally, we also have a definition for 'business-critical' assets. Take, for example, FedEx, not every postal distribution center worldwide is considered a material asset. However, with cement plants, it is a completely different situation. There are sector-specific differences. When we don't know the exact location of the assets, because we don't have the addresses, we typically approximate based on the country, state or postal code, depending on the data we have.” (P1)*

As noted above, corporate portfolios present specific challenges, particularly as transaction documentation often only includes information on company headquarters, with data on other sites and assets varying based on the nature of the transaction. Some institutions are now expanding their data collection to address this data gap. For example, one respondent (G) explained that their institution is increasingly turning to commercial data providers to obtain more detailed information on corporate assets, particularly in sectors like power. This expert highlighted that specialized data providers offer granular data on company assets, including asset types, locations and capacities. This information is then used internally and aggregated at the company level:

*“For our residential and commercial real estate portfolios, we already have most of the necessary data in our databases. We have geocoded addresses, which allow us to analyze physical risks. Corporate portfolios are different. The CSRD will bring more transparency to these assets, but for now, we rely on commercial data*

*providers for information on company assets, such as asset types, latitudes and longitudes. We work with data providers that are specialized in a particular sector, e.g., power. For example, in the power sector they can give us a list of a company's assets, the types of assets, their locations and the capacity of those assets. We use these latitudes and longitudes to run our climate models and then aggregate the results at the company level. Currently, we have a major internal project underway to expand our coverage to include more companies.” (G2)*

A distinction needs to be made between the physical assets of residential and commercial real estate portfolios (e.g., immovable property used as loan collateral) and those of corporates (e.g., production facilities). In the case of real estate, several risk experts (G2, B1, J1, J2, P1) noted that much of the necessary data is already available in their institutions' databases, as its collection is generally mandatory, particularly for collateral valuation purposes (EBA, 2023). For example, one respondent (J2) explained that their institution systematically collects data on energy performance (EPC) certificates to assess the energy efficiency levels of real estate assets:

*“We collect data on energy performance certificates and energy labels ourselves and have been doing so for several years, intensifying the process again starting one year ago. For new business, it is mandatory to obtain the energy certificate, and for existing business, we have gradually gathered this information. In this area, we don't see any value in purchasing additional data. If we need to fill gaps, we rely on the information we already have, such as the type of use and the building's age, and then generate a proxy ourselves.” (J2)*

### **Data on insurance coverage for corporate portfolios:**

While most institutions already collect insurance data for real estate portfolios, this practice does not systematically extend to corporate portfolios, as one respondent (J2) observed. Overall, several respondents (L1, F1, G2, H5) highlighted the importance of having comprehensive data on insurance coverage, particularly for the purpose of

quantifying physical risk exposure.

*“We collect insurance data. Our process involves matching real estate properties with this insurance information. Insurance and reinsurance providers often have the capability to pinpoint a property’s location and overlay various risk maps to assess potential risks associated with a specific address. Reinsurers can offer detailed information for almost any location globally. For example, by entering a property’s address, we can determine the level of earthquake or flood risk on a specific scale. If a property shows high flood risk, we conduct a deeper analysis to check for mitigation measures. If none exist, we might withdraw from the transaction. If mitigation measures are in place, we need to verify their effectiveness, including whether the insurance policy sufficiently covers the risk. This approach is primarily used for our real estate portfolio and our renewable energy portfolio, as well as selectively for other transactions.” (J2)*

One respondent (G2) explained that their institution has been working on improving the quality and coverage of internal data on insurance coverage, stressing that such information is crucial to gain a “net” view of risk. This expert also stressed the challenges posed by the global scope of their institution’s portfolio, where insurance policies often differ from one country to another. Other respondents (H5, L1) also underscored the importance of data on insurance coverage and assessing the extent to which companies are insured against physical risks. One respondent (H5) pointed out that insurance coverage is sometimes overlooked in current models and mainly accounted for through overrides.

*“Insurance is one of our major projects. Some insurance policies are systematically required, for example for certain assets. But, admittedly, for a global bank like ours, there are still procedures that can differ from one country to another. When it comes to insurance, national regulations apply. One of our key initiative this year is to consolidate this insurance data to better understand our risk exposure. At the moment, however, we do not systematically monitor this risk on a global*



*scale.” (G2)*

*“Insurance cover is an aspect that we would like to include in our model in the future through qualitative questions, but as of today it is not in the models and can only be taken into account today through an override.” (H5)*

### **Risk quantification with climate stress testing**

Another central component of the ICAAP and an important tool for quantifying risks, including climate risks, is stress testing. In essence, a stress test is a “what if” exercise that allows institutions to examine the potential impact of certain risks under altered macroeconomic and financial conditions based on predefined scenarios (Baudino et al., 2018; Wilkens and Leister, 2023). In this section, we outline key considerations, followed by a more detailed examination of how climate risks are integrated into stress testing practices in the subsequent sections.

All institutions in our sample are required to conduct stress tests on a regular basis as part of their ICAAP (ECB, 2018). Stress testing can be performed at multiple levels, from assessing the entire balance sheet and income statement to focusing on individual portfolios or specific exposures. In addition, stress testing can target specific risk types such as credit, market, liquidity and operational risk.<sup>43</sup> While comprehensive stress tests are generally conducted on a quarterly basis, other tests are conducted on an ad hoc basis for specific sub-portfolios (ECB, 2018). These exercises help institutions track changes in profitability, capital and liquidity; set and monitor their risk appetite limits and targets; and inform their business and capital planning (ECB, 2018). Stress tests are expected to cover both the normative and economic perspectives, providing insights into the impact of risks on regulatory capital ratios (e.g., CET1 ratio) and economic capital. In most cases, ICAAP stress tests are based on scenarios developed internally, which are updated at least annually to allow for reassessment and revision of the underlying assumptions, if necessary. From a governance perspective, ICAAP stress

<sup>43</sup>In essence, ICAAP stress tests can be broken down into different types of stress tests, including institution-wide stress tests with adverse scenarios, reverse stress tests, risk-type-specific stress tests and ad hoc stress tests.

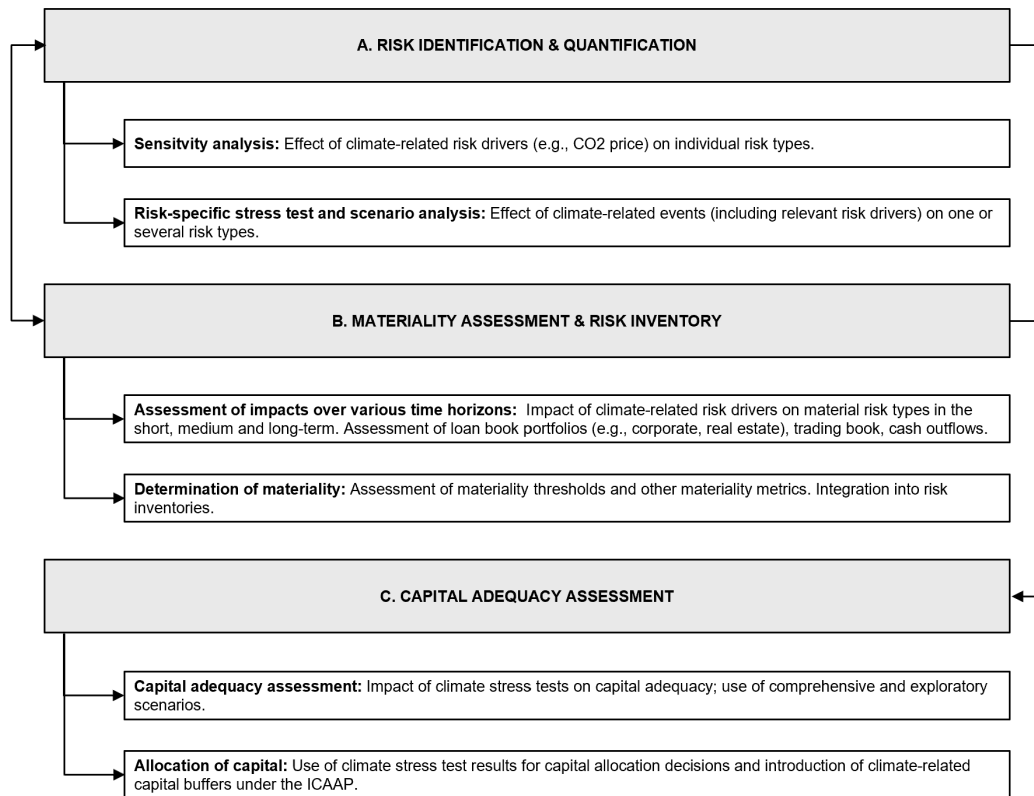
tests are typically subject to multiple governance layers, often involving a scenario and stress testing committee and a board risk committee (ECB, 2018).

In addition, institutions regularly participate in supervisory stress tests conducted by the ECB and the EBA. Under EU law, the ECB is required to perform stress tests on supervised institutions at least annually (see Art. 100 of the CRD). The ECB also conducts thematic stress tests, such as the 2022 climate stress test, while the EBA carries out EU-wide stress tests every two years (ECB, 2024g). These assessments typically focus on a short-term horizon of three years. In supervisory stress tests, institutions are presented with specific scenarios that impact their regulatory capital ratios and key performance indicators (e.g., large exposures), requiring them to evaluate how their capital positions would be affected by severe but plausible adverse economic conditions outlined in the scenarios.

The ECB expects institutions to perform stress tests in order to quantify the impact of climate risks on their exposures (see expectations 10 & 11 of the ECB Guide, ECB 2022c). In our sample, institutions tend to use climate stress tests and scenario analysis for three distinct but interrelated purposes (see Figure VII.9). First, climate stress testing is used for risk identification and quantification purposes, where specific climate-related risk drivers are closely examined across one or more risk types using sensitivity and scenario analysis. Second, scenario analysis, in particular, helps analyze how climate risks may evolve under different scenarios and time horizons, and translates these impacts into stressed risk parameters and capital measures. These analyses inform the materiality assessments and risk inventories discussed in Section VII.4.3. Third, climate stress testing can also play a role in assessing capital adequacy, determining the need for capital buffers, supporting capital allocation decisions, and refining risk appetite (see Sections VII.4.3 and VII.4.4). These aspects are discussed in the following sections.

**Integration of climate stress testing into stress testing framework** As part of the ICAAP, institutions perform a range of stress tests to quantitatively evaluate their risk profile, inform their capital planning and fulfill regulatory requirements. In

Figure VII.9: Key functions of climate stress testing.



*Remark:* This figure illustrates key functions of climate stress tests and is based on ECB (2022c).

particular, institutions are expected to perform tailored and in-depth reviews of their vulnerabilities, capturing “all material risks on an institution-wide basis” (p.35, ECB 2018).

To achieve this, institutions typically maintain a set of individual scenarios that are regularly updated and tailored to meet specific risk quantification objectives as part of their internal stress testing frameworks. The stress testing framework defines the internal scenarios, their objectives, key assumptions and methodologies and the roles involved in the stress testing process (BIS, 2018). ICAAP stress tests are typically subject to multiple governance layers, often involving a scenario and stress testing committee and a board risk committee (ECB, 2018). These governance bodies are expected to ensure the plausibility of the scenarios and the robustness of the underlying assumptions. Such responsibilities are usually also outlined in the stress testing framework.

As illustrated in Figure VII.10, institutions run adverse scenarios on a quarterly

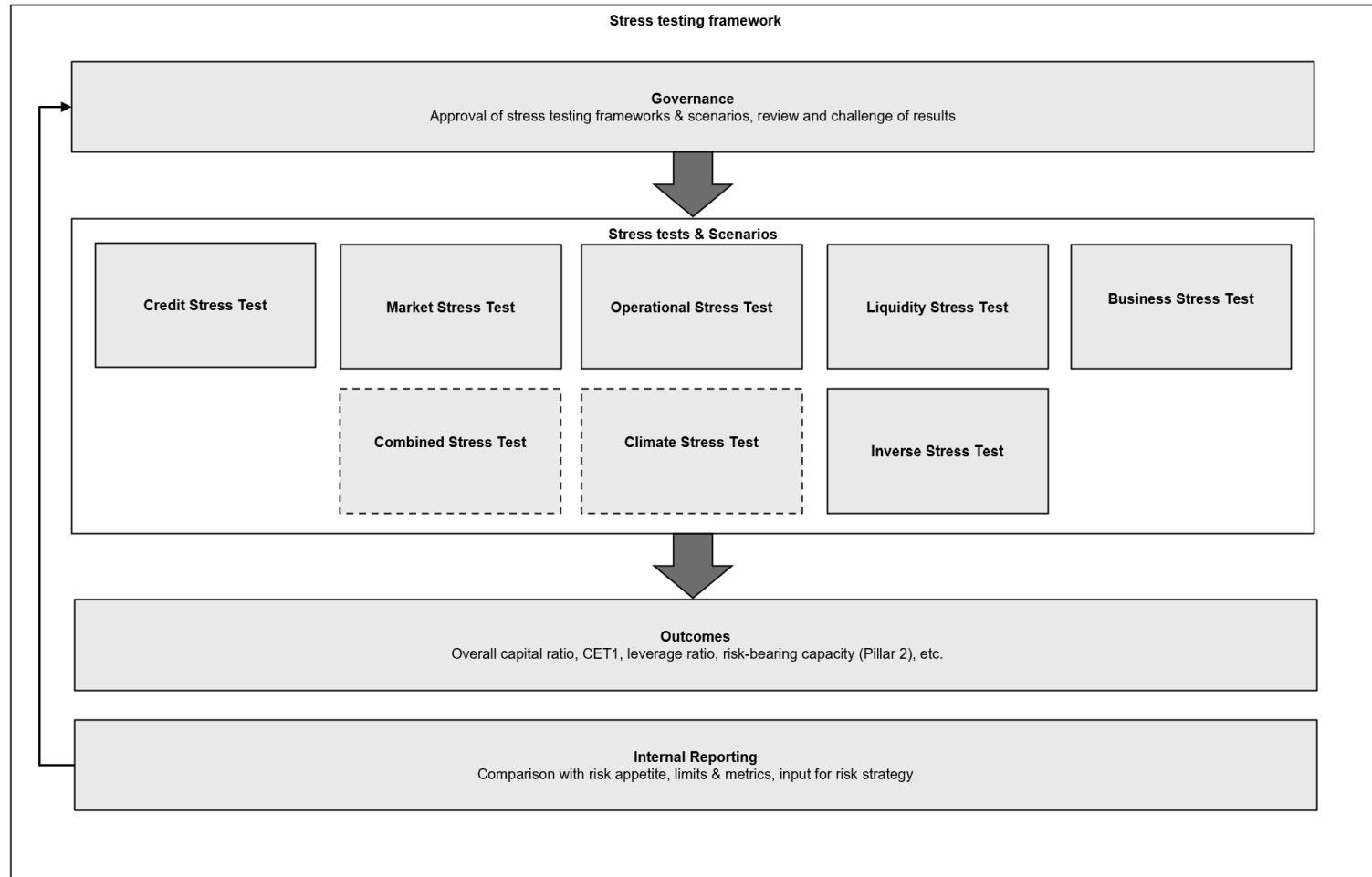
basis, taking a comprehensive approach by assessing the entire balance sheet and income statement and incorporating multiple risk types at once (“combined stress test”). Such combined stress tests provide information on whether capital levels are sufficient to cover different types of moderate to severe macroeconomic scenarios.<sup>44</sup> In addition, institutions also conduct exploratory stress tests that focus on specific risk types and targeted portfolios or sub-portfolios. Such exercises help to improve risk quantification.

Key risk quantification outcomes from these assessments may include metrics such as regulatory capital ratios (e.g., CET1 capital), leverage ratio, utilization of risk-bearing capacity, profitability and liquidity (Baudino et al., 2018). These outcomes are then compared against the quantitative objectives anchored in the risk appetite framework, as discussed in Section VII.4.4.

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<sup>44</sup>We also refer to these stress tests as “macroeconomic stress tests”.

Figure VII.10: Stress testing framework.



*Remark:* The figure presents a simplified overview of the structure of a stress testing framework and outlines its key components, such as governance structures, scenario types, result definitions, and internal reporting. It is based on EBA (2018) and ECB (2022c).

The ECB requires institutions with material climate risks to evaluate the appropriateness of their stress testing program, with a view to incorporating climate risks into their baseline and adverse scenarios (see expectation 11 of the ECB Guide, ECB 2020b). In response, several institutions have already integrated or are in the process of integrating climate stress tests into their internal stress testing frameworks, as noted by two respondents (N1, H5):

*“Climate stress tests are now an integral part of the regular stress testing program.”*

**(N1)**

*“Currently, climate and environmental stress tests still hold a certain special status and have their own reporting. However, the objective is to integrate them into the general stress testing framework in the future. The idea is that in future they will be treated like all other stress tests, so that we can assess potential impacts on capital and other factors, for example.”* **(H5)**

The incorporation of climate stress tests into the internal stress testing framework is approached in a variety of ways. A few institutions (O, J) have added climate-related components to their quarterly institution-wide ICAAP stress tests (i.e., the “combined stress test” in Figure VII.10). In addition to this, the majority of institutions have expanded their internal stress testing frameworks to add climate stress tests as a distinct stress test and scenario category. For example, two respondents (J1, O1) described how climate risks are integrated as specific climate-related scenarios and how climate risk factors are embedded into other internal stress tests:

*“As part of our stress test framework, we conduct various types of stress tests. This includes so-called ‘adverse’ scenarios, which we update on a quarterly basis. These scenarios incorporate climate-related components. For example, we have already started to include the CO2 price as a macro variable. In the future, we plan to integrate additional climate-related elements. We also perform ‘exploratory’ stress tests. For this, we create an annual stress test calendar in which we select 4 to 5*

*scenarios each year for in-depth analysis. For example, one year we might focus on a real estate market stress or interest rate risk scenario. Geopolitical scenarios, such as crises in the Middle East or Ukraine, may also be considered. In this context, we have now integrated an internal stress testing exercise for climate and environmental risks, which we aim to conduct every two years.” (O1)*

*“We currently have a set of 7 to 8 scenarios, including two that are explicitly focused on ESG and climate-related risks. Specifically, these are a short-term transition risk scenario and an ESG-related reputation risk scenario. In addition, several other scenarios have been enhanced to incorporate climate-related aspects. This means that climate considerations are not limited to our two specific ESG scenarios but are also embedded in others as well. This is particularly true for our shipping portfolio, where we use long-term forecasts for charter rates and market values that extend beyond the planning horizon. For example, we model the trend towards eco-efficient ships, as well as the expectation that non-efficient ships will experience greater losses in market value.” (J1)*

There are other examples of institutions incorporating climate scenarios into their internal stress testing framework. For example, one institution (E) mentions in its Pillar 3 report that it has incorporated climate risks into its internal stress testing framework, including in the form of “separate stress scenarios” for climate risks. Similarly, another institution (I) notes that ESG scenarios constitute a “separate scenario class” within its conceptual framework for stress tests and scenarios. Integrating climate stress tests into the broader stress testing framework also encourages institutions to conduct such stress tests on a regular basis (e.g., annually), while also ensuring that climate stress tests are subject to the same governance and reporting structures as conventional stress tests (e.g., stress testing committee, risk and credit committee, board of directors).

However, we find variation in the frequency with which these tests are conducted. For example, several respondents (E1, D1, H3, K2) indicated that their respective institutions conduct climate stress tests on an annual basis. Another respondent (O1)

reported that explorative climate stress tests are performed every two years. In contrast, one respondent (J1) explained that climate-related scenarios are now treated as “regular scenarios” and are run on a quarterly basis as part of the institution’s overall planning and forecasting process. These differences in frequency are also evident in the Pillar 3 report of one institution (K) in our sample, which states that macroeconomic stress test results are typically generated on a quarterly basis, while climate scenarios are conducted annually. However, a respondent (K2) from this institution indicated that a transition from the current annual approach to a semi-annual frequency is currently under consideration:

*“We have a set of scenarios that we use for stress testing, which has been in place for several years. Each year, we review this list to determine if it remains relevant, if any adjustments are needed, or if other issues with potentially greater impact should replace existing scenarios. Although the climate scenarios we have used over the past two years are important, they do not have the same severity as our top stress scenarios, and therefore are not included in that category. However, we still calculate them annually to ensure we stay alert to any developments that might justify their inclusion among our top scenarios. Unlike other stress tests, the time horizon for climate scenarios is much longer, projecting portfolio developments in business areas up to 2050. Currently, we run climate scenarios annually, while other stress tests are conducted quarterly. However, we are also evaluating whether annual assessments of climate scenarios are too infrequent and whether running them twice a year would be more suitable.” (K2)*

*“We have now established a regular internal stress testing exercise for climate and environmental risks, which we aim to conduct every two years. We have just completed the most recent iteration of this process.” (O1)*

**Climate scenario choices, assumptions and related challenges** Integrating climate stress tests into the broader stress testing framework requires the development and selection of appropriate scenarios. In addition, the availability of multiple climate



scenarios raises the question of which ones are best suited for risk quantification and stress testing purposes. This section examines key considerations related to climate scenarios and discusses challenges highlighted by our respondents.

A stress test typically begins with scenario development, where the first step is to define a narrative based on a set of high-level qualitative and quantitative assumptions. These assumptions are typically presented in the form of a coherent and plausible scenario outline. The second step requires the definition of shocks to some key macroeconomic variables (e.g., interest rates, unemployment, house price index) that are representative of an economic downturn or a recession (Baudino et al., 2018). The design of these shocks, including their intensity and transmission channels, has to be grounded in historical and/or scientific evidence and take into account current economic and market conditions (Baudino et al., 2018). In addition, the scenario narrative needs to address relevant risk factors to which an institution is exposed and cover a time horizon consistent with the overall objective of the stress test exercise and the characteristics (e.g., maturity) of the institution’s stressed portfolio (EBA, 2018).

While some institutions incorporate climate-related risk factors (such as CO2 prices) into their internally developed macroeconomic stress tests, most institutions rely primarily on publicly available external climate scenarios to conduct their climate stress tests, as indicated by our respondents (D1, E1, F1, G1, H4, I2, K2, N1, O1, P1). These scenarios are developed by external organizations, including scientific bodies and supervisory institutions such as the NGFS, the IEA and the Intergovernmental Panel on Climate Change (IPCC) (Acharya et al., 2023; Bank of England, 2024). Of these, the NGFS scenarios (“NGFS scenarios”) were the most frequently referenced by our respondents.

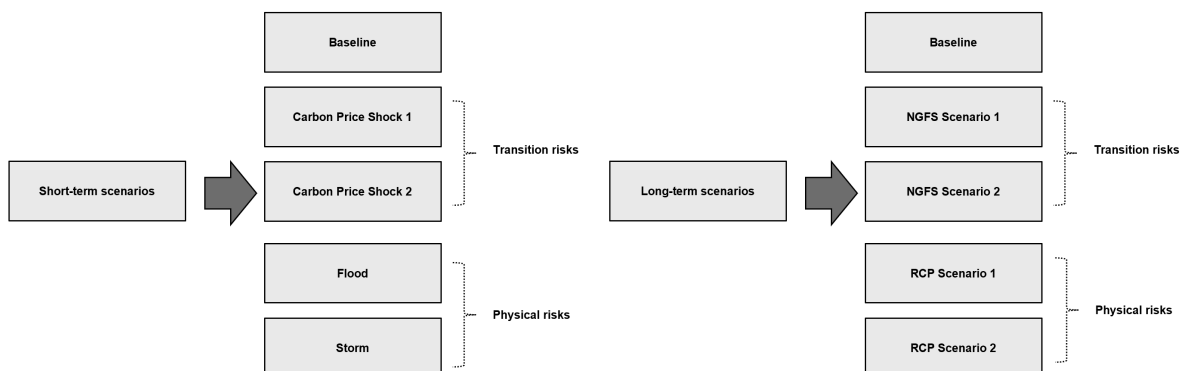
Several respondents reported that European supervisors, in particular the ECB, typically select NGFS scenarios for their own stress testing exercises, which in turn influences the scenario choices of the respective institutions. In addition, the respondents cited additional reasons for preferring external scenarios, including better comparability of results, reduced reputational risk and the notion that climate scenarios are “common good” resources that institutions should both contribute to and use. For example:

*“It is true that there are certain types of risk to which institutions are more or less vulnerable or sensitive. In such cases, it is useful to have your own scenarios. For example, if a bank only finances the automotive industry, it would be useful to explore certain aspects in more depth by developing specific in-house scenarios. But it is also important to remember that climate scenarios are a kind of scenario that describes how the world works. I don’t think it would necessarily be useful or desirable for every bank to have its own vision of how the transition could work. For scenarios that describe the world, such as climate scenarios, I think it is important that they are developed by somewhat external authorities, such as regulators or scientists; there is no reason why they should be specific to a bank. Also, for reasons of communication, comparison and application, I think it is questionable whether certain scenarios should be constructed by the banks themselves.” (G1)*

*“We initially considered creating our own scenarios, but ultimately decided against it for a number of reasons. Firstly, some scenarios are mandated by regulatory stress tests. For example, when the ECB conducts a climate stress test, the parameters provided must be used as specified. Adopting these external scenarios aligns with current best practices and with the regulator’s approach. In addition, using standardized scenarios ensures comparability and consistency. In all these scenarios, there is a very high degree of dependence on model inputs and assumptions. This risk does not diminish if we tweak them ourselves. Lastly, there is a reputation risk involved. We want to avoid a discussion where we have to justify ourselves for having set certain parameters in one way or another (...). Recently, we have been using NGFS scenarios a lot because they are also repeatedly picked out by the regulator.” (D1)*

*“The NGFS provides a widely accepted foundation. As soon as you develop something of your own, questions arise, such as why it is parameterized this way or how does it align with specific aspects. By using an industry standard, you can to*

Figure VII.11: Institution's scenario mix.



*Remark:* The figure illustrates a hypothetical scenario mix, highlighting the use of both short-term and long-term climate scenarios to assess transition and physical risks.

*some extent avoid these types of discussions.” (K2)*

*“In 2023, an internal climate stress test was conducted for the first time as part of the ICAAP stress testing program, encompassing multiple risk types. This test was partially based on the ECB’s 2022 climate stress test. Given our bank’s broad and diversified structure, it makes sense to primarily align with the ECB climate stress test. However, for more specialized banks, it would be more appropriate to have stress tests that are more specifically tailored to their portfolios (...).” (N1)*

The institutions included in our sample use a variety of external climate scenarios. Figure VII.11 provides a stylized illustration of an institution’s scenario mix. These scenarios can be broadly classified into two categories: short-term and long-term scenarios. Some scenarios examine transition risks, while others place greater focus on physical risks. Furthermore, they also use baseline scenarios, which we discuss in Section VII.4.3. We begin by discussing the use of short-term climate scenarios.

### Short-term scenarios:

A key motivation for using short-term scenarios is that the time horizon of such scenarios (e.g., 1 to 5 years) aligns with other key risk management and capital planning

processes, which typically span 3 to 5 years. For example, one respondent (J1) noted that their institution uses a short-term scenario similar to the NGFS “sudden wake-up call” scenario. This scenario describes an abrupt and unanticipated transition in which an event (e.g., a severe natural disaster) triggers a sudden change in policy stance (NGFS, 2023a). Similarly, another respondent (C1) described developing a short-term scenario centered on a severe carbon price shock. This scenario incorporates global forecasts for carbon prices and condenses their effects into a short-term framework. Finally, one respondent (O1) noted that their institution uses two short-term scenarios, each based on different levels of CO2 price shocks.

*“Our standard stress tests typically cover a time horizon of 3 to 5 years, so we need scenarios that align with this timeframe. We have developed two specific ESG scenarios with internal parameters. One of these is a transition risk scenario, which goes in the direction of the NGFS’s wake-up call scenario. It is a short-term scenario that models both a policy and confidence shock, including a rapid increase in carbon pricing.” (J1)*

*“We have developed an internal scenario, as the long-term NGFS scenarios are not well-suited for our internal assessments. Our short-term scenario is very conservative. We take research forecasts for 2030 and bring them down to today. We look at what research is forecasting in the more severe scenarios in terms of carbon prices around the globe, all at the same time, and we use those assumptions in our scenario as if they were occurring today (...). We have another transition risk scenario that assumes a sudden acceleration of green technology and analyzes what happens in different sectors (...). For the long-term scenarios, e.g., 30 years, we use NGFS as a base, but NGFS doesn’t cover all the variables that we need for our portfolio, so we expand NGFS scenarios. Our models always start with a set of core variables that are linked to the scenario in question. Based on historical behaviors and certain characteristics of the scenario, we expand this to a set of 700-800 variables that help us to implement the scenario on the entire*

*portfolio.” (C1)*

*“In the short-term scenarios, we consider different forms of a carbon price shock, which we then translate into PD shifts across individual sectors and apply to our portfolio.”(O1)*

A few respondents (E1, N1) also reported using modified versions of the scenarios employed in the supervisory climate stress test conducted by the ECB in 2022. For this exercise, the ECB provided several scenario projections, covering different time horizons, as shown in Figure H.1. One of the scenarios was a short-term horizon of three years, modeling a disorderly transition. The calibration of this scenario was primarily based on NGFS estimates, with adjustments introduced by the ECB (ECB, 2022a). Notably, the scenario entails a carbon price increase, which was frontloaded to 2022, 2023 and 2024 in the ECB’s climate stress test (ECB, 2022a). One respondent (E1) noted that the short-term disorderly transition scenario provided by the ECB served within their institution as a basis for further internal short-term climate stress testing exercises:

*“In the previous stress test, the ECB provided a short-term disorderly transition scenario as a guideline. This scenario focused on the crisis years. We used this as a starting point and foundation for our internal stress scenarios.” (E1)*

In terms of short-term physical risk scenarios, one respondent (O1) noted that their institution conducts stress tests focused on storm and flood risks using data from Munich Re’s NATHAN database (Natural Hazard Assessment Network):

*“In the short-term, we also look at scenarios for storm and flood risk. We use the NATHAN database, which contains data provided by Munich Re. Flood risk is a very relevant topic for us.” (O1)*

Furthermore, several respondents (E1, I2, G2, O1) reported that their institutions’ approaches to physical risk analysis were largely based on the ECB’s methodology (see

Figure H.1). The 2022 ECB climate stress test covered a short-term horizon of one year and encompassed both a drought and heat scenario, as well as a flood risk scenario (ECB, 2022a). The drought and heat scenario modeled the economic effects of a severe drought and heatwave in Europe, in particular a decline in sectoral gross value added growth as a result of a productivity shock to GDP. At the same time, the flood scenario modelled the risk of severe flooding in Europe. Both scenarios were designed by the ECB as instantaneous shocks, resulting in a much shorter time horizon compared to the transition risk scenarios (ECB, 2022a).

### **Long-term scenarios:**

We turn to the use of long-term scenarios. The scenarios used are typically from the NGFS or adapted versions of the climate scenarios introduced by the ECB in 2022 for the purpose of its supervisory climate stress test exercise (see Figure H.1).

In terms of NGFS scenarios, one commonly used scenario is the “current policies” scenario, which falls under the “hot house world” scenario category (NGFS, 2023b). This scenario assumes that existing policies remain unchanged, leading to approximately 3°C of global warming. The 3°C threshold is projected to be reached around 2090s, with important physical risks, such as floods and cyclones, expected to emerge by 2040 (NGFS, 2023b). As a result, the associated transition risks are relatively mild. Another commonly used scenario is the “delayed transition” scenario, which assumes that emissions will not decline until after 2030, necessitating more stringent and disruptive policies to limit global warming to below 2°C. This scenario is classified as “disorderly” and presents higher transition risks due to the delayed policy response (NGFS, 2023b). Lastly, the “net zero 2050” scenario assumes the EU will achieve net zero emissions by 2050, and that global warming is limited to 1.5°C through ambitious climate policies and innovations (NGFS, 2023b). In terms of ECB scenarios, the respondents frequently referred to the “hot house world” scenario and the long-term “disorderly transition” scenarios. These long-term scenarios, employed in the 2022 ECB climate stress test, are largely based on NGFS projections, but include various adjustments (ECB, 2022a). The main features of these scenarios are summarized in Table H.1 in the appendix.

Table VII.2: Examples of scenario mixes for long-term climate-related scenarios.

|                 | Scenario mix A                               | Scenario mix B                               | Scenario mix C                            |
|-----------------|----------------------------------------------|----------------------------------------------|-------------------------------------------|
| <b>Baseline</b> | below 2°C                                    | net zero 2050                                | macroeconomic scenario                    |
| <b>Adverse</b>  | 1) delayed transition<br>2) current policies | 1) delayed transition<br>2) current policies | 1) net zero 2050<br>2) delayed transition |

*Remark:* The table presents three examples (A, B, C) of long-term climate-related scenario mixes observed in the sample. Each scenario mix includes a combination of baseline and adverse scenarios. The examples highlight different approaches to scenario selection.

As shown in Figure VII.11, institutions tend to assess multiple long-term climate scenarios. The mix of scenarios is highly heterogeneous across institutions. By way of illustration, we provide in Table VII.2 three examples of climate-related “scenario mixes”, including baseline and adverse scenarios observed in our sample. We discuss these different approaches further below.

For example, one respondent (G1) explained that their institution commonly uses three NGFS scenarios: the below 2°C scenario as a baseline, and the delayed transition and current policies scenarios as adverse scenarios. Similarly, another respondent (K2) reported that their institution also uses three NGFS scenarios: the net zero 2050 scenario as the baseline, and the delayed transition and current policies scenarios as stress scenarios. Finally, one respondent (I2) described the use of three long-term climate scenarios: the delayed transition, disorderly transition and hot house world scenarios. To illustrate:

*“We use a below 2°C scenario, which represents an orderly transition, as well as a delayed transition scenario, which is a disorderly one, along with a current policies scenario. The goal is to have a baseline scenario and an adverse scenario that reflects a stressed projection compared to the baseline, allowing us to clearly identify the transition-related shock. The delayed transition scenario serves as the stressed version. We also consider the current policies scenario, known as a hothouse scenario, but intend to discontinue its use as we think it is highly unlikely to materialize.” (G1)*

*“We use the net zero 2050 scenario as our baseline, with two additional stress scenarios: delayed transition and current policies, all with a time horizon extending to 2050. This approach enables us to specifically capture the different dimensions, focusing on both transition and physical risks.” (K2)*

Some institutions also make internal adjustments to these long-term scenarios. For example, one respondent (I2) pointed out that their institution incorporated a CO2 price pass-through:

*“We base our analyses on the NGFS scenarios: hot house world, delayed, and disorderly transition. These scenarios are adjusted internally to better model sector-specific countermeasures. For each scenario and sector, we calculate the CO2 price pass-through rate to customers. Take, for example, the cement industry. If we were to apply a Disorderly Transition scenario without adjustments, it would lead to the collapse of the entire cement industry within approximately three years. The burden from CO2 prices would be so severe that companies would become unprofitable and lose creditworthiness, resulting in widespread defaults. However, Germany aims to construct many new homes annually until 2040, a goal that seems unattainable to us without cement. Therefore, we have developed a pass-through rate to model how much of the CO2 price can be passed on to the end customer across different sectors (...). The time horizon of these scenarios is 2050 (...).” (I2)*

Several respondents (D1, O1, P1) noted that their respective institutions use the net zero 2050 scenario as an adverse scenario in climate stress tests. For example, one respondent (D1) reported using both the net zero 2050 and current policies scenarios, explaining that the net zero 2050 scenario aligns with their institution’s net zero commitment, thus motivating its selection alongside the current policies scenario. Another respondent (O1) described using both the delayed transition and net zero 2050 scenarios as long-term transition scenarios. Similarly, respondent (P1) reported combining both a net zero and a delayed transition scenario in their approach:



*“We combine several scenarios. For transition risk, we use a net zero scenario. This is simply because, as a bank, we also have a net zero commitment. It is part of our strategy. For physical risk, we use a relatively warm scenario that triggers physical risk events. We have not chosen a scenario because we think it is inherently more likely to occur. We don’t think that it is possible to make such an assumption. We deliberately combine a net zero scenario with a relatively warm physical risk scenario. They are unlikely to happen at the same time, but we combine them anyway to get a more conservative view.” (D1)*

*“We believe that the net zero 2050 scenario is certainly a challenging scenario, and hopefully one that is not entirely unrealistic. That is what led us to choose it. We also included a delayed transition scenario, which captures the effects of a disorderly transition, alongside it on purpose.” (O1)*

*“We conduct a climate risk stress test with an exploratory focus, using NGFS scenarios and focusing on two key ones: delayed transition and net zero. We chose these scenarios because they have the most substantial impact and because our strategy is strongly aligned with the 1.5°C target. In addition, we also consider the delayed transition scenario to ensure a more comprehensive analysis. We view the net zero scenario as a stress test scenario, though its risk depends on the comparison. If we assume the world is on a current policies pathway, then the net zero scenario introduces substantial transition risks.” (P1)*

For long-term physical risks, the institutions in our sample tend to use Representative Concentration Pathways (RCPs), which are scenarios developed by the IPCC.<sup>45</sup> For example, one of the respondents (O1) elaborated on the use of two RCP scenarios:

*“We also incorporate very long-term scenarios in our analysis. For example, we use the RCP 8.5 scenario to assess severe flood risks with a time horizon extending*

<sup>45</sup>For a more detailed discussion of physical risk analysis, see Section VII.4.3.

*to 2050. Similarly, we apply the RCP 8.5 scenario with a time horizon up to 2100 to evaluate the impact of sea level rise. While we can't predict the exact composition of our credit portfolio that far into the future, we can apply these scenarios to our current portfolio to analyze what the potential implications would be for us.”(O1)*

The use of climate scenarios and their underlying assumptions is not without its challenges. Some of these challenges have been widely discussed in the literature (see e.g., BIS, 2023, 2024; Reinders et al., 2023). We complement this literature by documenting several important aspects raised by our respondents:

#### **Time horizon:**

A commonly cited challenge is the time horizon of climate scenarios, which often extends well beyond the typical timeframes considered by institutions in stress testing, risk management processes and capital planning. This presents both conceptual and technical difficulties, including issues related to IT infrastructure and data handling:

*“In a standard EBA stress test or ICAAP stress test, the time horizon is usually three years. However, for the ECB climate stress test, we have to consider time horizons extending up to 30 years, which makes a big difference (...). Even from an IT infrastructure standpoint, a three-year time horizon is much easier to conceptualize than a 30-year one.” (A2)*

*“The temporal dimension poses a major challenge. Transition risks with time horizons of 30, 50, or even 100 years are fundamentally different from the models currently used in stress testing. This creates a high degree of uncertainty when trying to assess the potential impact of climate risks on capital ratios over such long periods. Quantifying these impacts, as in other stress scenarios, involves a large number of assumptions, which in turn raises concerns about the accuracy of the results. One of the main challenges is reconciling our traditional five-year*

*management horizon with analyses that stretch over 50 to 100 years.” (E1)*

### **Overall scenario design and lack of severity:**

In addition to the time horizon, the design of climate scenarios also poses a significant challenge. Typically, institutions use scenarios that assume an economic downturn with significant macroeconomic shocks, such as a sharp decline in GDP. However, respondents frequently noted that several climate scenarios project only “mild” impacts on GDP. One challenge highlighted is therefore that NGFS scenarios do not provide the shocks “needed” for stress testing exercises. In addition, while internal ICAAP scenarios are typically updated quarterly to reflect changes in macroeconomic conditions, climate-related scenarios are rather reviewed only once a year. Institutions are therefore to some extent dependent on updates from the NGFS for any necessary adjustments:

*“There is a difference in scenario narrative or scenario design. In a typical stress test, there is more of a narrative based on the macroeconomic downturn. There are assumptions about GDP or unemployment rates. A climate stress test is more about climate risk drivers. These could be carbon price shocks or something like that. As I see it, the focus is not so much on saying that there is an economic downturn. Instead, GDP is almost more of an additional piece of information here or perhaps even more of an output variable from my point of view. In other stress tests, you sometimes start with an assumption of an economic downturn and then analyze what would happen. Here it’s more the case that you start with, let’s say, a carbon price shock or physical risks and then at some point GDP and other economic factors come in later on.” (A1)*

While acknowledging the serious threats posed by climate change, several respondents (B1, C1, F1, H4, I2, K2) also explained that most climate scenarios cannot be considered truly “adverse” and therefore have little impact on capital ratios. For example, one expert (A3) pointed out that traditional stress tests are designed to evaluate the effects of rather sudden, large-scale macroeconomic events that can rapidly under-

mine an institution's financial stability. In contrast, climate risks develop gradually over extended time periods, making them difficult to incorporate into stress testing frameworks. In addition, these experts compared NGFS scenarios with their internal macroeconomic scenarios, noting that the NGFS scenarios generally present less severe effects from a macroeconomic perspective:

*“The macroeconomic shocks from these scenarios are very mild. The scenarios are milder than any of the other scenarios that we run.” (C1)*

*“In ICAAP or inverse stress tests, we look at adverse macroeconomic events. Some of these events could happen overnight. For example, if a country in the European Union were to default, the impact would be felt overnight. It would have a direct negative impact on the bank's balance sheet. In the case of climate events, it is more likely to happen over the next years, but certainly not overnight. In that sense, it is a long-term and slow process. Much slower than the macroeconomic events that we typically look at.” (A3)*

*“In several NGFS scenarios there are significant CO2 price shocks and substantial changes in CO2 emissions, but the resulting change in GDP remains almost identical regardless of the magnitude of the CO2 price fluctuations. The impact on GDP often appears to be minimal.” (H4)*

*“In traditional stress tests, we can define a specific shift in the yield curve by a certain number of basis points, outline how FX curves behave, and make certain growth assumptions. This enables us to predict the impact on the bank's portfolio with reasonable accuracy. When it comes to transmission mechanisms, such as a two-percentage-point increase in interest rates, the bank can arrive at a clear understanding of the resulting effects. In contrast, with climate change, a two-degree temperature rise requires many assumptions before we can gauge any impact on a loan portfolio. Moreover, this impact does not occur immediately. While interest*

*rates respond quickly, FX even faster, the effects of CO2 accumulate gradually over time.” (D2)*

Several respondents (B1, E1, G1, J1) also point to some weaknesses in the scenarios used in the ECB’s 2022 climate risk stress test. They noted that the scenarios did not lead to significant stress effects:

*“Some of the forecasts were not really what you would call stress from a purely macroeconomic point of view (...). The growth rates under the various scenarios were far removed from any recession scenarios. In other words, on that basis alone, we did not find a stress effect at all. And I think that describes the challenge (...). Translating a specific climate stress scenario into a macroeconomic stress scenario is complex. We are talking about very long-term developments. What happens if, for example, long-term growth falls by an average of 0.3 percentage points and how that translates into credit risk is difficult to say. In general, stress test models react more to what happens if there is an extreme recession next year with -3% GDP growth. We are not interested in 0.3 percentage points up and down. Even if you had very granular data and very good regression models, at the end of the day, there would probably be very little difference.” (B1)*

*“I find the transition scenarios especially challenging because, in my opinion, the ECB’s parametrization of the climate stress test didn’t yield entirely plausible figures. For instance, when examining the macroeconomic parameters, such as the GDP data provided in the 2022 climate stress test, we faced difficulties in modeling an internal stress scenario based on that data. As a result, we made additional assumptions about an economic downturn to model PD shifts with the scenarios.” (E1)*

Lastly, another respondent (G1) argued that current climate stress scenarios do not qualify as true stress tests because they are based on overly optimistic mathematical models. These models assume ideal conditions, such as perfect agent behavior, un-

limited resources, and rapid technological advancement. Although some improvements have been made, such as considering imperfect international cooperation, this expert explained that the scenarios still fall short by not accounting for real-world non-optimal conditions:

*“It seems to us that there is currently no climate stress scenario as such. As far as we are concerned, the scenarios that are proposed are scenarios that are more or less favourable, but none of them are stress scenarios because they are all based on mathematical models that assume optimal behavior. The scenarios are all based on models that assume that everything is extremely fluid. Agents are all optimal. Resources are unlimited. Investments are immediately reflected in technological change. The NGFS and many others are currently working on this. For example, they have started to work on the fact that there is not necessarily perfect international cooperation. But so far we haven’t managed to take into account all the dimensions that wouldn’t be optimal. For example, even in a scenario with very high CO2 prices, we continue to assume that everything else works perfectly. This is also one of the reasons why we systematically end up with much lower impacts than in traditional stress tests.” (G1)*

#### **Low sectoral and spatial granularity:**

Several experts (A1, F1, I2, J1) highlighted the difficulty of isolating the effects of climate scenarios and accurately attributing them to particular sectors or specific geographic areas. They explained that a key limitation of these scenarios is their insufficient granularity, which makes it challenging to effectively capture the risks tied to an institution’s specific business model and portfolio:

*“In terms of GDP assumptions, some of them are given by the NGFS scenarios (...) but what is not always provided is, for example, what this means for the individual sectors. Part of it is given and part of it is based on additional assumptions that we make internally to differentiate the effects across sectors.*

*But if we make additional assumptions for, say, the automotive and transportation industries, then we have to make sure that everything fits in with the overall GDP assumptions (...). We have a team of economists that perform this variable expansion. Some of it is based on qualitative assumptions (...).” (A1)*

### **Probabilities of climate scenarios:**

Several respondents (G1, H5, K2) underscored that a discussion on the probabilities of different climate scenarios would be valuable. For example, one respondent (G1) explained that the current challenge is not the lack of scenarios, but rather the lack of probabilities associated with them. While many scenarios are used, each is typically analyzed in isolation. This expert made a case for analyzing scenario outcomes in a more conditional way, i.e., conditional on the probability of each scenario. Another expert (O1) argued that while institutions are faced with an increasing number of climate scenarios, the goal should be to focus on a more limited number of scenarios that are both highly probable and most useful for decision making. One respondent (K2) provided an example of how their institution has already begun to assign internal probabilities to climate scenarios based on expert judgement. These probabilities are taken into account in the ICAAP. By doing so, the institution prioritizes scenarios that it expects are likely to occur, thereby improving risk management and planning. Similarly, another respondent (H5) highlighted that their institution is actively working to assess what might be considered a likely scenario used for loan pricing:<sup>46</sup>

*“A current challenge is that there are no probabilities associated with climate scenarios. Each time, we focus on one scenario and analyze its outcomes. What could be interesting is if there were probabilities assigned to each scenario. This way, we could not only perform analyses for different scenarios, as is currently done, but also produce results that are conditional on the likelihood of each sce-*

<sup>46</sup>Probabilities may be assigned to scenarios in the context of expected credit loss calculations. For example, scenarios may be incorporated into the expected credit loss calculation and risk stage determination in a probability-weighted manner.

*nario. This would allow us to assess the overall risk by associating each scenario with its probability of occurring. I think this could be valuable to track how these probabilities evolve over time.” (G1)*

*“Our macro stress scenarios do not have an assigned probability. These are narratives that focus on potential impacts, without consideration of how likely the scenario is to occur. The situation is somewhat different with climate scenarios. In this case, we collaborate with economists, as there are specific estimates regarding the probability of occurrence for scenarios such as our baseline, the hot house world, and the delayed transition. While these probabilities are not directly factored into the calculations, they are considered in the overall assessment. For example, knowing that the current policies scenario has a 10% probability is quite different from it having a 70% probability. This also plays a role in determining the climate-related buffer.” (K2)*

*“A little further in the ECB Guide, we are asked to include climate and environmental risks into loan pricing. So we need to choose a scenario that we can use for our monitoring and that we can also use to set loan conditions for our customers (...). This scenario should be as realistic and close to expected developments as possible (...). For pricing, we try to focus on one scenario for the time being. We may at some point use a weighted average of several scenarios.” (H5)*

**Choice of baseline scenario** The degree of severity of the scenario outcomes is typically determined by comparing them to a baseline scenario. A baseline scenario is defined as a “non-stressed, central projection that serves as a basis of comparison for the other analyzed scenarios” (p. 10, BIS 2024). Thus, the baseline is usually the most likely scenario. The stress effect is then quantified by comparing the impact of an adverse scenario against the baseline (EBA, 2018). As with conventional stress tests, climate stress tests require the selection of one (or more) adverse scenarios and a baseline scenario. In this section, we outline the approaches taken by several institutions in our



sample to incorporate climate risks into their baseline projections and highlight key challenges.

A baseline scenario that completely ignores climate impacts would be counterfactual and unrealistic (BIS, 2024). Therefore, to provide a realistic path, climate risks should be accounted for in the baseline projection (BIS, 2024). Selecting an appropriate baseline scenario for climate stress testing presents significant challenges, however. One difficulty is assessing what constitutes a likely scenario. Another is to incorporate climate-related impacts from both transition and physical risks into the central projection. Incorporating climate risks into the baseline also adds complexity. Specifically, if the baseline already reflects a certain level of stress, the perceived severity of the adverse scenario may be reduced, blurring the distinction between the two. As a result, the adverse scenario may seem only marginally worse and could therefore fail to highlight the full range of potential risks. Ideally, the baseline scenario should strike a balance between accounting for climate risks and maintaining enough contrast with the adverse scenario.

Overall, we observe two main approaches among the institutions in our sample. One is to integrate climate risks into the institution-wide macroeconomic forecast, which serves as the baseline scenario for various purposes, including business and capital planning. The other is to use a dedicated climate scenario as a baseline. We provide an overview of the scenarios mentioned by our respondents in Table VII.3 and discuss them below. As a first illustration, and as shown in Figure H.1, institutions were provided with baseline projections in the supervisory climate stress test conducted by the ECB in 2022. For the long-term transition risk scenario, the baseline represented an orderly transition characterized by minimal transition and physical risks. For the short-term transition scenario, the baseline was based on the Eurosystem's December 2021 Broad Macroeconomic Projections Exercise (BMPE) (ECB, 2022a).

Due to the complexities involved, our respondents expressed varying views on the integration of climate risks into baseline scenarios. For example, one respondent (C1) argued that their institution had not incorporated climate risks into the standard baseline scenario and did not plan on doing so. This expert also noted a lack of clarity from

Table VII.3: Baseline scenarios.

| Baseline scenario name       | Organization | Challenge                              |
|------------------------------|--------------|----------------------------------------|
| Below 2°C                    | NGFS         | Overly optimistic                      |
| Fragmented World             | NGFS         | Contains transition and physical risks |
| Net Zero by 2050             | NGFS/IEA     | Contains transition risks              |
| Orderly transition           | NGFS/ECB     | Overly optimistic                      |
| Other macroeconomic scenario | Internal     | May ignore climate risks               |

*Remark:* The table presents a non-exhaustive list of examples of baseline scenarios used by the institutions in the sample.

regulators on this issue, as reflected in the following statement:

*“The net-zero scenario can serve as a kind of baseline scenario and might actually work as a baseline for other climate scenarios. However, we have not included climate risks in our own baseline and have no plans to do so (...). I think there are a lot of different approaches being used at the moment. For example, in the Bank of England’s climate stress test, the counterfactual did not include climate risks. The ECB provided a baseline, but in the results they publish, they never take the baseline into account – they always compare between scenarios. As a result, the baseline didn’t have much impact on the overall climate stress test. If you look at the results published by the ECB, they never compare anything to the baseline. Meanwhile, the Federal Reserve used the current policies scenario as the baseline, which is problematic because it includes a lot of physical risks in the baseline, yet they asked us to benchmark against that for transition risks. So, overall, I think we have quite a bit of freedom to decide what the baseline is and how to use it because the regulators are not clear (...) For the short term, we take into account the whole loss resulting from the adverse scenario.” (C1)*

Other respondents explained that their institutions already use, or plan to use in the near future, specific baseline scenarios incorporating climate risks for their internal climate stress tests. For example, two respondents (I2, P1) explained that their respective institutions use an internal scenario used for capital planning (so-called “economic plan scenario” or “rolling forecast”) as a baseline. Such scenarios are not specifically

designed as climate scenarios like the NGFS scenarios, but institutions do incorporate climate-related elements, for example related to CO2 prices. Such baseline scenarios are based on macroeconomic forecasts developed by the institutions' economic research departments. They cover shorter time horizons than the NGFS scenarios. The forecasts are updated at least quarterly. Consequently, more immediate macroeconomic effects of climate risks are likely to be naturally incorporated and covered by the forecasts, while longer-term climate-related effects may be limited or even overlooked.

*“For the short term, we use our internal scenario. We have an internal rolling forecast, which serves as the baseline scenario. Building on this, we then apply climate scenarios, such as the delayed transition, and break it down over a three-year horizon.” (P1)*

*“We have developed a scenario that reflects our expectations for upcoming macroeconomic developments. This scenario, referred to as our Economic Plan Scenario, is independently developed by our research department. As the risk control function, we independently adjust it in collaboration with the risk management units. Climate risk factors are included in the scenario, but their impact isn't felt until 2028 or 2029, so they are not highly relevant at this stage (...). Our expectation is that the first significant climate-related impacts won't occur immediately, but rather will begin around 2028-2029. This is reflected in our expected scenario (...). This scenario is reviewed quarterly. It is an iterative process and we are increasingly including climate-related aspects into our planning process.” (I2)*

Similarly, another respondent (O1) provided further insight into the use of a baseline scenario based on medium-term macroeconomic assumptions, including a gradual increase in CO2 prices:

*“In the baseline scenario, we primarily base our assumptions on our own medium-term planning and factor in an expected increase in CO2 prices, rising from 84 to 108 between 2023 and 2028. This baseline particularly plays a role for our*

*short-term carbon price shock scenarios.” (01)*

For the second approach, which uses dedicated climate scenarios as baselines, various NGFS scenarios are applied. For example, one respondent (G1) noted that their institution initially used the NGFS below 2°C (orderly transition) scenario as its baseline. This scenario belongs to the category of “orderly” scenarios and assumes that gradually more stringent policies provide a 67% chance of limiting global warming to below 2°C (NGFS, 2023b). However, the expert noted that this scenario is becoming increasingly unlikely, prompting their institution to adopt the NGFS Fragmented World scenario as the new potential baseline. This scenario assumes delayed and inconsistent climate policy actions, resulting in high transition risks in some countries and significant physical risks globally due to the overall ineffectiveness of the transition (NGFS, 2024b). A challenge with this baseline is its relatively high levels of both transition and physical risks, which could lead to an underestimation of the overall impact:

*“We use a baseline and an adverse scenario to really identify a shock associated with the transition. At the moment, we still consider the orderly transition scenario to be the baseline in the sense that it is the least risky scenario. But we are in the process of evolving on this point as well, because unfortunately this scenario itself is not at all likely. It should be understood as a favorable or optimistic scenario rather than a baseline scenario. In its new set of scenarios, the NGFS has a scenario called fragmented world. This will be our baseline scenario from now on (...). One of the limitations of all the work done on climate is that there is really no very robust, consensual baseline scenario.” (G1)*

Another expert (K2) explained that their institution uses the NGFS net zero by 2050 scenario as its baseline. This scenario is considered orderly, as it assumes global warming is limited to 1.5°C by 2050 through the smooth and immediate implementation of climate policies (NGFS, 2023b). As a result, transition risks are moderate and physical risks are low (see Table H.1 in the appendix). Similarly, one respondent (L1) noted that institutions also typically use the IEA’s net zero by 2050 scenario. This

expert argued that such a scenario may be particularly appropriate for institutions with a large portfolio of European companies, given the EU’s commitment to a net zero target by 2050. However, such choice of baseline would also be based on the assumption that clients within the institution’s portfolio follow this commitment path. Thus, understanding the behavior and trajectories of the institution’s clients is an essential aspect of selecting the appropriate baseline scenario.

*“We use the net zero 2050 scenario as our baseline, with two additional stress scenarios: delayed transition and current policies, all with a time horizon extending to 2050.” (K2)*

*“What can we use as a guide? A classic approach would be to use the IEA net zero 2050 scenario (...). This gives sectoral pathways with interim targets for 2030, 40, 50. Sometimes the only option we have is to say that our borrowers will follow the path that the IEA has set out in this scenario. Whether they do, or whether they go faster or slower [with the transition], is very hard to say. But you have to look at it and collect data.” (L1)*

*“If you take an optimistic baseline scenario like net zero 2050 and compare it to the less optimistic scenarios, such as current policies and hot house world, the impact becomes even more pronounced. In that case, the assessment would be rather conservative. But it is true that net zero 2050 is becoming increasingly unlikely.” (K2)*

In terms of incorporating physical risks into baseline scenarios, one expert (G1) highlighted the particular difficulty of incorporating long-term physical risks, noting that institutions still struggle to fully understand and model these effects. On the other hand, another respondent (O1) mentioned that short-term physical risks are more likely to be reflected and factored into the medium-term macroeconomic assumptions used in baseline scenarios:

*“When it comes to physical risks, we generally assume that these are initially reflected in our credit risk parameters and medium-term planning. If flood scenarios or similar events actually occur, we would likely face increased provision needs and higher risk-weighted assets. We can then compare these events to the baseline, but always in the context of the assumptions and goals set in our medium-term planning.” (O1)*

**Top-down modeling approaches** As outlined in Section VII.4.3, the institutions in our sample frequently conduct stress tests using a “top-down” approach as part of their ICAAP. These exercises typically consist of three key components: scenarios, models and outcomes (Acharya et al., 2023). In this section, we briefly examine some of the main steps of this approach and discuss the challenges that institutions face in this regard, as described by the respondents.

In their ICAAP, institutions typically use macroeconomic (“top-down”) stress testing approaches in which exogenous shocks are applied to key macroeconomic variables (e.g., interest rates, unemployment) to simulate an economic downturn or recession (Baudino et al., 2018). The shocks are realized through various transmission channels and processed by satellite models that translate the macroeconomic indicators into financial risk parameters for different types of risk (e.g., credit risk, market risk) (Schult et al., 2023; Reinders et al., 2023). The results of such scenarios can generally be expressed in terms of stressed capital ratios and used to highlight potential capital shortfalls under severe but plausible conditions (Acharya et al., 2023). Figure VII.12 shows the main steps of this top-down approach.

In the context of climate risks, the institutions in our sample also apply such approaches using climate scenarios and climate-related stress events. An important first step in top-down modeling approaches is scenario specification, which involves defining the specific conditions or events that the stress test will simulate. This step involves selecting the types of shocks or events (such as economic recessions, market crashes, climate-related disasters) and defining their magnitude, duration, and other parameters. This step is typically performed by the institution’s economic research department

in collaboration with the specific risk control teams responsible for stress testing.

*“Our colleagues in the economics department develop the macroeconomic scenarios. Key parameters include GDP, unemployment rates, interest rate trends, and so on. We provide some guidance on how adverse the scenario should be. They then apply their economic models, and we receive the parameters back, which we need to translate to the different risk types within our portfolio.” (O1)*

### **Scenario expansion:**

As discussed in Section VII.4.3, institutions typically rely on external long-term scenarios, such as those developed by the NGFS, for their climate stress tests. Although the NGFS develops the scenario narratives and provides a corresponding set of key variables, institutions typically have to perform a “scenario expansion”, which involves refining and extending the scenarios to meet their specific needs. Such climate-related scenario expansion process was described as particularly challenging by our respondents (A1, C1, F1, H4, J1, J2). While the institutions’ economic research departments are typically tasked with the scenario expansion, one institution (J) noted that several departments, including not only economic research and the chief economist, but also finance and risk management, contribute to scenario expansion, with risk management leading the process in this case.

In terms of scenario expansion, and by way of illustration, three respondents (A1, C1, H4) noted that while the NGFS scenarios provide GDP estimates at the country level, they lack detailed information at the sector level. This requires institutions to make assumptions about the macroeconomic impacts of climate change on specific sectors, including in terms of sector growth, but also price shifts (e.g., due to structural changes and shocks). Other issues such as changes in productivity (due to extreme weather) and socio-economic changes (such as changes in consumer behavior) may also require careful consideration at the sector level. For example:

*“We have a research department that parameterizes the scenarios in the internal stress tests and derives GDP, inflation and other parameters from the storyline. There are also qualitative parameters (...). Even if we take the NGFS scenario as a basis, we have to do what we call ‘scenario expansion’. For example, NGFS gives us GDP estimates at country level, but we need such estimates at both country and sector level, so we need to break such scenarios further down internally. That is something that, for example, we do ourselves internally. As a next step, we use these estimates in our satellite models.” (H4)*

*“In terms of GDP assumptions, some of them are given by the NGFS scenarios (...) but what is not always provided is, for example, what this means for the individual sectors. Part of it is given and part of it is based on additional assumptions that we make internally to differentiate the effects across sectors. We have a team of economists that perform this variable expansion.” (A1)*

*“For the long-term scenarios, e.g., 30 years, we use NGFS as a base, but NGFS doesn’t cover all the variables that we need for our portfolio, so we expand NGFS scenarios. Our models always start with a set of core variables that are linked to the scenario in question. Based on historical behaviors and certain characteristics of the scenario, we expand this to a set of 700-800 variables that help us to implement the scenario on the entire portfolio.” (C1)*

*“We have to analyze how, for example, climate policy may affect GDP, but what the effect may be for different sectors and companies. And that is a really big challenge that our economic research department is also facing. It is very difficult to quantify this effect. The NGFS models provide data, this data is now quite good and we can of course use it as a first step.” (L1)*

In expanding scenarios at the sector level, some institutions incorporate additional assumptions, such as the pass-through rate of CO<sub>2</sub> prices. For example, one respondent (I2) indicated that their institution estimates the capacity of specific sectors to transfer



increases in CO<sub>2</sub> costs to their consumers, a factor that is otherwise absent from the NGFS scenarios:

*“We take a top-down approach at the sector level, using data on CO<sub>2</sub> prices and sector GDP data as outlined in the scenarios. Based on the changes in sector GDP, we further estimate the impact on the sectors by incorporating additional assumptions about their ability to pass on CO<sub>2</sub> costs to consumers. These sector-level pass-through rate estimates are then applied to our clients’ actual CO<sub>2</sub> intensity. In essence, we assess each client’s CO<sub>2</sub> emissions and analyze their balance sheets to determine how future CO<sub>2</sub> prices may affect their profitability. If a client can pass on the full cost of CO<sub>2</sub> to consumers, their profitability will remain unchanged. However, if they can only pass on 50% of these costs, they will see a reduction in profitability. This allows us to calculate changes in PDs for individual clients based on their CO<sub>2</sub> intensity. Our ability to make accurate assessments at a sector level is already very good. However, when it comes to individual clients, particularly their ability to pass on costs, we recognize that there is room for improvement. This will improve as we collect more data, allowing us to better reflect the specific intensities of individual clients. In 2021, we started calculating sector intensities using data from MACS and applied these calculations to individual clients. For our largest clients, we have already collected detailed data and are now iteratively building a database based on real data.” (I2)*

### Satellite models and related challenges:

Once institutions have translated climate scenarios into macroeconomic impacts, including at the sector level, they typically use “satellite models” that translate the macroeconomic variables into financial risk parameters (Reinders et al., 2023). For example, one respondent (H4) explained that their institution’s top-down approach currently allows them to derive credit risk parameters and impairments<sup>47</sup> from climate scenarios. However, the respondent also noted that this top-down approach does not currently extend

<sup>47</sup>Under IFRS 9, impairments refer to the recognition of potential credit losses on financial assets, such as loans, based on expected credit loss models.

to the entire balance sheet and therefore does not consider the potential impact on all risk types. Several respondents (A1, G1) highlighted the limitations of satellite models when assessing climate risks. One issue is the reliance of such models on historical data for model calibration. Furthermore, these models may not effectively capture granular effects at the sector or even intra-sector level. As a result, institutions combine the top-down approach with microeconomic, or bottom-up, stress testing approach, which we discuss in Section VII.4.3.

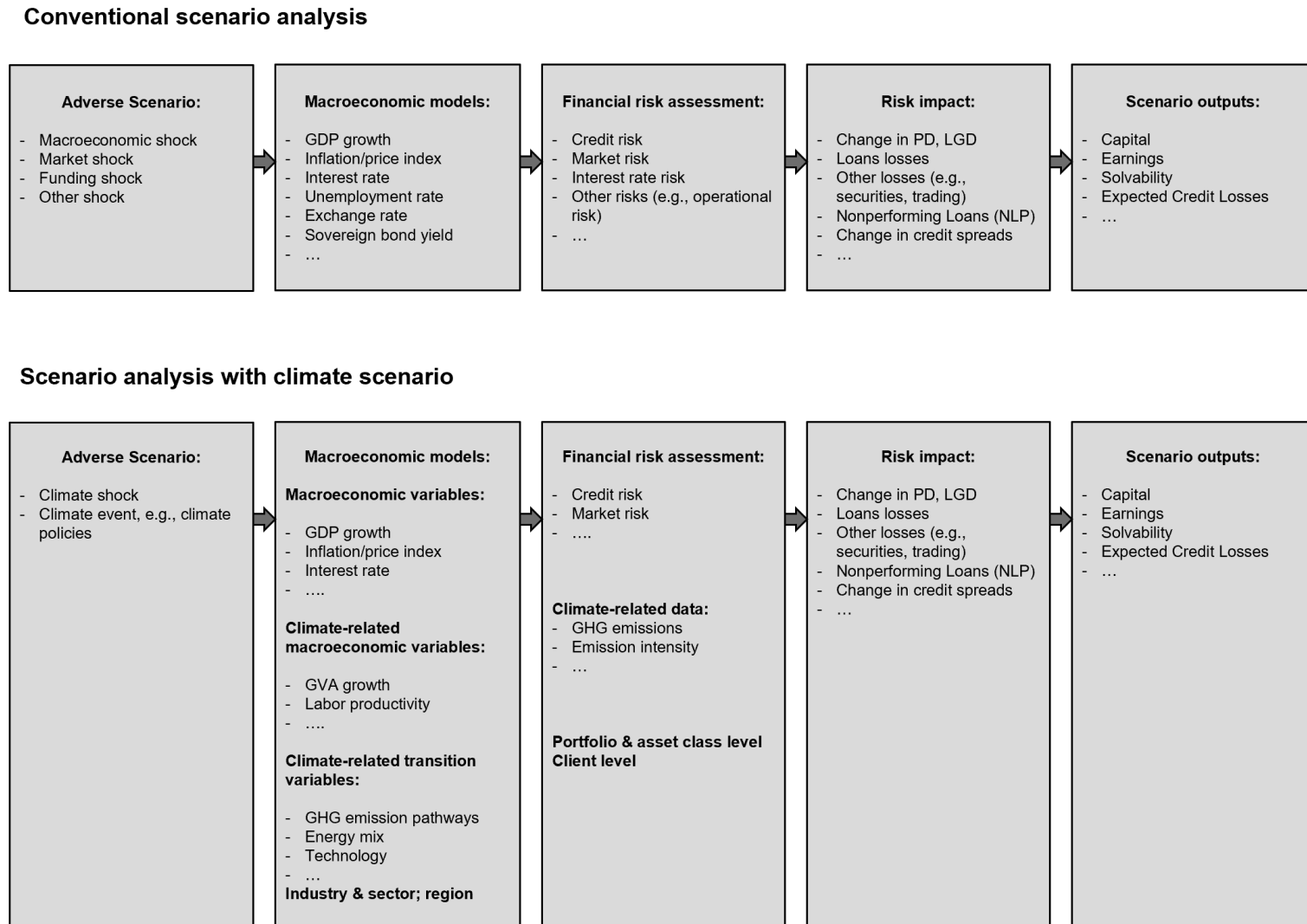
*“What we do is we stress PD, LGD and collateral for credit risk and then translate that into risk-weighted assets and impairments. To be fair, what we don’t do is actually stress the whole balance sheet.” (H4)*

*“We don’t like to work with these top-down portfolio models. If I have two companies, two energy producers for example, both in the same country and both with the same rating, our normal portfolio models would treat them the same. If the GDP is the same, everything is the same, the result will be the same. But maybe one has 100% renewable energy and no emissions at all. If the CO2 price goes up, nothing changes in terms of profitability. The rating might stay the same. And then there is the other energy producer that might have their whole business based on, let’s say, oil or coal, so they have a lot of emissions. If the price of carbon goes up, you can see that the company would have a lot of additional high costs and there would be a negative impact on profitability or leverage. So we think it is better to do very granular modeling in order to quantify climate risks, so that we can then look at those differences and really process them.” (A1)*

*“The issue is that we don’t have the capacity to produce mass statistics about things we have never observed. On the one hand, we can invent a climate z-factor, a climate sensitivity. We can write equations that feed into top-down models. There are lots of attempts to do that, and it is possible. On the other hand, we can’t calibrate them because we don’t have enough statistical observations. Fundamentally,*

*we don't know what the difference is in the default rate of a portfolio between a baseline level and a level where there would be a greater climate impact. So, we can write equations, but I don't think we can calibrate them. And as we can't calibrate them, we have to make assumptions about the future. So it seems to me that the only way to have an impact on portfolios is to simulate something that is a little theoretical and bottom up. Our conclusion to date is that to see any impact, as we do not observe anything at portfolio level, we have to go down to client level and try to build a microeconomic stress-test logic. That is why we are now working with a bottom-up approach."* (G1)

Figure VII.12: Top-down approach for scenario analysis without and with climate risk integration.



*Remark:* This figure shows key steps and characteristics of a top-down approach in the context of conventional scenario analysis and climate-related scenario analysis. It is based on based on ECB (2022c).

**Bottom-up modeling approaches** In light of the challenges described in Section VII.4.3, the majority of institutions in our sample have adopted a “bottom-up” modeling approach to complement their climate stress tests. In this section, we discuss this approach in greater detail.

Several respondents (C1, B1, H4, F1, K2, G1, N1) noted that their respective institutions are increasingly combining both top-down and bottom-up approaches, or even prioritizing bottom-up analysis for stress testing and risk quantification purposes. They described the bottom-up approach as particularly useful as it allows institutions to assess risks at a more granular level, enabling them to capture specific climate-related impacts that may be overlooked in a broader, macro-level analysis.

Bottom-up analysis often focuses on transition risks and involves adjusting clients’ financial metrics to reflect the impact of climate-related risk drivers (e.g., incremental costs from carbon price increases) according to specific scenarios and recalculating credit risk parameters at a granular level. This approach therefore allows for the assessment of changes in credit ratings under different scenarios.<sup>48</sup> For example, one respondent (C1) described their institution’s two-step process, which begins with assessing climate-related impacts from a macroeconomic perspective, followed by a detailed, client-specific analysis of carbon price impacts. Similarly, another respondent (G1) highlighted the importance of combining both approaches, noting that relying solely on a top-down analysis may lead to an incomplete risk assessment:

*“We have a two-steps process. Through the macroeconomic and market shocks, we capture the macro impact or systemic impact of the scenario. Let’s say the impact on GDP, inflation and interest rates. We capture those through our well-established macroeconomic models and satellite models. But on top of that, we follow the advice from the ECB to also use a bottom up approach. Therefore, at the counterparty-level, we apply shocks. For example, we look at the emissions on a name by name basis and we apply the prices that are assumed in the scenarios. By combining the bottom-up approach with the top-down analysis, we obtain a*

<sup>48</sup>For a more detailed discussion of such simulation exercises, see Section VII.4.3.

*comprehensive picture of the overall losses.” (C1)*

*“One way is to use historical data on macroeconomic and sectoral activity variables and run them through our regression models. We know how to do that. Unfortunately, it doesn’t allow us to take into account all climate issues, because there are many transformation aspects that don’t necessarily have a significant macroeconomic impact (...). For example, we could produce electric cars instead of cars with internal combustion engines. This may not drastically alter GDP figures, as the overall economic activity — producing cars — remains constant. However, the technological risks and the required investments for certain companies to achieve this transition may be significant and must therefore be accounted for. The challenge is to integrate such aspects into our models. Thus, in addition to the macroeconomic variables, we also integrate more direct effects related to the fact that certain companies will have to invest more and that the cost structure of companies may change. This is more difficult because these elements do not always have clear historical data to draw from, making it challenging to establish clear statistical links. As a result, we have to use our credit scoring models. We know that, for example, the more debt a customer has, the higher their credit risk, all else being equal. So what we do in our stress test is almost a classic client-by-client financial analysis. We take their financial ratios, their whole balance sheet and income structure, and we change them according to a specific scenario. We change their financial ratios and recalculate their credit rating.” (G1)*

The respondent (G1) also elaborated on the methodology, explaining that while the traditional regression models employed in macroeconomic stress tests are useful, they may not fully capture the broader transformation risks associated with the transition to a low-carbon economy. For example, a shift to electric vehicle production may not have a direct and immediate impact on GDP figures, but it could involve significant technological risks and investment requirements for specific companies. While such changes need to be taken into account in the models, a challenge is the lack of historical data

to draw clear statistical conclusions. The bottom-up approach is therefore particularly useful as it allows credit risk parameters to be formulated according to specific scenarios. The scenarios simulate macroeconomic conditions that may not have existed in the past, but can be fed into risk models to simulate financial ratios, and hence credit risk parameters, conditional on such scenarios:

*“We use both approaches. The reality is that both the macro and micro view are important. If you only look at one, you may miss something important. On the micro side, it is important to simulate credit ratings in a bottom-up approach. These ratings are probabilities of default, which, in line with regulatory requirements, are ‘through the cycle’ PDs. What is certain, therefore, is that the PDs associated with the ratings fluctuate over the cycle. In other words, these PDs tend to be higher when the macro-economy is bad and lower when the macro-economy is good. For us, this is where the articulation comes in. A bottom-up approach gives us versions of the credit ratings that would theoretically be obtained assuming a certain scenario. A top-down approach gives us a vision of the defaults associated with a particular macroeconomic environment (...). It is possible that sometimes the two overlap a little bit, but there is still this dual reality (...). Having only a top-down approach is clearly not enough. We can ask ourselves whether we can only do a bottom-up approach, because in reality the macroeconomic effects are not very strong, so in theory it might not make much difference to only do the bottom-up approach. We do both in order to have a more complete approach and to cover all dimensions.” (G1)*

Another respondent (H4) also mentioned the use of both approaches, highlighting the importance of linking traditional macroeconomic analysis with the direct assessment of climate-related risks, such as changes in carbon prices. In addition, this expert explained that the approach involves deriving shift factors for key credit risk parameters from the top-down and bottom-up analyses. These shift factors are then weighted using expert judgement:

*“We approach this in two ways. First, through traditional macroeconomic analysis using our satellite models. Second, by directly assessing climate-related changes in CO2 prices and emissions at the level of individual clients. The challenge lies in linking these two perspectives. While this is still under review, our current method involves simply weighting these two effects or perspectives. We have what we call shift factors for PDs and LGDs, as well as shift factors derived from scenario paths. These shift factors are weighted based on expert judgement to produce final shift factors. This is still work in progress.” (H4)*

One respondent (B1) highlighted the use of a bottom-up approach, particularly for valuing property portfolios and assessing potential market value changes. This method is especially effective in capturing factors not reflected in broader economic indicators, such as renovation costs and their financial implications. Another respondent (N1) shared a similar view:

*“We tend to take a bottom-up approach to stress testing. We analyze how individual factors that do not necessarily depend on GDP could affect market value [of real estate properties] in different scenarios. For example, what happens if the price of CO2 rises and, in particular, how does this affect market value if the owner has to bear most of the CO2 price? We also look at what happens if, for certain reasons, a property needs to be renovated. These are the two factors we take into account in the transition stress test (...).” (B1)*

*“The economic transmission channels of transition and physical climate and environmental risks to our risk types operate at both the micro and macro levels. When it comes to stress testing, I believe the bottom-up, micro-level approach is the most valuable. It allows us to closely examine how changing conditions impact specific sub-portfolios. For instance, what would an increase in CO2 prices mean for real estate costs and, consequently, property values? This approach yields a much more nuanced understanding than simply projecting a general GDP decline,*



*for example.” (N1)*

An key challenge highlighted by the respondents is that the bottom-up approach requires highly granular data (e.g., client-level CO2 emissions) at the client level. One respondent (G1) mentioned that their institution is already able to cover all corporate clients and industries using this approach. For institutions without access to comprehensive data, the expert recommended using representative samples and clients to conduct this analysis:

*“We cover all clients and all industries in our bottom up approach. However, if we want to make savings, or if we don’t have a lot of data or a lot of computing power, we are able to do something hybrid, which means that we can be deceptively granular by creating representative companies, for example. In theory, we don’t have to take all the companies in your portfolio and analyze them one by one. There are a lot of things you can do with samples (...). If we assume that our credit risk models are reliable and that the relationship between profitability, leverage and credit risk remains stable, then we can derive very useful information.”*  
(G1)

**Balance sheet assumptions** The approach to balance sheet projections, whether static or dynamic, significantly influences the quantification of climate risks in the context of climate stress tests. A static projection assumes that the size, composition and risk profile of an institution’s balance sheet remain unchanged throughout the stress testing period. In contrast, a dynamic projection allows for variations in the size, composition or risk profile of the institution’s balance sheet over the testing horizon (ECB, 2022c). This section explores key considerations associated with dynamic balance sheet assumptions and summarizes the challenges highlighted by our respondents.

As most climate scenarios span 30 years or more (see Table H.1 in the appendix), the ECB considers dynamic projections to be more appropriate for assessing the impact of strategic decisions over long time horizons (ECB, 2022c). The 2022 ECB climate stress

test used both static and dynamic balance sheet assumptions, providing institutions with initial methodological guidance. For the short-term (three-year) delayed transition scenario, institutions were allowed to apply a static balance sheet, thus replacing maturing loans with loans of similar credit quality and maturity (ECB, 2021a, 2022a). In contrast, for the long-term scenarios extending to 2050, institutions were required to project changes to their balance sheets (ECB, 2022a).

Traditional stress tests, including those conducted by the EBA, typically have a time horizon of 3 to 5 years. The introduction of dynamic balance sheet modeling for time horizons of up to 30 years poses significant challenges. The ECB also underlined the innovative nature of this approach and recommended a focus on collecting data on clients' transition plans to facilitate further progress in this area (ECB, 2021a, 2022c,a). In this context, several respondents identified dynamic assumptions as a particularly challenging aspect that is likely to receive increased attention in the future. For example, one respondent (A2) acknowledged the need to account for more distant realizations of climate risks through dynamic assumptions, but cautioned that such models may produce unrealistic and unreliable results:

*“From a climate risk perspective, it makes sense to look at a 30-year horizon. But from a calculation point of view, this leads to completely different challenges. Simplified assumptions that may work for a three-year period are unlikely to hold over 30 years. Standard stress tests often assume that the balance sheet remains unchanged over a three-year period. While this may not be entirely accurate, it simplifies calculations and generally yields plausible results. Currently, the EBA stress test methodology explicitly requires the assumption of a constant balance sheet. This means that the modeling must assume that a maturing loan is replaced by an identical loan, or that a maturing bond is replaced by a new bond with the same characteristics. In contrast, projecting 30 years into the future under the assumption of a constant balance sheet implies that the business remains static. This significantly reduces the plausibility of the results.” (A2)*

Several experts (G1, I2, K2) indicated that their institutions have started to im-

plement dynamic balance sheet approaches. However, they acknowledged that this implementation is still at an early stage and that estimates are subject to large uncertainties. For example:

*“We use static balance sheets for certain analyses and dynamic ones for others, which always involves a great deal of uncertainty. This is partly because we typically only plan for up to three years, then extend that plan further, making assumptions about how things will evolve. With dynamic balance sheets, you also need to make assumptions about factors like how technologies will develop and how the greenhouse gas intensities of these financings will change. This leads to very large uncertainty. We use dynamic balance sheet assumptions because we are required to, but whether we fully stand behind it — I’m not sure.” (K2)*

Several respondents highlighted the importance of aligning dynamic balance sheet assumptions with an institution’s strategic objectives, particularly in relation to supporting clients’ transition efforts and/or reducing specific exposures. For example, many institutions have committed to phasing out lending to the coal sector, a shift that should be reflected in balance sheet assumptions (Acharya et al., 2023). For example, one respondent (L1) explained that the dynamic balance sheet approach needs to be consistent with an institution’s strategic decisions and their underlying assumptions. Similarly, another respondent (G1) stated that their institution’s focus on supporting clients in their transition to a low-carbon economy will likely result in greater exposure to sectors vulnerable to transition risks. The institution developed dynamic assumptions that reflect the expectation that exposure risk will become more concentrated in sectors requiring significant investment for the transition:

*“As a bank, you have to somehow translate your business strategy into a dynamic balance sheet. This also means that you need to know what your borrowers are going to do. In other words, you also need to understand how they are going to decarbonize by 2030, 40, 50 and by what percentage. Some of this information is already available, but it is far from being comprehensive.” (L1)*

*“The dynamic balance sheet is a key issue. We believe that if we are looking at a 30-year horizon, we need a dynamic balance sheet perspective, otherwise we end up with something that is not very realistic or even internally contradictory, because if there is a transition, it is legitimate to expect our portfolio to evolve. We know that the tricky thing about dynamic balance sheets is that they can have a very significant impact on stress test results. Nevertheless, our view is that our bank will seek to finance the transition. It is a very important source of income for our institution, and by funding the transition, our bank will actually be taking on more risk because the portfolio will grow in the exposure categories that are most exposed to transition risk (...). Our guiding assumption is that we are supporting our customers, so we have estimated our customers’ needs in our dynamic balance sheet modeling. We expect our exposures to grow in line with our clients’ investment needs. As a result, we see a kind of concentration in those sectors that require massive investments. In other words, we expect to be much more exposed to certain sectors. We assume that there are no sector limits. So the structure of our portfolio will be very similar to the structure of the financing needs for the transition.” (G1)*

One respondent (I2) provided further insight into the methodology behind their institution’s dynamic balance sheet approach, outlining how it is aligned with internal strategic guidelines. The method involves adjusting future portfolio weights in line with the institution’s strategic objectives and anticipated economic growth. Similarly, several respondents (C1, N1) highlighted the importance of aligning balance sheet assumptions with institutional strategy and considering macroeconomic data when developing the assumptions underlying the dynamic assumptions:

*“We developed a dynamic balance sheet approach by first analyzing potential changes in our portfolio weights. Starting with the current portfolio distribution, we evaluated whether there are areas, according to our strategic guidelines, that we intend or are likely to exit. From this analysis, we determined future portfo-*

*lio weights while also factoring in expected balance sheet growth. Using the GDP forecast for Germany, we projected the increase in our total balance sheet. We then adjusted the portfolio weights accordingly, discussed these adjustments with the board, and used this foundation to calibrate a dynamic balance sheet extending to 2050.” (I2)*

*“We expect our balance sheet to move with the economy. Whatever the economy does in the scenario, it is reflected in our balance sheet. We have had a lot of discussion internally about how to do that. It is a point that risk analytics teams can spend a lot of time on.” (C1)*

*“In the ECB’s climate stress test of 2022, specific guidelines were already provided. If I were to design such a test myself, I would base it on long-term studies from organizations like the United Nations, focusing on factors such as population development and GDP growth. Using these indicators, it would be possible to estimate whether a bank will grow or shrink in the future.” (N1)*

**Physical risk scenario analysis** Physical risk scenario analysis holds a distinct status, with institutions employing individual approaches and scenarios to quantify the potential impact of specific climate-related physical events over different time horizons. In this section, we provide a brief overview of different approaches to physical risk scenario analysis and highlight challenges identified by respondents.

The institutions in our sample regularly conduct physical risk scenario analyses, with methodologies differing depending on the time horizon. In the case of short-term analysis, several respondents indicated that their institutions rely primarily on the methodology set out by the ECB in the 2022 supervisory climate stress test. For example, one respondent (E1) indicated that their institution’s flood-related scenario analysis was based primarily on the parameters provided by the ECB:

*“So far, we have taken a pragmatic approach, relying on the scenario guidelines from the 2022 ECB stress test. They provide a parametrization that we have used internally. For example, we have based our internal scenario on the flood risk scenario provided by the ECB, rather than developing our own flood risk scenario with our own flood maps. We took this pragmatic approach because we don’t have in-house experts who are deeply involved in climate modeling or have significant experience in this area.” (E1)*

In the 2022 ECB climate stress test, two specific scenarios were introduced: one addressing flood risk and the other covering drought and heat risk (see Figure H.1). The objective of both scenarios was to assess the impact of these physical events on credit risk. The flood scenario focused on institutions’ mortgage exposures and other real estate-backed loans. This scenario modeled the risk of severe flooding in Europe. To this end, the ECB divided geographical regions (NUTS-3) into several risk categories (low, medium, high) and provided data on projected declines in residential and commercial real estate prices (ECB, 2022a). The drought and heat scenario, on the other hand, examined the economic effects of a severe drought and heatwave in Europe, specifically a reduction in sectoral gross value added (GVA) growth caused by a productivity shock to GDP (ECB, 2022a). In this case, institutions were asked to evaluate how these events would affect the credit risk of their corporate loans. Both scenarios were designed with a one-year time horizon (ECB, 2022a).

Several respondents (I2, J1) noted challenges with the ECB’s flood scenario, citing the lack of spatial granularity due to the use of broad NUTS-3 regions. As a result, one respondent (I2) explained that their institution decided to build on the ECB’s approach by integrating address-level data sourced from Google Maps:

*“In the ECB stress test, NUTS codes were used, which essentially correspond to postal codes. This means that every building within a postal code area was treated the same. What did we do? We built a tool that, using Google Maps, retrieves the precise geographical location of an address. This allows us to take into account*

*elevation profiles — whether the property is in a low-lying area or on a hill. Based on this information, we are able to assess the level of flood risk for each property according to its elevation.” (I2)*

In addition, this institution (I) has developed an internal physical risk tool that allows for three different assessment levels: a location-based assessment of real estate collateral, a regional assessment of regionally focused companies and a sector-based assessment of geographically diversified companies. For the location-based assessment of collateral, the exact address of the collateral is used and evaluated through access to hazard maps. To this end, the institution uses publicly available hazard maps from the World Bank and the European Joint Research Centre, which depict potential catastrophic events for each selected risk type (e.g., a 100-year flood event). The institution then translates the obtained hazard values into a qualitative assessment of exposures.

With regard to the assessment of regionally focused companies, the institution (I) classifies corporate clients based on their regional dependency. This is done using information from rating systems. If such data is unavailable, company size is used as an approximation. For clients classified as regionally focused, the institution assumes that their production facilities, supply chains, and customer bases are primarily located in a single region. As a result, the physical risk for these clients is assessed based on that region. To do this, clients are first assigned to the appropriate NUTS-3 region based on their headquarters. In a second step, the exposure to physical risks for these regions is assessed. A region is classified as highly exposed if at least 10% of its area is identified as highly affected based on precise queries. Finally, companies with a geographically diversified presence are assumed to have minimal regional dependencies and thus generally not significantly affected by acute climate risks, which are more localized in nature. As a result, an assessment of the sector is performed. One respondent (I1) from this institution described the tool as follows:

*“We have a physical risk tool application (...). We distinguish between regional and international companies. For regional companies, we look at the extent to which a region is exposed to physical hazards. For example, we look at a city and say that if more than 10% of it is at risk of flooding, then the entire city is flagged as being at risk. In turn, we mark companies that operate regionally in that city as potentially exposed to flooding. For international companies, we simply look at the sector. This is because large companies are generally able to replace certain assets. A flood may cause damage, but it may not lead to credit defaults of these companies. Therefore, we tend to perform a sectoral analysis and flag sectors that are particularly exposed to physical risks. There are certain sectors that are significantly more affected by physical risks, agriculture or tourism for example, and we take that into account.” (I1)*

Similarly, one institution (G) reports collecting detailed location data, allowing it to apply more granular price shocks at the property-level than in the 2022 ECB climate stress test. The approach takes into account the fact that all properties are not hit at the same time during a realistic flood event. Furthermore, one respondent (O1) explained that their institution refined the ECB’s methodology by incorporating data from Munich Re’s NATHAN database (Natural Hazard Assessment Network) for flood risk. Furthermore, the institution assesses storm risk, in addition to flood risk, in the short term:

*“In the short-term, we also look at scenarios for storm and flood risk. We use the NATHAN database, which contains data provided by Munich Re. Flood risk is a very relevant topic for us.” (O1)*

In order to conduct long-term physical risk analysis, institutions implement a variety of strategies. Several respondents mentioned using the RCPs from the IPCC, though the choice of RCP varies across institutions.<sup>49</sup> For example, one respondent (O1) mentioned

<sup>49</sup>RCPs represent various scenarios of future greenhouse gas concentrations and other radiative forcings, ranging from lower to higher levels (Acharya et al., 2023). Four pathways are used for climate modeling and research: RCP 2.6, 4.5, 6.0 and 8.5, named after a possible range of radiative forcing



that their institution applies the RCP 8.5 with a time horizon extending until 2050 for river flood risk and the RCP 8.5 with a time horizon until 2100 for assessments related to sea level rise:

*“We also incorporate very long-term scenarios in our analysis. For example, we use the RCP 8.5 scenario to assess severe flood risks with a time horizon extending to 2050. Similarly, we apply the RCP 8.5 scenario with a time horizon up to 2100 to evaluate the impact of sea level rise. While we can’t predict the exact composition of our credit portfolio that far into the future, we can apply these scenarios to our current portfolio to analyze what the potential implications would be for us.” (O1)*

One institution (G) reports having assessed its residential real estate portfolio against riverine and pluvial flood risks under RCP 8.5 2085 conditions. In addition, one of the respondents from this institution (G2) elaborated on the institution’s approach, stating that it has constructed multiple models based on scenario projections to conduct a range of physical risk assessments at the portfolio level and consider the spatial correlation between assets within the portfolio:

*“For portfolio analysis, we use various in-house models that allow us to project climate risks over different time horizons and according to different climate scenarios for specific asset locations. These locations are identified either by an address or based on latitude and longitude coordinates, since we can geocode the assets. We can assess the exposure of specific assets to risks such as flooding, heat, drought, and other physical risks. Each type of risk has its own model because the data required varies. For example, when analyzing flood risk, we use the probabilities and depths of flooding at a particular location. Ultimately, we can aggregate the results of these different risk assessments. Additionally, our stress test approach considers the spatial correlation between assets and simulates risk events to evaluate their impact on the entire portfolio.” (G2)*

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values in watts per square meter in the year 2100 (Acharya et al., 2023).

Another institution (F) explains in its Pillar 3 report using exposure scores provided by Standard & Poor's. These exposure scores forecast climate event probabilities for different hazards (e.g., tropical cyclone, extreme heat, extreme cold, fluvial floods, coastal floods, wildfire and drought) and different climate scenarios. The exposure scores represent the likelihood of each climate hazard and scenario over several decades. In conducting physical risk analysis, this institution uses the exposure scores corresponding to the RCP6 (2.0° – 3.7°) scenario projection for the decade 2020-2030. An exposure is deemed to be impacted by acute climate risk if the exposure scores exceed the 98% confidence level for any one of the analyzed hazards.

An additional institution (K) indicates in its Pillar 3 report that it applies the SSP2-4.5 scenario, which represents a moderate socioeconomic pathway.<sup>50</sup> The institution uses this scenario to assess the sensitivity of exposures to physical risks over different time horizons, such as 2030 and 2050. Finally, one respondent (P1) outlined an approach for assessing flood risk based on different scenarios and RCPs. The respondent stated that their institution acquired data from a third-party provider to integrate so-called “damage functions” into the analyses. These functions help translate potential weather events into projections of economic damage (Diaz and Moore, 2017).

*“In cases where we have information about the locations of our clients, we use the precise geographic data of our assets to determine whether they are situated in potential flood zones. To do this, we rely on scientifically recognized maps that depict various scenarios and RCPs. We evaluate these maps to assess the level of risk. Additionally, we have acquired so-called ‘damage functions’ from insurance companies, which have decades of experience in damage assessment. These functions help us estimate the financial impact of flooding based on its severity, allowing us to quantify the potential damage in monetary terms. From this, we derive a probability assessment and the corresponding potential damage,*

<sup>50</sup>Shared Socioeconomic Pathways (SSPs) complement the RCPs and explore five potential pathways for global development, considering factors such as population growth, economic trends, education, urbanization, and technological advancements (Acharya et al., 2023). These pathways illustrate how varying levels of climate change mitigation can be achieved when combined with RCP scenarios (Acharya et al., 2023).

*leading to an overall risk evaluation.” (P1)*

**Data for climate stress testing** Having comprehensive and granular data is crucial not only for risk quantification, but also for internal reporting purposes (see expectation 6 of the ECB Guide, ECB 2020b). This section discusses key data points that respondents highlighted as often missing and posing important challenges, particularly in the context of climate stress tests.

A particularly important data point relates to transition plans. Several respondents (A2, E1, L1, J1, J2) highlighted that transition plans are important because they provide a forward-looking perspective that allows for a more nuanced assessment of risk within sectors. They also provide a clearer picture of clients’ strategic objectives and their alignment with long-term sustainability goals. For example, one of our respondents (A1) noted that a common current practice among institutions is to rely on scenario-based projections to estimate how clients might evolve over the coming decades. However, this approach has limitations, as it often assumes homogeneous behavior among clients within a sector and does not account for differences in individual strategies. Access to more granular data directly from clients would provide a more refined and accurate assessment of their transformation efforts. In addition, obtaining transition plans from clients would help institutions develop more robust transition plans for themselves. For example, one respondent (E1) highlighted that their institution is currently developing a transition plan based largely on proxies and assumptions, and that access to more client data would greatly enhance this process. To illustrate:

*“It is crucial to have more forward-looking data. This is something that as bank we very much would like to use. If you don’t have that, what can you use? The classic approach would be to use the net zero 2050 scenario. Many of us use it as a guide. The scenario provides sector pathways with interim targets in 2030, 2040 and 2050, which is sometimes the only way for us to model how our clients will behave in the future. In this case, we assume that they will follow the path that the scenario sets out. Whether this is true, or whether they move faster or slower,*

*we don't know. Another challenge with this approach is there is no differentiation. According to this scenario, everyone within one sector is ticking in the same way. This is why it is so important to get granular, forward-looking data. It is also a really big pain point in risk management at the moment (...). Transition plans would be helpful here, i.e., defined targets by 2030, 40, 50 for how far you want to have reduced your greenhouse gas emissions. Against a clear benchmark, of course. For example, compared to 1990 or 2010.” (L1)*

*“Transition plans are valuable and contain information that we actively consider. We are particularly interested in detailed insights into specific strategic actions aimed at addressing climate risks. These plans improve our understanding of how clients are preparing for future climate-related challenges and offer a clearer view of the concrete measures being taken to mitigate these risks.” (J1)*

In addition to transition plans, respondents identified several key data points that, while difficult to obtain or model, would greatly improve the accuracy of climate-related stress tests. One key data point mentioned by several experts (A2, I2, J1, L1) is the pass-through of CO<sub>2</sub> costs, which indicates how effectively companies can pass these costs on to their consumers. According to our respondents, this factor is largely overlooked in current climate stress tests. As noted in Section VII.4.3, one of the respondents (I2) emphasized that considering the dynamics of price transmissions is particularly important in the context of climate stress testing. This respondent explained that their institution has developed and is implementing a model-based approach to estimate CO<sub>2</sub> cost pass-through rates at both the sector and client level. Similarly, another respondent (L1) pointed out that companies with monopolistic positions are more likely to pass on rising CO<sub>2</sub> costs to consumers, a factor that should be more accurately reflected in stress test models:

*“What I think would be very important is an estimate or information on how well prices are being passed on. Sometimes there are monopolists in a sector who may*

*be better able than others to pass on their costs to their consumers. In other words, the increased costs resulting from CO2 would not affect them as much as companies that are not able to do so.” (L1)*

*“More data on sensitivities would be useful. For example, how sensitive are companies, especially their revenues, to changes in CO2 prices, and how are prices passed on?” (A2)*

Other important data points include the level of future investment required and the depreciation potential of fixed assets, as outlined by one respondent (L1). This expert highlighted the importance of estimating the level of investment required by clients to transition to greener technologies and underlined the need to assess their risk of stranded assets. In particular, information on the depreciation potential of fixed assets is often lacking and would be useful:

*“It would be helpful to know how much companies will have to invest in the future in order to transform themselves. Take the example of a steel producer that has not invested in green technologies such as hydrogen-powered plants: how much would it need to invest to reduce its emissions? This would make it possible to estimate how debt ratios, for example, will develop in the future (...). Furthermore, if we think in terms of stranded assets, it would be helpful to know how many brown assets a company has on its balance sheet. When we look at a company’s balance sheet, one of the things we see is the fixed assets. Unfortunately, at the moment we cannot see what is brown and what is green. There is no such classification of assets. Nevertheless, it would be helpful if we could estimate the depreciation potential of these fixed assets because that has an impact on equity and then on the probability of default.” (L1)*

Further data points are discussed in Section VII.4.3. For example, most institutions do not systematically take insurance coverage into account in their stress tests. One of the reasons for this is the lack of such information. While most institutions already

collect insurance data for real estate portfolios, this practice does not always extend to corporate portfolios. In addition, several respondents (I2, G2, L1, O1) highlighted the challenge of obtaining comprehensive data on the geolocation of corporate assets and their strategic or operational relevance, in particular to assess corporate exposure to physical risks.

### **Integration of climate stress test results into business and risk strategies**

Stress test results are commonly used for a variety of risk management purposes, including refining the risk appetite framework, setting limits, determining capital adequacy and informing strategic planning (ECB, 2021a; AFME, 2023). In this section, we discuss the integration of climate stress testing results into the broader risk strategy framework and highlight challenges reported by respondents.

In line with prior studies (see e.g., AFME, 2023; Dietz, 2022), several respondents reported that their institutions primarily use climate stress test results for exploratory purposes, including assessing portfolio sensitivity. The incorporation of these results into risk management and business strategies is still in its early stages, with varying degrees of integration across institutions. In terms of challenges, one respondent (O1) highlighted the difficulty of deriving actionable insights from the multitude of climate scenarios currently being examined internally. This respondent explained that their institution conducts climate stress tests primarily in an exploratory manner, i.e., to assess portfolio sensitivities and identify potential vulnerabilities:

*“We now have a wide range of tools and scenarios at our disposal. However, what remains challenging is translating these insights into concrete actions. The key question that many banks are currently grappling with is: What do we actually derive from these climate stress tests? In the future, we want to go deeper in analyzing the results, rather than continually expanding our set of climate scenarios. A key questions to ask are: What have we learned from this? Where are we most impacted? Which scenarios make the most sense for us? And based on the probabilities of occurrence we estimate, which scenarios are the most important*

*to examine closely? What kind of feedback loop do we get from these scenarios, and do we see anything there that we don't in other analyses? Our goal is to dive deeper and focus on fewer but more relevant scenarios.” (O1)*

Furthermore, several respondents (C1, D2, G1, H3, J1, N1) noted that climate scenarios often involve much longer time horizons than those used in capital planning processes, which typically span 3 to 5 years. For example, respondents (C1), (J1) and (D2) reiterated the challenge of reconciling the insights from long-term climate stress tests with the shorter time horizons used in risk management. They all emphasized that the use of the results is limited by the high degree of uncertainty and the numerous assumptions underlying the scenarios:

*“I view long-term scenarios and stress tests as valuable for strategic considerations, particularly in assessing how counterparties may evolve during a transition. However, at present, these long-term scenarios are primarily used for informational purposes. In contrast, our ICAAP and other key risk frameworks focus on a three-year time horizon.” (C1)*

*“Presenting my management with stress test results for 2040 or 2050 is pointless. At best, this is a ‘nice to have’, but not practical for management decisions, as overall market conditions could change dramatically by then. Most of our planning is done based on a time horizon of 3 to 5 years.” (J1)*

*“We are expected to consider what might happen in 30 years through climate stress tests, but we don't even know what will happen in the next 3 to 5 years. In that sense, it is almost impossible to derive anything meaningful, especially with such long time horizons. Even for risk types where we have a lot of data and information, like yield curves, making predictions over 30 years is pure speculation (...). There is still some work ahead of us to use the results of the climate stress tests as a fully integrated management tool for a bank governance.” (D2)*

The uncertainty associated with climate risks poses a challenge to the integration of climate stress test results into broader risk management and business strategies. Nevertheless, several institutions are increasingly taking this uncertainty into account in their capital adequacy assessments (see Section VII.4.3). Climate stress tests also yield insights that are incorporated by several institutions into their risk appetite frameworks and internal reporting structures (see Section VII.4.4). For example, several respondents (C1, K2) noted that their institutions have developed limits and key risk indicators (KRIs) derived from climate-related stress tests. These KRIs are included in the regular internal reporting shared with governance bodies, such as the executive board. Finally, a few respondents (G1, H5) indicated that climate scenario analysis plays an increasingly important role in credit provisioning and loan pricing. We discuss the integration of climate risks into loan pricing in greater detail in Section VII.4.5.

*“We plan to incorporate these climate scenarios and their impact into the calculation of credit risk provisions by the end of this year. This will have a very rapid impact on pricing considerations because it means that as soon as we originate a transaction, and even for existing transactions in their internal billing, we will see the impact of these scenarios (...). This means that we will include default probabilities that are conditional on these scenarios.” (G1)*

## **Internal capital adequacy assessments and capital considerations**

**Integration of climate risks into scenarios for capital adequacy and capital planning** As outlined in the ECB guide to the ICAAP, institutions are required to develop comprehensive strategies and processes to ensure that their material risks are adequately covered by capital (ECB, 2018). A key process in achieving this objective is stress testing. As discussed in Section VII.4.3, all institutions in our sample are required to conduct regular stress tests as part of their ICAAP (ECB, 2018). In addition, in accordance with the ECB guide on climate risks, institutions are also expected to perform stress tests to quantify the impact of climate-related risks and appropriately incorporate these considerations into their ICAAP (see expectations 10 & 11 of the



ECB Guide, ECB 2022c). In this section, we discuss key considerations regarding the integration of climate risks into ICAAP stress tests and highlight some of the main challenges raised by respondents.

In Section VII.4.3, we show that institutions generally maintain a diverse set of scenarios within their stress testing frameworks and as part of their ICAAP. These scenarios fall into two broad categories. The first category includes “comprehensive” scenarios, typically macroeconomic in nature, which are assessed on a quarterly basis. Within these comprehensive scenarios, there are further subcategories. Some scenarios serve as baseline estimates, providing a standard macroeconomic forecast (see Section VII.4.3), while others present variations with different levels of severity and shocks. These scenarios allow institutions to assess multiple risk types simultaneously, for example in the context of institution-wide adverse stress tests, and are also used for capital planning.<sup>51</sup> Second, there are also “exploratory” scenarios, which focus on specific risk drivers and, in some cases, target specific portfolios or sub-portfolios (see Figure VII.10). These exploratory scenarios are rather used for risk-type-specific stress tests and ad hoc stress tests. Such scenarios are used for exploratory stress tests that are conducted on a regular basis, e.g., annually or every two years. Some risk-type-specific stress tests are also conducted on a quarterly basis. Both categories of scenarios are complementary.

Some institutions have started to integrate climate risks into their comprehensive scenarios. For example, one institution (O) included climate-related elements such as CO2 prices in its scenarios. Similarly, another institution (J) incorporated climate-related aspects into several scenarios, in particular for the analysis of its shipping portfolio, where long-term forecasts for market values and charter rates are made. These forecasts now take into account the transition to eco-efficient ships and the devaluation of non-efficient ships:

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<sup>51</sup>For example, the ECB indicates that “although institutions may not ‘plan’ to enter into adverse conditions, the assessment of adverse scenarios is a key element of capital planning as it helps institutions to continue operating even in a prolonged period of stress.” (p.39, ECB 2018).

*“Our colleagues in the economics department develop the macroeconomic scenarios. Key parameters include GDP, unemployment rates, interest rate trends, and so on. We provide some guidance on how adverse the scenario should be. They then apply their economic models, and we receive the parameters back, which we need to translate to the different risk types within our portfolio. Currently, we are working with the economists to incorporate the CO2 price as a fixed component in the scenarios. In the future, we may add additional factors, but this is still under discussion. These additions could, of course, be a result of the exploratory climate stress tests we are conducting.” (O1)*

*“Several other scenarios have been enhanced to incorporate climate-related aspects. This means that climate considerations are not limited to our two specific ESG scenarios but are also embedded in others as well. This is particularly true for our shipping portfolio, where we use long-term forecasts for charter rates and market values that extend beyond the planning horizon. For example, we model the trend towards eco-efficient ships, as well as the expectation that non-efficient ships will experience greater losses in market value.” (J1)*

An institution (Q) uses three different scenarios of future economic development, which are also used to calculate expected credit losses: a baseline scenario, a negative scenario, and a positive scenario. The scenarios are designed to provide a sense of the range within which the economy, as well as interest rates, exchange rates, and other variables, are likely to move over the short to medium term. The scenarios describe a range of either negative or positive outcomes. The institution indicates that climate issues are now included in all three baseline, positive and negative macroeconomic scenarios. Regarding the negative scenario, for example, the climate issues include assumptions based on a disruptive transition that would affect the economy, as well as assumptions on the impact of nitrogen regulations in the Netherlands on GDP.

Finally, one institution (P) reported conducting an “internal combined climate risk stress test” in 2022, which included climate-related components. The stress test covered

the full credit risk portfolio as well as other risk types such as interest rate risk in the banking book and operational risk. In terms of narrative, the scenario consisted of the following events: a prolonged war in Ukraine triggering full suspension of the Russian gas supply to Europe; extreme weather events (i.e., fires in Southern Europe and floods in Northern Europe) were assumed to create additional burdens on European economies and energy consumption patterns change; EU governments stepped up their efforts to meet the well-below 2°C Paris Agreement target by creating a New Green Deal which led to soaring carbon taxes; a disorderly transition followed, and the institution faced greenwashing claims.

In terms of exploratory scenarios, and as discussed in Section VII.4.3, institutions use a variety of short- and long-term climate scenarios that model transition and physical risks. To date, the stress tests conducted mainly focus on one risk type, in particular credit risk (Baudino et al., 2018). Even the 2022 ECB climate stress test predominantly targeted credit risk, with some attention given to market risk (see Figure H.1). Although exploratory, these climate scenarios are becoming an important part of capital adequacy assessments and complement the comprehensive exercises described above.

For example, one institution (G) reports in its Pillar 3 disclosures that climate scenarios are now integrated in the ICAAP and documented in a dedicated section of the corresponding ICAAP report. The institution indicates conducting, on the one hand, an assessment in relation to credit risk, and on the other hand, an assessment of losses calculated from operational risk events for which climate risk has been identified as a material risk factor. The institution adds that climate risks are treated as risk drivers — in particular of credit and operational risks — rather than stand-alone risks. Furthermore, it notes that such scenarios are not used for capital planning purposes, but rather to assess the impact on its internal capital requirements of events that may be exacerbated by climate risks. Similarly, one of the respondents (I2) described their institution’s current approach by stating that climate stress tests focus primarily on risk types for which climate risks are considered to be material drivers. Since climate risks are deemed to have a material impact on credit risk, this area forms the primary focus of their institution’s exploratory stress tests:

*“In line with the ICAAP guidelines, we consider both comprehensive ICAAP scenarios and risk-specific scenarios. Based on our risk inventory, climate risks currently primarily affect credit risk. However, if we were to assume that climate risks require a comprehensive risk assessment, we would need to ask ourselves: How does climate impact all other types of risk today? This means we would need to examine how climate risks impact not only credit risk, but also market risk, liquidity risk, and operational risk. So far, we do not find that an increase in CO2 prices leads to substantial changes in market volatility. In our current approach, climate is only material for credit risk. In the comprehensive ICAAP scenarios, the effects of the climate scenarios are included in a rudimentary form (...). There we have to consider all material types of risk or provide a well-founded justification for excluding them (...).” (I2)*

Thus, institutions are starting to develop both exploratory and comprehensive scenarios that incorporate climate risks. These scenarios provide complementary insights and play an important role in integrating climate risks into capital adequacy assessments and capital planning.

**Climate-related capital adequacy assessments** As outlined in the ECB guide to the ICAAP, institutions need to have in place comprehensive strategies and processes to assess and maintain on an ongoing basis the “amounts, types and distribution of internal capital” that they consider adequate to cover risks to which they are or may be exposed (p.41, ECB 2018). A key element of this process is the concept of capital adequacy, which refers to the degree to which risks are covered by capital (ECB, 2018). This section discusses key considerations raised by the respondents regarding capital adequacy in relation to climate risks. The following section (see Section VII.4.3) explores how some institutions are introducing climate-related capital buffers and similar “add-on” approaches to setting aside capital to mitigate climate risks.

Institutions are required to assess the potential impact of climate risks on capital adequacy (see expectation 7.6 of the ECB Guide, ECB 2020b). The ECB expects in-

stitutions to “take into consideration the impact of climate-related and environmental risks when determining their capital adequacy in a way that enables the institution to sustainably follow its business model by ensuring economic and normative capital adequacy” (p.34, ECB 2020b). As a result, if climate risks were to result in important losses (e.g., exceeding a certain materiality threshold during a stress test), the institution in question may need to reserve additional capital. As a best practice, the ECB has already observed that some “institutions allocate economic capital specifically to the management of material transition and physical risk drivers. In such cases, economic capital is typically allocated to credit, market, or operational risk, based on scenario analysis outcomes” (p.9, ECB 2022d).

Capital adequacy assessments typically rely on stress testing, which involves running one or more scenarios based on narratives that impact different risk types. The primary purpose of these stress tests is to evaluate an institution’s capital adequacy by estimating potential capital stress losses, which then guide capital allocation decisions. Before delving into the integration of climate risks into these considerations, we first provide a simplified example of a capital adequacy assessment, illustrated in Figure VII.13. A similar methodology can be applied to climate scenarios and climate stress tests, where the potential capital loss resulting from such scenarios similarly informs capital allocation decisions.

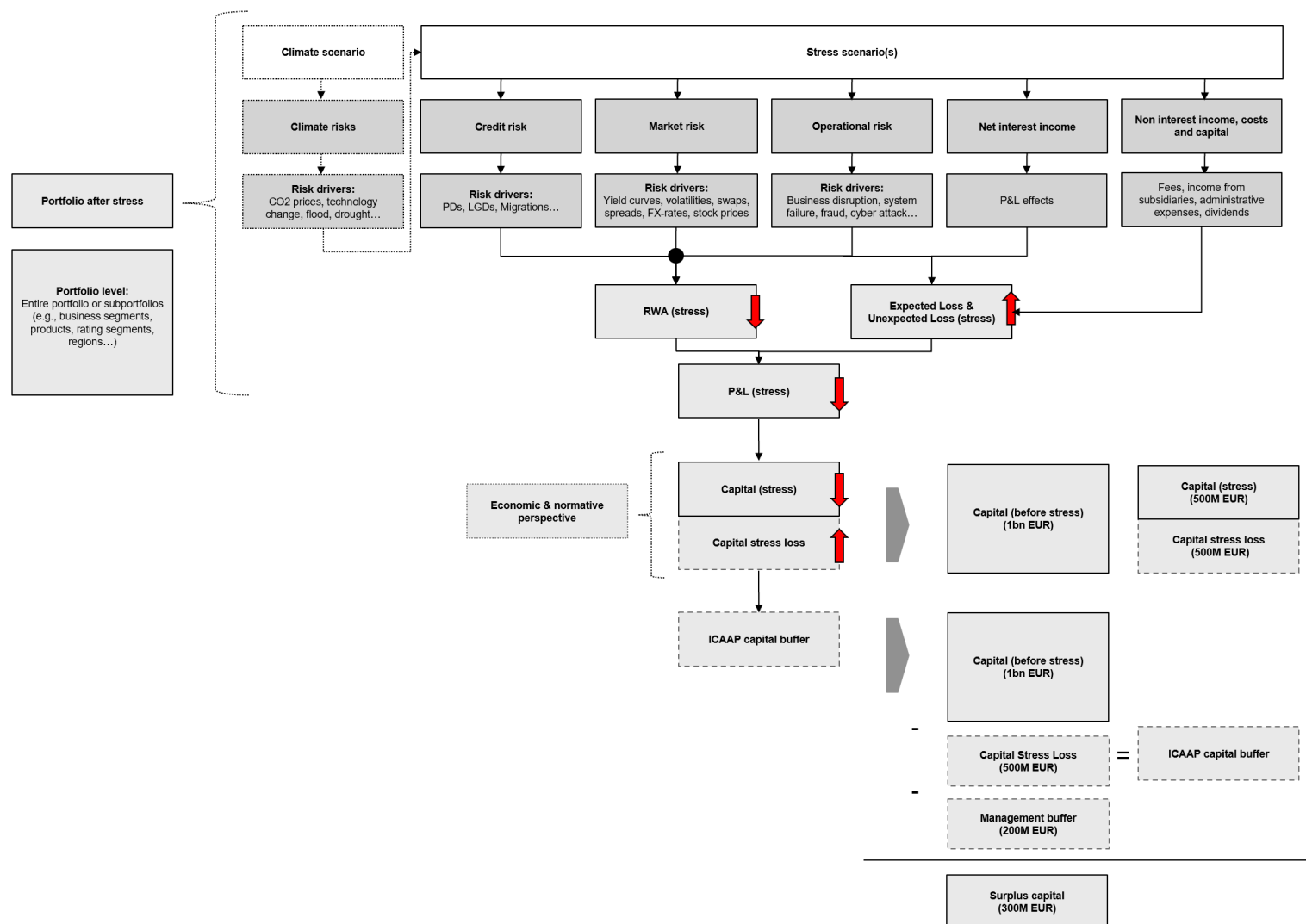
In our simplified example, the remaining capital amount, after meeting the minimum capital requirements under Pillar 1 is 1 billion EUR. After applying the stress scenario,<sup>52</sup> this amount is reduced to 500 million EUR, resulting in a capital stress loss of 500 million EUR. This stress loss represents the capital that needs to be “buffered” to ensure capital adequacy. To calculate the capital surplus, we subtract the capital stress loss of 500 million EUR from the original capital of 1 billion EUR, leaving a surplus of 500 million EUR. This surplus is further reduced by additional buffers, such as a management buffer, which is detailed in Section VII.4.3 and amounts to 200 million EUR. After accounting for the management buffer, the final total capital surplus is 300 million EUR.

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<sup>52</sup>It should be noted that if a loss is realized through the P&L and deducted from capital, the total RWA under Pillar 1 will decrease.

This surplus serves as the foundation for further capital allocation decisions, including the amount available for dividend payouts. This example illustrates how capital buffers reduce the total available capital surplus for other business considerations and determine the amount to be set aside.

Figure VII.13: Capital adequacy assessment.



*Remark:* This figure displays a simplified example of a capital adequacy assessment. Note that if a loss is realized through the P&L and deducted from capital, the total RWA under Pillar 1 will decrease.

We begin by discussing the motivations of institutions that have decided not to implement specific capital measures for climate risks. For example, one institution (N) states in its Pillar 3 report that a separate, additional capital allocation for climate and environmental risks within the ICAAP is not considered necessary, mainly due to the very limited impact of climate risks identified in the 2023 internal climate stress test. In the same vein, another institution (G) explicitly reports that while it continuously monitors the contribution of climate-related events to its internal capital requirements, it does not currently calculate a capital charge specifically linked to climate-related risk. A respondent (G1) from this institution expressed reservations about implementing a climate-specific capital buffer, explaining:

*“Buffers are almost a philosophical question. We are completely against the idea of seeing capital as the sum of buffers. We already have a lot of capital. This capital is designed to cover crises with very high levels of stress. We can therefore assume that our capital already covers a wide range of scenarios. It would not really make sense to add capital for each driver that could lead to an increased level of stress. The question is the maximum plausible level of stress, not the addition of all driving causes. We do not explicitly allocate capital to geopolitical risks or unemployment, for example. Our aim is to develop holistic scenarios that include climate. We aim to integrate climate considerations into all aspects of our risk management, but not in a way that is structurally different from other risk drivers.” (G1)*

Similarly, several respondents (C1, J2, G1) noted that capital adequacy and the corresponding capital needs are primarily driven by the results of comprehensive ICAAP stress tests. They pointed out that capital needs are evaluated through multiple scenarios, with the most severe stress test typically guiding the required buffer size. At present, climate scenarios tend to be less severe than the economic downturn scenarios commonly used in these assessments. For example:



*“We have integrated climate into our ICAAP for four years now. It is important to say that climate risk doesn’t result in large losses in our scenarios. Overall, we don’t see a large effect from climate risk. Now, to determine capital, we use more severe scenarios than the climate-related ones (...).” (C1)*

*“Our approach is to always derive our risk appetite from the results of our stress tests. We have developed two specific ESG scenarios, both well-parameterized, though less severe than our usual downside scenario, even after frontloading some of the effects from NGFS scenarios. When it comes to planning and determining the amount of capital that needs to be allocated across different risk types — essentially the buffer that needs to be maintained — we always consider all scenarios. The worst-case scenario determines the amount of capital that needs to be allocated. We do not have a separate capital buffer specifically for climate risks. Instead, we incorporate climate risks into our stress test scenarios and use the results to decide how much capital should be allocated to each risk type. Such decisions are based on the outcomes of the stress tests.” (J2)*

A few respondents (I2, J2, H5) expressed reservations about implementing climate-specific capital buffers, but also noted the possibility of allocating economic capital to specific risk types, such as credit, market or operational risk. They explained that this approach may be relevant if certain risks are perceived to be inadequately captured by existing models and risk management processes. For example, one respondent (H5) explained that their institution does not currently hold a capital buffer specifically for credit or market risk to account for climate-related risk factors. The reason for this is that stress tests have shown an insignificant financial impact in terms of economic capital, suggesting that no significant gap currently exists:

*“An essential element of stress testing under Pillar 2 is the concept of risk-bearing capacity. For certain risk types, such as operational risk and reputational risk, climate is already integrated into capital adequacy considerations. For example,*

*we have a large insurance subsidiary that insures against natural catastrophes, and we already allocate significant amounts of capital to this area, as well as to operational risks. However, there are other risk types, such as credit risk and market risk, where potential gaps may exist. For example, we have an ESG credit risk scorecard, but it is not yet factored into our capital requirements. Our focus has therefore been on identifying and addressing potential gaps for such risk types [credit risk and market risk]. We asked ourselves by how much the 99.9% quantile in our models would be affected if we incorporated climate and environmental risk parameters. In other words, while our portfolio models already include a high level of stress, we adjusted parameters such as PDs or spread movements to reflect an expected climate scenario. As of 2023, the resulting euro amounts were so minimal that we currently do not find a significant gap.” (H5)*

*“We do not think that our PDs and LGDs are inadequately measured or that our processes for climate risks are insufficient, necessitating an additional capital buffer for climate risks.” (J2)*

One respondent (I2) argued that a climate-specific capital buffer may be necessary if an institution believes that current ratings do not adequately capture climate risks.<sup>53</sup> The objective of the buffer would therefore be to account for the uncertainty associated with climate risks. Furthermore, this expert pointed out that, in theory, such a buffer should diminish over time as climate-related defaults are increasingly reflected in the data and incorporated through the recalibration of PD models. Overall, this expert expressed doubts about the value of implementing such a buffer, highlighting the potential risk that institutions may consider themselves exempt from further refining their climate-related risk management strategies:

<sup>53</sup>For example, as discussed in Section VII.4.2, institutions are increasingly quantifying climate risks through climate-related scores but rarely integrate them quantitatively into their rating systems and PD models. Such integration, particularly for long-term climate risks, remains a major challenge.

*“If I apply a buffer today, it simply means that I believe my current ratings are not adequate. This buffer should typically decrease as actual defaults related to climate risks occur. As these defaults are integrated into my time series and subsequently factored into future PD calculations through recalibration, such risks will naturally be captured and reflected in my observations (...). Some institutions already allocate capital specifically for climate-related risks, which is a valid approach, but one I don’t fully endorse. Why? Because I question whether this truly supports internal climate goals. For example, if a bank’s objective is to achieve climate neutrality by 2035 or 2040, particularly in its lending activities, how does setting aside capital for climate risks contribute to that goal? In my view, it doesn’t. Allocating risk capital today as a reserve for potential climate risks may signal preparedness in terms of planning, but it doesn’t equate to actively addressing such risks through robust monitoring and management.” (I2)*

**Climate-related capital buffers** A few institutions (I, N) are either actively exploring the implementation of capital buffers (or similar instruments) for climate risks or have already done so (D, K, O, P). In this section, we examine their approaches and motivations, as well as the challenges identified by our respondents.

A central motivation for establishing such a buffer is the concern that traditional risk models may fail to adequately capture climate risks over the medium to long-term horizon. For example, one respondent (K2) explained that the primary rationale for implementing a climate risk buffer was precisely this concern. Although the institution’s Pillar 3 report indicates that stress test outcomes indicated no significant capital or liquidity requirements stemming from climate risks in the scenarios considered,<sup>54</sup> this expert indicated that the institution very recently opted for a climate-related buffer to mitigate potential medium- to long-term risks that existing portfolio models may not account for:

<sup>54</sup>The institution’s Pillar 3 report indicates minimal impact on the Tier 1 capital ratio and only a modest rise in risk capacity utilization within the single-digit percentage range.

*“In terms of capital adequacy, we need to make a distinction. In the short term, we consider climate risks to be covered by our existing productive models, which have a one-year time horizon. However, in the medium term, they are not covered, which is why — this is a very recent development — we have recently introduced a buffer for climate and environmental risks. We are currently working on integrating this buffer into our overall risk-bearing capacity concept to safeguard against potential medium-term losses as a precautionary measure (...). At present, our risk-bearing capacity calculations have a one-year horizon, meaning that the risks we identify are those that, with a certain confidence level, will not be exceeded within the next 12 months. In other words, losses that may occur in the coming year are covered, but not beyond that period. All the parameters that we use are designed to reflect this short-term focus. Therefore, a CVaR covers a one-year risk horizon, but does not include risks beyond that horizon. This inevitably creates a gap, particularly for medium- and long-term climate and environmental risks, which are not accounted for within the existing risk limits.” (K2)*

There are different approaches to designing such a buffer, and more generally to “reserving” capital for climate risks. This can be approached as an extension to existing risk types, as a “general” (or cross-risk) capital buffer addressing multiple risk types, or as an enhancement to an existing management buffer (see e.g., ECB, 2022d).

#### **General (cross-risk) buffer:**

At least two institutions (K, O) in our sample have allocated capital in the form of a general buffer for climate-related risks. For example, one respondent (K2) explained that their institution opted for a comprehensive capital buffer. The main motivation was that capital requirements are based on risk models that have a one-year time horizon and thus do not take longer-term climate risks into account. Although not derived from a precise quantitative formula, the size of the buffer was determined based on insights from internal climate stress tests (e.g., the cumulative impact of climate risks over several years):

*“We asked ourselves whether this should be addressed as an “add-on” to the existing risk metrics — such as having an add-on for CVaR, market risk and operational risk. Or should we establish a comprehensive buffer specifically for climate and environmental risks. We opted for the latter. We decided to introduce this buffer right at the beginning of our risk-bearing capacity calculations, essentially subtracting it directly from our risk appetite and available capital. We are essentially setting this amount aside. There is no exact mathematical formula guiding this process. Instead, we carefully analyze the available results, particularly from climate scenarios, and then make qualitative judgements about the likelihood of these events. We use specific climate scenarios as part of our macroeconomic stress testing, assessing impacts over a longer time horizon, up to 2050. In reviewing the scenario outcomes, we consider both financial and risk-related indicators. By combining these insights with our medium-term planning — focused on a three-year horizon — we make management decisions about how large the buffer should be and how quickly it needs to be built up as a precautionary measure. With this buffer, we focus on a medium-term perspective. We only consider what is required in the near term and gradually adjust it. This means that the buffer builds up over time. We can already assume that it will continue to grow over the coming years. It may eventually decrease if the risks are sufficiently captured in the models. However, as long as this isn’t the case, we will need this buffer.” (K2)*

Similarly, one institution (O) explains in its Pillar 3 disclosures that an additional capital amount was allocated to the “reserve for other risks” at the end of the year 2023. This buffer is intended to cover potential climate-related risks that are not yet fully captured by risk models. The institution also adds that, while previous qualitative and quantitative analyses do not indicate an immediate need for adjustments to the risk models, further planned analyses may provide new insights, thus justifying the current buffer. One respondent (O1) from this institution elaborated on this approach:

*“In the economic ICAAP, we look at the sum of individual risk types, such as credit risk, market risk, liquidity risk and operational risk. In addition, there is a reserve in the numerator for all other risks that are not explicitly captured. This reserve is then compared to the economic risk capital in the denominator. Last year, we added an extra amount to this reserve as a temporary buffer to account for climate-related risks. This buffer represents roughly a 6% add-on to our risk potential. The size, however, is not derived from extensive scientific analysis. For now, we have set aside a relatively large amount of capital, but the long-term goal is to incorporate these climate-related risks into the models, particularly our credit portfolio models. And the expectation would be that, once we have properly integrated it into the credit portfolio models, the surcharge generated by the model would be smaller than the current buffer. As our models become more sophisticated, the buffer will gradually be reduced, and we will be able to remove the additional allocation.” (O1)*

### **Management buffer:**

Another institution (B) in our sample has incorporated climate-related considerations into its management buffer. Specifically, this institution states in its 2023 Pillar 3 report that its management buffer has been adjusted to account for potential climate-related risks. This approach is similar to the one described above, except that management buffers particularly play a role in the normative perspective of the ICAAP. Management buffers are defined by the ECB as “an amount of capital above the regulatory and supervisory minima and internal capital thresholds that the institution considers necessary in order to sustainably follow its business model and to remain flexible regarding possible business opportunities, without endangering its capital adequacy” (p.42, ECB 2018). In essence, the management buffer serves as an additional capital reserve, illustrated in Figure VII.13, designed to prevent capital (e.g., CET1) from falling below regulatory thresholds. The size of this buffer (and its climate-related adjustments) is typically established through a combination of stress testing and expert judgement.

**Economic capital allocated to credit or market risk:**

Another approach consists in implementing an economic capital add-on to an existing risk category. In other words, instead of setting aside a general buffer, a larger amount of capital could be allocated to credit or market risk in the ICAAP. For example, one institution (D) explains in its Pillar 3 report that, based on the scenario-specific volatilities associated with the climate scenario, it has concluded that transition risk is a material driver of market risk over the long term. The institution has an ICAAP capital buffer for this risk that explicitly takes climate risks into account. A respondent (D1) from this institution explained:

*“We want to finance the transformation because we believe that we understand the business and the transition risks reasonably well. This is anchored in our business strategy. Accordingly, we have accounted for this in the ICAAP by incorporating a capital buffer for climate risks.” (D1)*

Furthermore, another respondent (P1) explained that their institution considers climate risks to be a material driver of credit risk and thus considers this aspect in its add-on to credit risk:

*“We apply a small add-on for credit risk as a precautionary measure. It is a single-digit percentage. We generally assume that we are currently underestimating the risks. That is why we introduced this small add-on proactively. If the risks were perfectly captured in our internal models, there would logically be no need for the add-on anymore. Essentially, the add-on exists because we haven’t fully mastered the rest yet.” (O1)*

Finally, one institution (Q) has adopted both an economic capital add-on for climate-related credit risk under the ICAAP and a management overlay for climate risks within IFRS 9 models. In its Pillar 3 disclosures, the institution highlights that incorporating climate risk into credit risk models remains challenging, primarily due to the lack of granular data and limited historical instances of climate risks impacting credit risk.

As current models may not fully capture climate-related risk drivers, the institution considers future estimates of credit risk to be associated with uncertainty. As a result, the institution has introduced an economic capital add-on for climate risks under the ICAAP. Furthermore, it has established a EUR 25 million management overlay for climate transition risk, both of which were informed by a materiality assessment.

### Challenges:

While recognizing the key motivations for implementing these buffers, such as addressing modeling uncertainty, several respondents (D2, N1, I2) observed that their current size remains modest and primarily precautionary. At present, these buffers are largely estimated using expert judgement and insights from materiality assessments and stress tests, which often suggest a moderate impact in the short to medium term. One expert (N1) added:

*“I believe many institutions are currently implementing these measures to meet ECB requirements, and as a result, we will eventually introduce a buffer as well. However, the question remains whether a small buffer will have any significant impact. Institutions generally have very high risk-bearing capacity ratios. For example, with a 175% risk-bearing capacity, adding a 5% buffer for climate risks can easily be done to show action. But will it meaningfully affect portfolio steering? I don’t think so. I haven’t seen any institution with a buffer substantial enough to make a real difference in terms of steering effect, and I doubt any bank will set a buffer so high that it limits itself. Nonetheless, introducing a buffer can be justified by uncertainties in the models. If climate risks aren’t adequately reflected in the models, having a buffer makes sense. That is why we plan to introduce one, though the risks are currently minimal within the bank’s decision-making horizon (...). In my opinion, the most reasonable approach is to base such buffers on climate stress tests and related analyses.” (N1)*

Another respondent (D2) noted that setting aside capital for climate risks may reduce dividend payouts, potentially making shareholder support relevant to the suc-



successful implementation of climate-related buffers in the future. Finally, one expert (I2) expressed concerns about the overall usefulness of climate-related capital buffers, arguing that instead of prioritizing the introduction of such instruments, a more effective strategy would be to define clear sector-specific targets and implement a limit system that restricts lending to high-risk sectors. In particular, this expert argued that simply allocating capital to climate risks does not actively support the achievement of long-term climate goals:

*“The capital market also has to be on board with this approach. If the capital market accepts this, why not, we can build such a capital buffer. But if we allocate a substantial amount of capital to hypothetical risks, there is a chance that shareholders may become dissatisfied, as it would mean paying out less capital in the form of dividends.” (D2)*

*“Allocating risk capital today as a reserve for potential climate risks may signal preparedness in terms of planning, but it doesn’t equate to actively addressing such risks through robust monitoring and management. I believe a more effective approach would be to establish sector-specific targets and a limit system as management tools and to ask: How should the proportion of green investments grow over time to achieve climate neutrality? Incorporating climate-related considerations into the management buffer is one thing, but it is crucial to operationalize them through a limit system and sector-specific targets.” (I2)*

**Economic and normative perspectives** The ECB requires an assessment of the impacts of climate risks on capital adequacy from both a normative and an economic perspective (see expectation 7.6 of the ECB Guide, ECB 2020b). As shown in Figure VII.13, both perspectives offer different views of an institution’s internal capital adequacy. In this section, we briefly outline the key features of each ICAAP perspective and highlight some of the approaches and challenges identified by our respondents.

The normative perspective relies on accounting and prudential values (ECB, 2018). Specifically, this perspective focuses on the impact of material risks on an institution’s

balance sheet, P&L structure, regulatory indicators, key performance indicators (KPIs) and limits (ECB, 2018). The assessment of the normative perspective is typically based on stress tests with a minimum time horizon of three years. Moreover, the normative perspective is closely tied to the concept of capital planning, which requires institutions to assess their capital adequacy through a multi-year projection of their capital demand and supply, accounting for both baseline and adverse scenarios (p.43, ECB 2018). The overall objective of the normative perspective is to ensure that an institution remains sufficiently capitalized to pursue its planned business strategy on an ongoing basis, even under adverse conditions. In contrast, the economic perspective focuses on a shorter time horizon (one year) and is based on economic value considerations (ECB, 2018). For example, while the normative perspective conceptually considers the accounting value of assets, the economic perspective focuses on a fair value / net present value perspective of such assets to derive risk and capital requirements (BaFin, 2018). Therefore, the focus is less on regulatory capital ratios and more on value at risk quantification metrics as well as the identification of “hidden losses” (p.23, ECB 2018). In this sense, the economic perspective is also closely related to the concept of economic capital discussed in Section VII.4.3.

Regarding the normative perspective, several respondents (C1, E1, H5) described the integration of climate risks into their institutions’ internal stress testing frameworks as a critical step towards embedding climate risk within this perspective. They indicated that their institutions had either already integrated climate risks into these frameworks or were in the process of doing so (see Section VII.4.3). However, one respondent (G1) reiterated the challenge of reconciling the longer time horizons of climate stress tests with the typical three-year time horizon used in the normative perspective, making it difficult to incorporate climate risks into capital planning. Another respondent (H5) described initiatives to include climate-related KPIs into capital planning and business environment analysis, both of which are essential elements of the normative perspective. In addition, one respondent (E1) further highlighted plans to incorporate climate-related factors into the institution’s risk appetite and limit system:

*“We have integrated climate into our stress test framework. The normative perspective is therefore well covered.” (C1)*

*“We currently address the normative perspective through stress tests. In our discussions with the supervisors, we have observed that this approach is well accepted. Of course, this expectation also involves the integration of climate-related considerations into our risk appetite. This is the next step. This means, for example, explicitly incorporating climate into our current limit system. Our bank-wide limit structure is derived from the Board’s risk appetite, which is then broken down into different risk types and portfolios. So far, climate has not been an explicit criterion, so we are now in the process of incorporating it in a meaningful way.” (E1)*

*“The normative perspective has a very strong focus on information from stress tests. We plan to include climate and environmental risks into our internal stress testing framework. We are still working on this, but we expect this to be done by the end of the year. After that, we will have the normative perspective and the impact on RWA and own funds. Another important aspect of the normative perspective is capital planning. There we have expectations 1 and 2 of the ECB Guide, which require us to integrate climate and environmental risks into our business environment analyses. We have a large number of KPIs that we have included in the baseline scenario. We also now include KPIs such as the CO2 price or similar aspects in our strategic planning (...).” (H5)*

With respect to the economic perspective, one respondent (C1) noted that their institution integrates climate risks into internal ratings, so that climate risks feed into the economic ICAAP perspective. Two respondents (E1, N1) noted that sensitivity analysis and stress testing are also used in the economic perspective to assess the impact of climate risks:

*“As far as the economic perspective is concerned, since we have integrated climate-related aspects into the credit ratings, it is now also part of the economic perspective because all these ratings feed into the economic perspective. Thus, I think that climate risk is well integrated in this area as well.” (C1)*

*“From an economic perspective, we perform ad hoc analyses of PD shifts. These analyses also go in the direction of stress testing.” (E1)*

*“We have rating models that we use under both Pillar 1 and Pillar 2. For Pillar 2, we also take portfolio effects into account, for example through our portfolio models. We apply specific scenarios to assess the impacts on our risk-bearing capacity. In practice, we have models that allow us to assess the economic perspective.” (N1)*

#### **VII.4.4 Pillar II: Integrating climate risks into risk appetite, risk metrics and limit system**

##### **Linking risk appetite, risk strategy & business strategy**

In 2021, the ECB observed that only “few institutions have put in place climate and environmental risk practices with a discernible impact on their strategy and risk profile” (p.2, ECB 2021b). One way for institutions to effectively align their risk practices with both their business strategy and risk profile is by clearly defining their risk appetite. This section discusses key considerations related to the risk appetite and its role in the broader risk strategy. Subsequent sections discuss specific approaches to integrating climate risks into the risk appetite framework, including KRIs and limits.

An institution’s risk appetite is set at an aggregate level, outlining the types of risks it is exposed to and the actions it intends to take to manage those risks in line with its broader business strategy (ECB, 2018). This is typically formalized through a “risk appetite framework” and a “risk appetite statement” (ECB, 2018), both of which ensure that the institution’s risk appetite is effectively communicated and consistently monitored at all levels. In the context of climate risks, institutions are expected to

explicitly incorporate these risks into their risk appetite framework (see expectation 4 of the ECB Guide, ECB 2020b). The risk appetite framework ensures that risk-taking is aligned with the institution’s strategic priorities, capital and liquidity plans (ECB, 2020b), and is typically approved by the board of directors.

The risk appetite statement, as part of the risk appetite framework, is a comprehensive document that defines the types and levels of risk that the institution is willing to accept or wishes to avoid (ECB, 2020b). It includes both qualitative statements and quantitative targets, together with specific limits and thresholds for managing these risks. In addition, the risk appetite statement outlines the governance structures and processes in place to address breaches of risk limits (ECB, 2020b). Furthermore, the risk appetite framework and the corresponding risk appetite statement are typically segmented by risk type. For example, institutions generally have specific appetites for credit risk, market risk etc. This risk appetite may be further subdivided. Table VII.4 provides a stylized example of a risk appetite statement for credit risk.

Defining a clear risk appetite for climate risks requires integrating climate risks into the risk appetite framework and risk appetite statement for risk types that are considered to be materially impacted by such risks (see expectations 4.1 and 4.2 of the ECB Guide, ECB 2020b). This integration requires institutions to formulate qualitative risk appetite principles, while also establishing risk metrics, limits and responsibilities. We discuss some of these metrics and limits in Sections VII.4.4 and VII.4.4.

Several respondents highlighted that their respective institutions were still in the early stages of integrating climate risks into their risk appetite frameworks. For example, one respondent (N1) explained that their institution was working on translating sector-specific targets and pathways into key risk metrics and limits that would eventually become part of the risk appetite framework. To illustrate:

*“As a bank, we have committed to adhering to climate goals, including interim targets for 2030. This involves adhering to specific climate or CO2 reduction pathways for different industries, such as cement and aviation. We are currently translating these pathways into risk metrics, including limits. The objective is to*

Table VII.4: Risk appetite statement for credit risk.

| Credit Risk                                                                                                                                                                                                                                                                                                                                                                                                        |                                                             |                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------|
| Definition: Internal definition of credit risk.                                                                                                                                                                                                                                                                                                                                                                    |                                                             |                                                                    |
| Owner: Internal control organs and product owners.                                                                                                                                                                                                                                                                                                                                                                 |                                                             |                                                                    |
| Objective: Internal definition of overall objective, e.g., achieve the highest quality loan portfolio in line with profit and risk parameter targets.                                                                                                                                                                                                                                                              |                                                             |                                                                    |
| I. Qualitative Risk Appetite Statement (RAS)                                                                                                                                                                                                                                                                                                                                                                       |                                                             |                                                                    |
| Description of key qualitative principles put in place to achieve overall credit risk objective.                                                                                                                                                                                                                                                                                                                   |                                                             |                                                                    |
| Inherent risk                                                                                                                                                                                                                                                                                                                                                                                                      | Unaccepted risk                                             | Controls                                                           |
| Description of inherent risk with respect to credit risk.                                                                                                                                                                                                                                                                                                                                                          | Description of unaccepted risk with respect to credit risk. | Description of controls and processes with respect to credit risk. |
| II. Level, Limits and Thresholds                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                                    |
| Description of key quantitative principles put in place to achieve overall credit risk objective.                                                                                                                                                                                                                                                                                                                  |                                                             |                                                                    |
| Level                                                                                                                                                                                                                                                                                                                                                                                                              | Description                                                 | Limit/Red Threshold                                                |
| E.g., board, head of department, etc.                                                                                                                                                                                                                                                                                                                                                                              | Specific credit risk indicator                              | e.g., 10% ; >9,5%                                                  |
| <p><i>Remark:</i> This table provides a simplified overview of a risk appetite statement for credit risk. Such a statement typically includes a qualitative description of inherent risks, unaccepted risks, and associated controls. It also includes quantitative elements, such as limits and thresholds, and a delineation of key responsibilities necessary to achieve the overall credit risk objective.</p> |                                                             |                                                                    |

*monitor whether we are significantly deviating from the path we, as a bank, have committed to—approved by the board. In the next phase, we will integrate this into the risk appetite framework, using multiple indicators and limits to establish control mechanisms that trigger alerts if something falls off track.” (N1)*

*“Integrating ESG factors into our risk appetite is essential, particularly ensuring they are explicitly included in our risk appetite framework. This serves as the foundation for managing these risks effectively. At present, we are only measuring and observing these risks. Without a clear strategic goal on how we intend to address them, we cannot develop effective risk management measures. Limits can*

*only be imposed once we have made a strategic decision that we do not want to take on these risks in the future. Defining our risk appetite must come first. From there, we can implement appropriate management tools, such as limits, exclusions, in a top-down approach.” (E1)*

For some institutions, the integration of climate risks is more advanced. While institutions generally do not publish their risk appetite statements, some do disclose updates and additions to their frameworks in their Pillar 3 reports. For example, one institution (P) mentions that it has used the results of its climate-related risk heatmap exercise to integrate climate risks into its credit risk appetite. A key element of this integration involves limits for sectors that are particularly vulnerable to transition and physical risks. Furthermore, the institution notes that climate-related risk aspects were incorporated into the market risk banking book risk appetite through the introduction of climate-related sensitivity metrics. A few other institutions disclose key climate-related qualitative principles that have recently been added to their risk appetite framework. These principles, often presented as commitments, primarily focus on carbon neutrality, such as sector-specific targets or a net-zero plan. For example, one institution (I) discloses in its Pillar 3 report key qualitative principles, including achieving carbon-neutral banking operations (scopes 1 and 2) and a carbon-neutral portfolio (scope 3); setting sector-specific climate targets for 2030 for the highest emitting sectors in its portfolio; measuring the climate impact of its credit portfolio and aligning its management with national and international targets. Similarly, another institution (F) reports having incorporated key principles into its risk appetite framework, including aligning operations and business activities with a five-step net-zero plan; setting interim targets (2025, 2030 and 2035) based on a quantitative carbon budget at the sector level; reducing the carbon footprint of operations (scopes 1 and 2); supporting client transition by offering green products and engaging with clients to further develop methodologies.

Beyond incorporating climate risks into risk appetite, institutions often face the challenge of aligning their business strategy with their risk strategy. In this context, several respondents (D1, B2, L1) noted the importance of establishing a clear business

strategy, which then serves as the foundation for the risk strategy. They also stressed the importance of having the right processes, policies and documentation in place to effectively implement and operationalize these strategies:

*“I think it all starts with strategy. You have to be clear about the strategy you want to pursue and then align the other processes accordingly. In other words, the whole credit process and risk management can only contribute to what the strategy means — for example in terms of future deals, but also for future defaults or loss amounts.” (B2)*

*“It is a misconception to think that current loans are not relevant from a climate perspective just because they have a five-year maturity. In five years’ time, new loans will have been taken out for another five years. Unless a bank’s strategy has fundamentally changed, the profile of borrowers is likely to be the same. The strategy therefore plays a key role.” (L1)*

### Key risk indicators (KRIs)

Institutions typically monitor their risk appetite through a dedicated system that is organized around a set of key risk indicators (KRIs) (ECB, 2022d). Such KRIs are usually included in the risk appetite statement and reported internally (e.g., quarterly) to the management and/or supervisory body as well as relevant committees (e.g., risk committee). Common KRIs include metrics such as internal and regulatory capital ratios (e.g., CET1 capital), leverage ratio, total RWA and breakdown of RWA by risk type and liquidity ratios (e.g., Liquidity Coverage Ratio, Net Stable Funding Ratio). In this section, we provide an overview of climate-related KRIs and highlight the approaches described by the respondents in establishing such indicators.

As part of the integration of climate risks into risk appetite frameworks, the ECB expects institutions to develop KRIs designed to manage climate risks (see expectation 4.2 of the ECB Guide, ECB 2020b). While KRIs primarily serve as tools for risk monitoring, they can also be used for observation purposes before formal limits are



established. Several institutions included in our sample have already developed or are in the process of developing KRIs to incorporate climate-related risks into their regular risk monitoring and reporting. As with other risk management tools, the design of the climate-related KRIs varies across institutions. We provide an overview of these KRIs in Table VII.5 and discuss them below.

For example, one institution (G) monitors the share of coal in the electricity production mix of the power generation portfolio it finances. It also considers several KRIs derived from its net zero targets for the oil and gas, power and automotive sectors. Another institution (Q) monitors for its residential mortgages portfolio the assets with an increased physical risk exposure and checks the percentage of vulnerable collateral in areas of high physical risk. Furthermore, it tracks an indicators of data quality of financed emissions. Furthermore, one institution (K) uses a set of climate-related KRIs linked to its business strategy, climate scenario outcomes and credit and operational risk. A respondent (K2) from this institution described the approach as follows:

*“We have several indicators that are directly tied to our business strategy. For example, we assess how much green business we are conducting and the volume of assets eligible for green bonds. Additionally, we have cross-risk and risk-specific indicators. We focus on the outcomes of climate scenarios, using metrics like the utilization of our risk-bearing capacity and the CET1 capital ratio as key indicators. Furthermore, we have developed specific risk metrics, such as those based on the results from our internal ESG scorecard, which we apply to credit risk assessments. In the domain of operational risk, we track the number of service locations that are exposed to physical risks — particularly those that lack appropriate mitigation measures. Another operational risk metric, which is more aligned with legal risks, is the tracking of lawsuits and customer complaints linked to ESG issues.”*

**(K2)**

One institution (O) uses several KRIs linked to climate risks and specific risk types, including market, liquidity and operational risks:

*“We have developed some indicators for market and liquidity risks. For liquidity risk, for example, we look at the Liquidity Coverage Ratio (LCR) buffer and assess how much of this securities buffer is associated with entities highly exposed to transition risks. In market risk, we examine the portion of credit spread risk. For operational risk, we track incidents related to climate and environmental issues.”*

**(O1)**

Another institution (H) has introduced two climate-related KRIs: one tracks the proportion of credit exposure to companies with the lowest transition score, and the other measures the total gross carrying amount exposed to physical climate events. This latter KRI is linked to the climate-related disclosures outlined in Template 5 of the Pillar 3 disclosures:

*“We monitor the proportion of our lending volume to companies that fall into the lowest category according to our internal scoring system. This system assigns a transition score from 1 to 100, divided into five classes, each spanning 20 points. Specifically, we use a KRI to track our total credit exposure to companies in the fifth and lowest category. For physical risks, we apply a similar approach. In relation to our disclosure requirements, we use Template 5, which provides highly granular information on maturities, sectors and the gross carrying amounts exposed to physical risks. This data is disclosed both for our domestic market and for foreign markets. We aggregate this information into a single metric, which represents the total gross carrying amount of our portfolio exposed to physical risks, and use it as a KRI.”* **(H1)**

One institution (E) has a comparable strategy, encompassing one KRI that monitors credit volumes based on the institution’s internal ESG scoring system, and another KRI that tracks exposure to climate-related physical risks, with a particular emphasis on flood risks:

*“We have implemented a set of KRIs, which are now part of our overall risk reporting system. Currently, these indicators follow traditional risk management methods. For example, we use our internal ESG scoring system to track how many clients fall into each scoring category, ranging from A to G. This helps us understand the distribution of credit volumes across these categories, especially for new business. Moreover, we place a strong emphasis on monitoring exposure to specific climate risks, with flooding being a key focus. In this regard, we assess our exposure across various flood risk categories.” (E1)*

Another institution (J) in the sample tracks six climate-related KRIs, including the number of blacklist cases, a carbon intensity indicator for the shipping and real estate portfolios, and a KRI that monitors credit volumes highly exposed to physical risks. One expert (J2) elaborated:

*“We ensure that we really do not have any blacklist cases and we also track the proportion of our portfolio with a poor ESG score. Additionally, we analyze the distribution of energy efficiency classes, particularly in the shipping portfolio. We also examine the distribution of energy efficiency classes within the real estate portfolio. Furthermore, we monitor the portion of the credit portfolio that is exposed to high physical risk. We have also implemented a trigger based on changes in the ESG score which require discussion in the credit watchlist meeting. Here, we have integrated ESG criteria to monitor cases that deteriorate and are added to the watchlist.” (J2)*

One respondent (I1) mentioned that their institution has developed a KRI to monitor progress toward decarbonization targets, focusing particularly on the emissions intensity of both the corporate portfolio and the real estate and project finance portfolio:

*“We have set ourselves the goal of decarbonizing our portfolio. Each year, we assess the long-term decarbonization trend to determine the level of ambition and then track our progress to ensure we are meeting our targets. This process requires monitoring of the emissions intensity of our portfolio. Our KRI is specifically designed to track this intensity at the bank and segment level.” (I1)*

Another respondent (P1) elaborated on the use of multiple KRIs to monitor decarbonization objectives, while also addressing potential greenwashing risks related to energy label downgrades in the real estate portfolio:

*“We use various KRI, for example, to monitor our decarbonization goals. In the areas of construction financing and residential real estate, we look at how many renovation projects of existing properties are happening within our portfolio. We have also set a target that we need to meet in order to achieve a specific internal scenario we have outlined. In addition, we monitor greenwashing risks from a compliance perspective. For example, we offer a discount on loans for real estate properties with certain sustainability labels. We ensure that this incentive is not misused by verifying that the properties being built genuinely meet the initial criteria we set. It can happen that a property receives a lower label than expected once it is completed. We monitor these label downgrades as well.” (P1)*

## Limits and exclusions

As part of their risk appetite framework, institutions typically implement a comprehensive limit system that sets specific quantitative thresholds for individual risk types and sub-risks identified in their ICAAP (ECB, 2018). In addition, institutions often establish limits at an aggregate level, tied to capital metrics such as the CET1 ratio or overall economic capital adequacy ratios (ECB, 2020a). These limits allow institutions to operationalize their risk appetite by defining maximum acceptable risk exposures. In this section, we briefly discuss the concept of limits and examine the approaches and challenges reported by respondents in integrating climate risks into their limit systems,

Table VII.5: Climate-related key risk indicators (KRIs).

| KRI type                       | KRI description                                                                                                                                                                           |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Transition risk KRI            | Based on an internal transition score. Tracks total credit exposure to companies with the lowest transition scores.                                                                       |
| Physical risk KRI              | Based on Template 5 of Pillar 3 disclosures. Monitors the total gross carrying amount exposed to physical risks.                                                                          |
| Collateral KRI                 | Tracks the percentage of vulnerable collateral in areas of high physical risks.                                                                                                           |
| Internal score KRI             | Based on the overall internal score. Tracks credit volumes within each scoring class.                                                                                                     |
| Emissions intensity KRI        | Tracks emissions intensity across key portfolio segments.                                                                                                                                 |
| Emissions data KRI             | Tracks data quality of financed emissions.                                                                                                                                                |
| Blacklist KRI                  | Tracks the number of blacklist cases.                                                                                                                                                     |
| Efficiency Classes KRI         | Monitors the distribution of energy efficiency classes within real estate and shipping portfolios.                                                                                        |
| Green bond-eligible assets KRI | Monitors the volume of amount of assets within the portfolio that can be classified as eligible for green bonds.                                                                          |
| Risk-bearing capacity KRI      | Monitors the results of the climate scenarios in terms of risk-bearing capacity (ICAAP).                                                                                                  |
| CET1 ratio KRI                 | Monitors the results of the climate scenarios in terms of common equity Tier 1 capital ratio.                                                                                             |
| Legal risk KRI                 | Monitors the number of lawsuits and customer complaints related to ESG topics.                                                                                                            |
| Oprisk KRI                     | Focuses on operational risk by tracking the number of critical service locations that are exposed to physical risks without mitigation measures in place.                                 |
| Oprisk KRI                     | Tracks the number of incidents related to climate and environmental issues.                                                                                                               |
| Liquidity risk KRI             | Based on the LCR buffer and tracks the proportion of entities that are highly exposed to transition risks.                                                                                |
| Decarbonization KRI            | Based on the net zero targets set in key sectors. Tracks alignment of emissions intensity of exposures to key sectors with the institution's sectoral targets or overall net zero target. |
| Coal KRI                       | Based on the share of coal in the capacity mix of the financed power generation portfolio.                                                                                                |

*Remark:* This table provides a non-exhaustive list of climate-related KRIs used by the institutions in the sample.

along with exclusion strategies.

The ECB defines a limit system as follows: “A documented and hierarchical system of limits set in line with the overall strategy and risk appetite of the institution in order to ensure that risks and losses can be limited effectively in line with the capital adequacy concept. The limit system is expected to lay down effective boundaries for risk taking for, for example, different risk types, business areas, products and group entities” (p.41, ECB 2018). Limits are often linked to various triggers, which can lead to different actions such as hedging transactions to mitigate risks or even halting new transactions if certain thresholds are breached. Internal reports, usually generated monthly, provide governance bodies with information on the utilization of both individual and overall risk limits.

The form and scope of these limits can vary. For example, to avoid excessive credit risk concentration, institutions are subject to a regulatory limit, known as the “large exposure limit”, which restricts total exposure to a single counterparty or a group of related clients to 25% of an institution’s Tier 1 capital at any time (see Art. 395 of the CRR). Institutions may also apply limits for credit exposures to single names, industries and countries (ECB, 2020a). In this context, ratings are often a key input parameter in determining credit risk limits. For example, sovereign ratings are important for establishing country limits, and a downgrade in a country’s rating may lead to a reduction in its associated limit. For industries or sectors, institutions generally apply a risk-oriented sector key, which combines sector segments that have high economic dependencies along certain value chains (ECB, 2020a).

In the context of climate risks, the ECB expects institutions to set “appropriate” limits to manage such risks (see expectation 4.2 of the ECB Guide, ECB 2020b). Institutions use different approaches to incorporate climate risks into their limit systems. In Table VII.6, we provide an overview of the climate-related limits observed in our sample and discuss these examples further below.

For example, one institution (C) uses a “climate stress loss limit” across credit and market risks. To monitor potential credit and market risk losses against this limit, this institution runs a short-term transition risk carbon repricing scenario assuming that

a global effort to address carbon emissions leads to a sudden and sustained carbon repricing across all countries. The results of this scenario are assessed on a monthly basis against the limit. The limit itself is reviewed annually. As described by one respondent (C1), the climate stress loss limit operates as follows:

*“The climate stress loss limit is expressed as a specific loss amount and reflects our appetite for climate risk. We tie this to the broader macroeconomic stress loss limit, which represents the firm’s overall risk appetite. We run macroeconomic stress scenarios on a regular basis to measure market and credit risk loss potential and to monitor those against the macroeconomic stress loss limit. Given that transition risk is a material risk for us, we use carbon pricing as the key scenario for monitoring this risk, and we assess this limit specifically against potential losses from carbon repricing. The climate stress loss limit covers both credit and market risk. As our transition scenario includes market shocks, it has the potential to trigger market losses, which we also monitor. We use the same methodology as for any other shock and cover the entire portfolio. It think this approach sets us apart from other institutions, which often only focus on specific portfolio segments. In contrast, we run the scenario across the entire portfolio, including both lending and trading exposures (...). We’ve developed an internal scenario, as the NGFS scenarios are not well-suited for short-term evaluations. Our scenario is deliberately conservative. We take forecasts of carbon price scenarios for 2030 and apply them to the present day. We look at what research is forecasting in the more severe scenarios in terms of carbon prices around the globe, all at the same time, and we use those assumptions in our scenario as if they were occurring today.”*

(C1)

Several institutions apply limits to sectors or industries that are particularly exposed to transition and physical climate risks. Such limits are typically expressed in terms of aggregated credit risk net exposure, either risk-weighted or non risk-weighted (e.g., total amounts in EUR million). For example, one institution (C) has specific industry limits that complement the climate stress loss limit. These limits are based on a sub-industry

segmentation approach and take into account expert credit assessments, greenhouse gas emission data and external physical risk scores:

*“We have sector limits for industries highly exposed to transition or physical risks, using internal methodologies to assess these risks, based on industry scores and expert judgement (...). The limits are set at the industry level, tied to the industry of the company in the transaction. For instance, if a new transaction is originated in the energy industry, it has to fit into our limit (...). This approach allows us to manage new lending in sectors particularly vulnerable to these risks. Since our primary climate risk arises from credit risk, we implemented this credit exposure limit below the Climate Stress Loss Limit for more targeted monitoring.” (C1)*

Another respondent (O1) outlined a similar strategy, incorporating both sector limits and an additional limit tied to the portfolio’s exposure to physical risks:

*“In an initial step, we deliberately chose a simple approach. We didn’t want to set limits based on CO2 intensities across the entire portfolio right away. Instead, we started with a relatively straightforward method. We developed industry-specific limits and thresholds. For example, we monitor a specific indicator that tracks the share of our portfolio in five high-risk sectors: agriculture, aviation, real estate, non-renewable energy and the food industry. This means we examine how much exposure we have in these sectors, and the overall exposure is capped. We also have a second indicator that measures the portion of the portfolio located in physically high-risk areas. This is further broken down into subcategories. For real estate, we assess the collateral, and for companies, we evaluate their physical locations. We consolidate this information into one indicator and map it using data from Munich Re. We’ve also incorporated ‘defender’ scores. For example, in the Netherlands, there is significant flood risk, but substantial investments have been made in dike systems, which we can factor into our scoring. We then evaluate what remains in the portfolio that falls into these high-risk areas, and this share of the portfolio is also capped. Looking ahead, the topics of CO2 emissions*



*and emission intensities will play a more prominent role. However, for now, we are focusing on gaining more experience in this area, as there is still considerable uncertainty around data and modeling. Therefore, we haven't imposed limits in this regard yet. We continually review the sector-specific pathways as part of this process.” (O1)*

A more advanced and complex approach involves setting limits based on CO<sub>2</sub> intensities for specific sectors, as well as carbon footprints in lending and investment portfolios. For example, one institution (F) has established quantitative thresholds for several carbon-intensive sectors (e.g., power generation, automotive, steel production). These thresholds have been incorporated into its risk appetite statement and are directly linked to the institution's net zero targets for each sector. In addition, any new transaction that has a significant impact on the institution's financed emissions has to be reviewed by a dedicated net zero forum. Similarly, another institution (P) uses a combination of instruments, including sector-specific limits for industries highly exposed to transition risks, limits tied to energy efficiency labels for the residential and commercial real estate portfolios, and a concentration limit aimed at managing physical risk exposures:

*“In the area of residential and commercial real estate, we have set limits based on energy efficiency labels and energy efficiency classes. In addition, we have a concentration limit in relation to physical risks. The objective here is to limit our credit exposures to geographies subject to high physical risks. For wholesale banking, we have established so-called ‘growth caps’ for individual sectors, such as oil, gas and coal. These caps are aligned with the climate goals we are pursuing. For example, for oil and gas, we have a phase-out scenario and corresponding limits in place to support this reduction process.” (P1)*

Similarly, another institution (N) is considering the introduction of a limit system on the basis of sectoral emission intensity:

Table VII.6: Climate-related risk limits.

| Limit type                                  | Limit description                                                                                                                                                                                                         |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Climate stress loss limit                   | A limit on potential credit and market losses resulting from a transition risk scenario, such as sudden carbon repricing. This limit is assessed monthly and reviewed annually.                                           |
| Sector limits for transition/physical risks | Limits on aggregated credit exposure to sectors particularly exposed to transition and physical risks (e.g., energy, real estate). These are based on industry scores, credit risk assessments, and physical risk scores. |
| Physical risk exposure limit                | A cap on the share of the portfolio exposed to areas or industries with high physical risks (e.g., flood zones), often based on external data and risk assessments.                                                       |
| Energy efficiency label limit               | A limit on credit exposures in residential and commercial real estate portfolios based on energy efficiency labels or classes.                                                                                            |
| CO2 intensity limits                        | Quantitative thresholds for carbon-intensive sectors (e.g., power generation, automotive), aligned with net zero targets. Transactions significantly affecting financed emissions are reviewed by a dedicated committee.  |
| Concentration limits for physical risks     | A limit on credit concentration in geographies or industries highly exposed to physical risks, such as natural disasters.                                                                                                 |
| Growth caps for high-risk sectors           | Limits set on the growth of exposure to high-risk sectors like oil, gas, and coal. These caps align with decarbonization goals, often tied to phase-out scenarios.                                                        |

*Remark:* This table provides a non-exhaustive list of examples of climate-related risk limits used by the institutions in the sample.

*“We are focusing on intensity-based climate pathways, such as CO2 emissions per ton of steel or per ton of cement produced in the case of cement manufacturers. The main challenge is aggregating these diverse metrics. However, we are currently exploring how to express this as a deviation from our climate pathway, for example, by determining how many months or years we are behind the target and what needs to be done to catch up. The aim is to consolidate this into a single figure for the bank, though it is still very much a work in progress at this stage.”*

(N1)

Rather than limiting exposure to climate risks as described above, institutions may also choose to exclude certain sectors or industries from their lending activities alto-

gether. To facilitate the implementation of these exclusion policies, the institutions in our sample have developed checklists, blacklists or similar tools to systematically evaluate new loan applications based on specific criteria. These procedures are typically tailored to specific asset types (e.g., corporates, project finance, countries) and are subject to regular review, often overseen by an exclusion criteria committee. For example, a few institutions (G, F, I) have also introduced guidelines for sector-specific exclusions based on climate-related criteria. Typically, the sectors targeted are large CO2 emitters.

For example, one institution (I) no longer provides project finance to companies that build, expand and/or upgrade coal-fired power plants or coal mines. Similarly, this institution has set new thresholds for general purpose financing to energy utilities that derive a large part of their revenue from coal or operate one or more coal-fired power plants. Another sector to be subject to exclusion policies is the oil and gas sector. One institution (G) no longer grants financing for the development of new oil fields. Furthermore, it has introduced a phasing out of financing for non-diversified oil upstream companies and excludes financing dedicated to the development of new capacities for gas exploration and production. As noted by several respondents (B1, B2), these exclusions are often particularly driven by strategic decisions and reputation risk concerns:

*“The ESG checklist is an expression of our bank’s reputation risk.” (B2)*

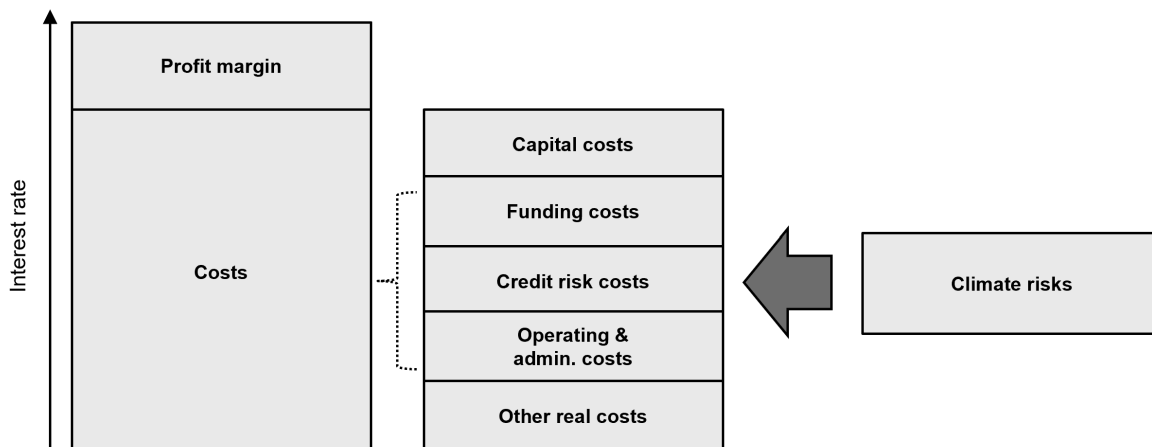
*“These exclusions, which are designed to limit new business in certain sectors, are currently more the result of strategic and reputational considerations, rather than a consequence of stress test results.” (B1)*

## VII.4.5 Pillar I & II: Integrating climate risks into loan pricing

### Background and rationale

A key issue raised on multiple occasions by our respondents is the topic of loan pricing in the context of climate risk integration. This aligns with the ECB’s expectation that

Figure VII.14: Costs affecting loan pricing.



*Remark:* This figure illustrates the costs components affecting loan pricing and is adapted from KPMG (2023) and EBA (2020). Note that the relative size of the cost components is not to scale.

loan pricing should reflect the “different costs” driven by climate risks (see expectation 8.6 of the ECB Guide, ECB 2020b). Meeting this expectation requires a conceptual understanding of how “traditional” cost parameters affect loan pricing, and how these may be adjusted to better account for climate risks. In this section, we briefly outline key considerations related to loan pricing, followed by a summary of the approaches and challenges highlighted by our respondents.

According to the EBA’s guidelines on loan origination and monitoring (EBA, 2020), institutions need to consider and reflect several types of costs in their loan pricing, including the cost of capital (both regulatory and economic capital), the cost of funding, operating and administrative costs, credit risk costs (based on historical losses and, where applicable, using expected loss models), other real costs associated with the loan, and parameters related to competition and prevailing market conditions (EBA, 2020). Figure VII.14 provides a simplified illustration of such costs.

Climate risks can influence loan pricing in several ways. In particular, the ECB notes that the “impact of climate-related and environmental risks may play out through various cost drivers, such as the cost of capital, funding or credit risk” (p.38, ECB 2020b). As we show in the next sections, institutions have started to implement climate risk integration strategies across all three cost drivers — capital, credit and funding.

### Pricing of climate risks through capital considerations

Cost drivers can arise from both Pillar 1 and Pillar 2 considerations. In particular, the EBA recommends incorporating the cost of capital (taking into account both regulatory and economic capital), resulting from the existing capital allocation, into loan pricing decisions (EBA, 2020). This recommendation underscores the importance of aligning pricing with the institution’s overall capital requirements. Building on this idea, Gruenewald et al. (2023) argue that integrating climate risks into Pillar 1 capital requirements would ensure that these risks are adequately accounted for in internal business decisions, such as loan pricing.

In support of this, one respondent (C1) explained that their institution captures climate risks in loan pricing by incorporating such risks into internal ratings. Furthermore, as noted in Section VII.4.2, most respondents consider the short-term financial effects of climate risks are to be implicitly captured by the ratings, either by the quantitative rating criteria (e.g., financials) or by more qualitative factors (e.g., competitive positioning, industry risk). Institutions are also increasingly relying on tools such as climate-related scores and applying rating overrides to account for more longer-term effects of climate risks. Such tools have an impact on capital requirements and thus on loan pricing.

*“Climate risk is integrated into our pricing because we have incorporated it into our internal ratings and it is part of the PDs.” (C1)*

As shown in Section VII.4.3, several institutions allocate economic capital specifically for climate risks or set aside dedicated capital buffers. For example, one institution (K) has established a comprehensive climate risk buffer within its risk-bearing capacity calculations, effectively reducing the institution’s available capital. This approach may also have an impact on loan pricing. In addition, one respondent (K1) explained that their institution’s loan pricing framework is driven by economic capital considerations, with credit portfolio models under Pillar 2 playing a key role in shaping loan pricing decisions:

*“For us, pricing is primarily driven by Pillar 2. We use a credit portfolio model, essentially a value at risk model, and from that, we derive profitability which then determines loan pricing. Once these climate-related risk drivers are incorporated into Pillar 2, where they are currently already much more prominent than in Pillar 1, they influence pricing (...).” (K1)*

Such approaches may nevertheless result in a more ad hoc and fragmented inclusion of climate risks into loan pricing. Although achieving a more systematic integration of climate risks is seen as particularly challenging, three respondents (H5, D1, P1) noted that integrating climate risks into internal risk models remains an important long-term goal for risk-based pricing:

*“There are regulatory requirements that we have to take climate risks into account for loan pricing. Some institutions, who were perhaps more proactive, have already allocated capital for climate risks in some way, making it easier for them now because the cost of capital is factored into loan pricing. As a result, they have little else to do. We, on the other hand, did not take this approach. Based on our risk inventory and sensitivity analyses, we concluded that climate risk was not material and therefore did not allocate capital for it. As a result, climate risks are not systematically reflected in our pricing. Our credit risk scorecard is likely to play a role in the future for pricing, but this is still under development.” (H5)*

*“Ideally, climate risks would be automatically incorporated into the PDs and consequently into risk-adjusted pricing. Of course, we can, and in certain cases we certainly will, set opportunistic price incentives independently of the PD. In a perfect scenario, these considerations would be embedded within the PD, ensuring automatic risk adjustment. Until we reach that point, we may need to intervene individually in certain sub-portfolios or with selected customers.” (D1)*

*“Ideally, this would be managed through our internal models, allowing us to price the risks accordingly. However, this would require adjustments to our internal models, and we are not quite there yet in terms of progress. What we are doing at the moment are post-model adjustments, or overrides. For example, when we see that certain risks are not adequately reflected in the model, we can make adjustments, which results in the customer receiving a higher interest rate. Otherwise, the adjustments are more on the business side, in terms of economic calculations. For example, I have a target ROE [Return on Equity] for the entire portfolio that I want to maintain, say 10% ROE. I can offer discounts on certain loans, and for others with higher risk, I can apply a premium. This way, I can distribute the impact across the portfolio and still achieve my target.” (P1)*

In addition, one respondent (O1) noted that, although their institution does not view climate risks as being internally mispriced, loan origination teams may offer pricing incentives for transactions that support the institution’s emissions reduction targets. This approach, however, is driven by strategic priorities rather than adjustments in cost of capital or risk modeling considerations:

*“At the moment, we are not explicitly intervening by making green loans cheaper or brown loans more expensive. We have consciously chosen not to take that approach. One reason is that we consider these risks to be already implicitly reflected in our ratings, through factors such as business model or collateral valuation. We do not feel that we are incorrectly measuring or pricing credit risk. As a result, we haven’t seen the need to intervene from a risk management perspective by, for example, requiring higher margins for certain sectors. However, what is happening is that the loan origination divisions, within their decision-making authority, are offering incentives and may accept a few basis points less in terms of margin premium (...). This allows us to support transactions that contribute to our CO2 emissions reduction targets. But this is more of a business decision made by individual loan origination departments, rather than something risk management*

*mandates because of concerns about incorrect pricing.” (O1)*

### **Pricing of climate risks through credit risk and funding considerations**

In addition to capital considerations, the EBA recommends loan pricing to also account for the cost of funding and credit risk costs (EBA, 2020). The credit risk costs may be determined based on historical losses or, where applicable, on expected loss models (EBA, 2020).

One institution (K) applies a combination of strategies to incorporate climate risks into loan pricing, differentiating between short-term and long-term risks. Short-term climate risks are captured through credit risk costs and reflected in profit margin requirements, while long-term risks are addressed by leveraging potentially lower refinancing costs via a green refinancing curve and adding a margin premium based on the internal ESG scorecard, with particular attention to the environmental scores and loan maturities. A respondent (K2) from this institution explained:

*“We consider our short-term climate-related risks to be included in our credit risk costs, which are ultimately reflected in our profit margin requirements. We have also factored in potentially lower refinancing costs through a green refinancing curve. While this curve does not significantly differ from the standard refinancing curve at the moment, we have structured it in a way that allows us to account for larger differences if they arise in the future. Additionally, last year we introduced a margin premium in response to the ECB’s requirements. This premium is determined based on the results of our internal ESG scorecard and loan maturity. You can think of it as a matrix: the longer the term of a loan and the worse the ESG score, particularly the environmental sub-score, the higher the premium. These aren’t arbitrary numbers that would price us out of the market. Instead, we have implemented a structural framework to address issues that are not otherwise captured by risk parameters such as probability of default and loss given default in the short term (...). Although a rating usually has a one-year time horizon, the*



*additional profit margin requirement considers the entire loan duration. For example, a poor internal score on a two-year loan may not have a significant impact on the margin, but for a 20-year loan, the effect would likely be different.” (K2)*

In terms of credit risk costs, two respondents (H5, G1) highlighted that their institutions are increasingly relying on scenario analysis to integrate climate risks into loan pricing considerations. In this context, individual scenarios are used to assess potential shifts in credit risk parameters and expected credit losses. For example, respondent (G1) explained that their institution developed a methodology for expected credit loss provisions (credit risk provisions)<sup>55</sup> that relies on default probabilities conditional on climate scenarios:

*“By the end of this year, we plan to integrate the impact of climate scenarios into the calculation of credit risk provisions. This will have pricing implications, as the effects of these scenarios will be felt from the moment a transaction is originated, and even for existing transactions in their internal billing. To implement this, we are developing default probabilities that are conditional on these climate scenarios. Historically, provisions were based on three-year scenarios, but this year, we have developed a comprehensive methodology to incorporate the effects of longer-term scenarios into short-term projections. In this context, it is important to consider the concept of the term structure of default probabilities. In our stress tests, we assume a continuously renewed portfolio and typically focus on one-year default probabilities projected over longer time horizons, such as 30 years. For provisioning, we account for this by adjusting the marginal default probabilities. This means that, starting today, when we look at the term structure of default probabilities for a loan in the portfolio with a 30-year horizon, for example, the entire structure will shift to an extent that depends on the horizon in relation with a climate scenario.” (G1)*

Finally, one institution (Q) uses a combination of economic capital buffer, provi-

<sup>55</sup>Expected credit losses under IFRS 9 are deducted from capital (Krüger et al., 2018).

sioning for expected credit losses and incorporation of climate risks in macroeconomic scenarios used to estimate future expected credit losses. The institution notes that the incorporation of climate risks into such models is challenging due to a lack of data. Despite these challenges, the institution notes that it has implemented a strategy to partially integrate climate risks by embedding them into macroeconomic forecasts commonly used to assess expected future losses. The institution adds that, as a result of the materiality assessment, a management overlay of EUR 25 million has been taken for expected credit losses.

## **VII.4.6 Pillar II: Integrating climate risks into the Supervisory Review and Evaluation Process (SREP)**

### **Background and rationale**

Unlike regulators, supervisors cannot enact binding rules, but they can offer guidance on how they interpret specific regulatory requirements, thereby influencing institutions' expectations and behavior (Smoleńska and van 't Klooster, 2022). Under the SSM, the ECB directly supervises significant institutions in euro area countries through the SREP. In recent years, the ECB has included climate risks as one of its new priorities in SREP assessments (Gruenewald et al., 2023). Although the SREP is a tool for supervisors rather than institutions, it can help shape institutions' risk management practices with respect to climate risks and therefore contribute to a greater integration of such risks. The SREP also influences individual capital requirements for institutions. This section outlines key aspects of the SREP, while the subsequent sections explore how this process may further enhance the integration of climate risks into risk management and capital requirements.

The SREP is an annual process in which supervisors evaluate, on a case-by-case basis, the risks faced by institutions and their ability to manage these risks in terms of risk controls, capital and liquidity (ECB, 2023g). It is structured around four key thematic elements and results in three primary outcomes, as shown in Figure VII.15. The first element is a business model assessment, where supervisors evaluate both the

viability and sustainability of an institution's business model (EBA, 2022a). Specifically, they assess the viability of the institution's current business model based on its ability to generate sufficient returns over the next 12 months, and the sustainability of its strategy, considering its capacity to generate sufficient returns over a period of at least three years, considering strategic plans and financial forecasts (EBA, 2022a). In addition, supervisors are required to develop a clear understanding of the "current and future business conditions in which an institution operates or is likely to operate based on its main or material geographic and business exposures" (p.42, EBA 2022a).

The second element of the SREP methodology focuses on governance and risk management. In this context, supervisors evaluate whether an institution's internal governance framework is appropriate for its risk profile and business model. They also assess whether the governance structures are properly aligned with sound risk management mechanisms and other corporate policies (EBA, 2022a). The third element involves assessing and scoring the risks to capital deemed material for the institution. Supervisors conduct a detailed evaluation of risk types, such as credit and counterparty risk, market risk and operational risk (EBA, 2022a). In addition, they review other risks identified in the institution's ICAAP (e.g., reputational risk) and assess the quality and effectiveness of the controls in place to manage these risks. Lastly, the fourth element addresses liquidity and funding risks, focusing on the institution's ability to meet short-term cash requirements (EBA, 2022a).

As shown in Figure VII.16, the combined assessment of these four elements results in an overall SREP score, ranging from 1 (low risk) to 4 (high risk), reflecting the supervisors' comprehensive evaluation of the institution.<sup>56</sup> Institutions also receive a detailed report outlining the outcomes and identified shortcomings through a formal ECB SREP decision or "SREP feedback letter".

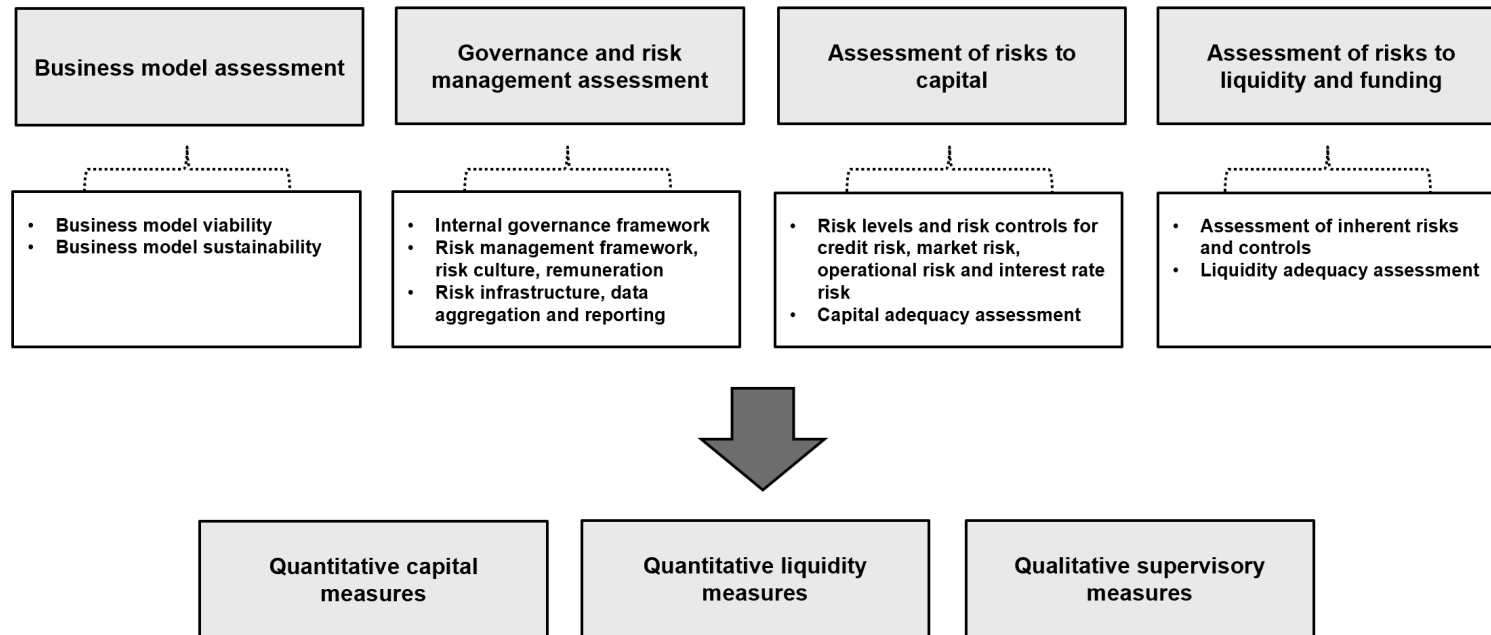
A key outcome of this process, and in particular of the SREP score, is the P2R. The P2R is a legally binding capital requirement that complements Pillar 1 minimum capital requirements (ECB, 2023f). It is applied when the ECB comes to the conclusion,

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<sup>56</sup>In 2023, the average overall SREP score in 2023 was 2.6, based on 106 SREP decisions (ECB, 2023a).

through the SREP assessment, that certain material risks are either underestimated or inadequately covered. For example, below average SREP scores (e.g., 3 or 4) may trigger higher P2R levels. P2Rs are typically expressed as an additional percentage of capital that must be held in relation to RWA, and both the ECB and supervised institutions have to publicly disclose current P2R levels (ECB, 2023f, 2024h). This process allows the ECB to make tailored decisions regarding additional capital and liquidity requirements and to introduce qualitative supervisory measures.

Figure VII.15: Key components and main outcomes of the Supervisory Review and Evaluation Process (SREP).



*Remark:* This figure describes key features of the SREP and is based on EBA (2022a) and ECB (2023g).

**Business model, governance and risk management assessments**

As described in Section VII.2.1, by the end of 2024 institutions are expected to comply with the ECB’s supervisory expectations on climate risks established in 2020, including the full integration of these risks into their ICAAP and stress testing frameworks (ECB, 2020b, 2023a). In addition, the ECB is increasingly integrating climate-related aspects into key supervisory assessments under the SREP, a development which is further explored in this section.

In both the 2022 and 2023 SREP cycles, the ECB conducted a thematic review of climate risks. In the 2022 cycle, the review focused on qualitative aspects, resulting in 40 binding qualitative measures for around 30% of supervised institutions (ECB, 2022b). These measures mainly addressed governance, business model and credit risk-related issues (ECB, 2022b).

The ECB noted that most of the measures from the 2022 review were focused on “strategic and operational plans”, highlighting that supervisors view this area as a “key enabler” for effective climate risk management (ECB, 2022b). In addition, some measures required institutions to improve materiality assessments across various risk types (e.g., credit, market), enhance internal climate stress tests and scenario analyses, and further integrate climate risks into risk appetite frameworks (ECB, 2022b).

In the 2023 SREP thematic review, the ECB reported that around one-third of the 40 binding measures issued in 2022 had been resolved and completed. However, approximately 12% of significant institutions were issued additional binding measures to address ongoing deficiencies or newly identified shortcomings (ECB, 2023a). These measures again focused primarily on climate-related issues, particularly in relation to governance and business models, and included the integration of climate-related considerations into strategic and operational plans. In addition, for institutions with “persisting severe weaknesses”, the ECB issued ad hoc supervisory board decisions (ECB, 2023a).

These recent developments, based on the 2022 and 2023 SREP cycles, suggest that climate risks now play a role in at least three key elements of the SREP: the business model assessment, the corporate governance and risk management assessment, and the

risks to capital assessment. A recurring theme is the integration of climate risks into business models and strategies. For example, one respondent (A1) noted that climate risks are now being addressed in SREP feedback letters. This respondent pointed out that the ECB provided feedback on both areas of improvement and areas needing further attention, including the evaluation of climate impacts on the business model and their integration into overall strategy:

*“Every year, we receive a very comprehensive SREP letter from the ECB. It is structured around different points, including quantitative requirements, qualitative requirements, facts, findings, and recommendations. The ECB also outlines findings related to the business model and notes areas where we have improved. In this context, it may include observations on the integration of climate risks into strategy and the assessment of the impact of climate risks on the business model. We had something related to that.” (A1)*

The relevance of climate risks in the context of the first SREP element, i.e., business model assessment (see Figure VII.15), is particularly evident in the ECB’s corresponding methodology paper (ECB, 2023b). This methodology underscores that institutions, due to their business model and risk profile, may be operating in markets, sectors, or geographic areas that are particularly exposed to material transition and physical risks, making them vulnerable to the impacts of climate change. As a result, the ECB expects supervisors (e.g., joint supervisory teams) to assess how these risks affect institutions’ business environment and strategies, as well as the establishment and monitoring of “key performance indicators” over short, medium, and long-term horizons (p.9, ECB 2023b).

In contrast, the methodology for the second SREP element, which deals with governance and risk management assessment, is less explicit in its approach to integrating climate risks. The corresponding document only mentions that the methodology will be continuously updated to address new factors arising from the evolving economic and regulatory landscape, such as risks associated with climate change and the environment (ECB, 2023d).

Finally, in relation to the third SREP element, both the credit risk and market risk assessment methodologies explicitly address climate risks. For credit risk, the methodology specifies that the assessment should cover any credit risk-related aspect potentially affected by climate risks. This includes considering “concentrations in economic sectors or geographical areas more vulnerable” to such risks (p.10, ECB 2023c). It also covers other aspects, such as residual risk, settlement and delivery risk and other elements that are material to credit risk (ECB, 2023c). Regarding market risk, the ECB indicates that supervisors should assess whether institutions have an adequate “monitoring and reporting framework for market risk in place, which includes the effect of climate-related and environmental factors on their current market risk positions and future investments”, also ensuring that senior management or the management body takes prompt action when necessary (p.11, ECB 2023e).

### **Pillar 2 Requirement (P2R) and Pillar 2 Guidance (P2G)**

As climate risks are increasingly integrated into the SREP framework (as discussed in Section VII.4.6), and considering that the first three elements of the SREP — business model analysis, internal governance and risk management, and risks to capital — are key determinants of initial Pillar 2 capital requirements (P2R) (ECB, 2024b), the influence of climate risks on individual SREP scores and P2R levels for institutions is expected to grow. This section provides a discussion of these dynamics.

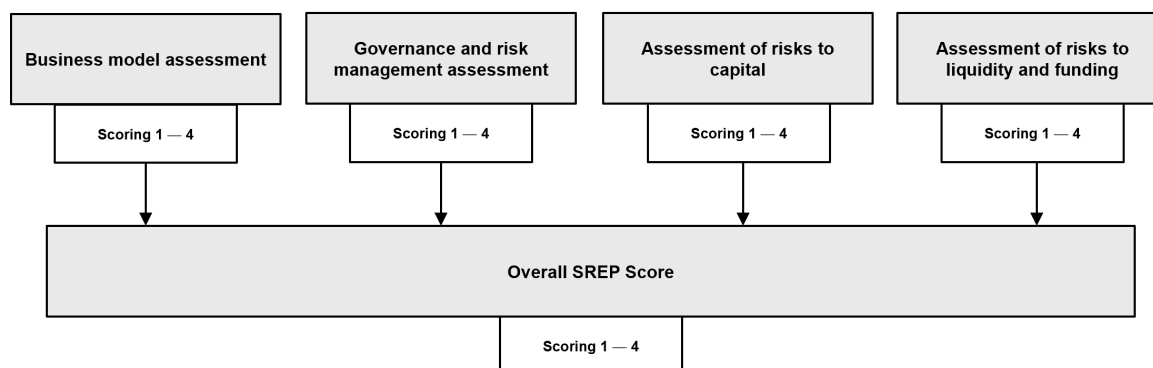
As shown in Figure VII.16, each SREP element generates a sub-score that contributes to an institution’s overall SREP score.<sup>57</sup> The integration of climate risks into SREP assessments can contribute to improving or worsening sub-scores, particularly regarding the first three elements discussed in Section VII.4.6. As a result, this may lead to changes in the overall SREP score, which in turn affects the level of P2R imposed on institutions (ECB, 2024h). The P2R represents an additional capital buffer that institutions must hold beyond the minimum capital requirements set under Pillar 1.<sup>58</sup>

<sup>57</sup>For a detailed description of the SREP methodology, see EBA (2022a) and ECB (2023g).

<sup>58</sup>Institutions with lower SREP scores are viewed as having lower risks and sounder risk management and therefore face lower P2R levels. Conversely, higher SREP scores indicate greater vulnerabilities and weaknesses in risk management, leading to higher P2R levels to address these additional risks.



Figure VII.16: Scoring framework under the Supervisory Review and Evaluation Process (SREP).



*Remark:* This figure provides a simplified overview of the SREP scoring elements and is based on EBA (2022a) and ECB (2023g).

In fact, the ECB already observed, following the 2022 SREP cycle, that the qualitative integration of climate risks impacted the SREP scores of a few supervised institutions (ECB, 2022b). Specifically, the ECB noted that the “qualitative integration of climate and environmental risks had an impact on the SREP scores of a small number of institutions, although this did not translate into higher overall capital requirements” (ECB, 2022b). In contrast, following the 2023 SREP cycle, the ECB reported a slight shift, where “in terms of quantitative measures, climate and environmental risks are seen as a factor in determining P2R levels for a larger number of institutions than in the SREP 2022” (ECB, 2023a). This suggests that climate risks are increasingly becoming a factor that can affect Pillar 2 capital requirements.

Several respondents noted that they expect climate risks to play an increasingly important role in future SREP assessments. For example, one respondent (O1) noted that market standards are likely to develop as institutions implement the supervisory expectations outlined in the ECB’s Guide on climate risks (ECB, 2020b). Once such market standards are established, these practices are likely to be more systematically reviewed and incorporated into the SREP process, potentially influencing institutions’ SREP scores:

*“The integration will gradually be included in the standard SREP process, eventually becoming a component influencing the overall SREP score. Currently, banks are developing a variety of approaches and solutions, which are being reviewed by the ECB. I expect that a standard will eventually be established for all institutions based on these findings.” (O1)*

Another tool available to supervisors, although less binding than the P2R but still capable of influencing risk management and climate risk integration, is the P2G. The P2G is an institution-specific recommendation that indicates the level of additional capital supervisors advise holding beyond mandatory capital requirements (ECB, 2024e). This guidance is typically based on institutions’ performance in supervisory stress tests (ECB, 2024e).

Currently, supervisory climate stress tests do not affect institutions’ P2G levels. For example, the results of the ECB’s 2022 climate stress test were not used to determine capital guidance under Pillar 2. This decision reflects a broader consensus among supervisors that climate stress testing methodologies are still in development, making their integration into the P2G framework premature (Calipel and Fidel, 2023). However, as climate-related stress testing practices become more advanced, it is likely that such tests will be incorporated into the P2G framework in the future.

A key advantage of the P2G is its forward-looking approach, as it is grounded in stress testing exercises that align with the long-term nature of climate risks. In addition, as a non-binding, institution-specific recommendation, it provides a flexible and tailored approach that incentivizes institutions to integrate climate risks into their risk management practices. Several respondents (A1, C2) described the P2G as a potentially useful tool for integrating climate risks and establishing market standards, particularly in the context of stress testing.

*“I think a good approach going forward would be to use the Pillar 2 guidance. As a bank, you can look at climate risks with different stress scenarios, with different counterparties that you highlight and analyze. You have a freer and more*

*qualitative view of things (...).*” (C2)

## VII.5 Discussion and conclusion

This study examines the integration of climate risks into both Pillar 1 and Pillar 2 frameworks, focusing on the main approaches and tools that institutions and supervisors are using to address these risks more effectively. We shed light on these approaches by adding the perspective of risk experts, highlighting which methodologies are currently considered practical and implementable, and identifying the key challenges institutions face in conducting this integration. We also situate these approaches within the broader regulatory landscape, highlighting the unique characteristics of the approaches required to manage climate risks compared to other risk types and drivers. Our findings aim to inform both academics and practitioners involved in developing methodologies for incorporating climate risks into risk management policies and regulatory frameworks.

Several limitations of this study suggest directions for future research. First, the majority of participants and institutions in our sample are based in Germany, potentially limiting the broader generalizability of some findings. Nevertheless, the ECB’s guide on climate risks applies uniformly to all supervised institutions (ECB, 2020b), which helps mitigate such concerns. Future research could include a wider range of institutions to develop an even more comprehensive understanding of climate risk integration in banking practices.

Second, specific aspects of capital requirements fall outside the scope of this study. In the context of Pillar 1, our focus is primarily on credit risk, especially on PD considerations, which are critical for understanding risk management under Pillar 2. Other risk types, such as market and operational risks, which are considered less relevant for climate risks, are not extensively covered. Similarly, this study does not provide a detailed examination of the integration of climate risks into collateral valuation under Pillar 1, an area that has already been extensively commented on by the EBA (see EBA 2023). In addition, this study does not examine the integration of climate risks into macroprudential capital buffers, such as the Systemic Risk Buffer (SyRB), which

is designed to address systemic risks but is not specifically calibrated for climate risks (Bartsch et al., 2024). Future research could expand on our conceptual framework by exploring additional potential avenues for climate risk integration and assessing their implications for the capital requirements of supervised institutions.

Lastly, we also do not address in detail expected credit loss models under IFRS 9. This is an aspect that is likely to become increasingly relevant in the context of climate risks and merits additional research. It is worth noting that institutions appear to increasingly combine the integration of climate risks into credit loss provisions with the allocation of capital buffers for climate risks. As credit loss provisions reduce available capital, while capital buffers require to hold additional reserves, analyzing the net impact on capital in this context would provide valuable insights.

Despite these limitations, our findings have broader implications for risk managers, supervisors and policymakers. First, our study indicates that financial institutions are making significant strides in integrating climate risks into risk management practices, including the ICAAP. Nonetheless, our findings also reveal considerable disparity among institutions and persistent uncertainty regarding specific methodologies, particularly with regard to climate risk stress testing. In addition and related to this issue, our study highlights that supervisory practices and expectations strongly shape this integration. For example, the climate risk scenarios selected by institutions for the ICAAP and exploratory stress tests are heavily influenced by those used by the ECB in its 2022 supervisory climate stress test. Supervisors and policymakers therefore have a critical role to play in establishing market standards and best practices.

While a degree of ambiguity may be beneficial in the early stages, providing institutions with the necessary flexibility to develop and test different methodologies, it may also hinder a more robust and consistent integration of climate risks into risk assessments and governance structures at a later stage. We therefore recommend that supervisors and regulators publish comprehensive best practice guidance once the 2024 deadlines for implementing the ECB's expectations have been met. Our study aims to support this effort by analyzing the current state of climate risk integration and progress in related methodologies.

# Appendix A

## Appendix to Chapter II: KPI classification

Table A.0: KPI classification.

| Category                                       | Example                                                                                                                                                                                |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Environmental</b>                           |                                                                                                                                                                                        |
| Biodiversity                                   | Conserve, promote and protect biodiversity and ecosystems.                                                                                                                             |
| Energy consumption and energy efficiency       | Reduce energy consumption, improve energy efficiency.                                                                                                                                  |
| Renewable energy                               | Increase the share of renewable energy produced or installed, increase the share of renewable energy used or sold, increase the share of electric vehicles in the total vehicle fleet. |
| Circular economy                               | Increase recycling rates, increase recovered materials from production waste, reduce waste of resources using recycled and/or reusable raw materials, reuse and repair equipment.      |
| Sustainable resources and responsible sourcing | Increase the use of sustainable raw materials in production, sourcing and use of products from responsible sources, sustainable and transparent supply chains.                         |
| Environmentally sustainable investments        | Increase the share of sustainable investments to total investments that contribute to environmental sustainability.                                                                    |

Table A.0 – continued from previous page

|                                            |                                                                                                                                                                                                                                              |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reduction and elimination of waste         | Reduce & avoid waste, reduce waste & avoid landfilling of waste, improve waste separation & collection.                                                                                                                                      |
| Greenhouse gas emissions                   | Reduce scope 1, 2 and/or 3 greenhouse gas emissions, achieve carbon neutrality in own operations, and use emission-free machinery and vehicle fleets.                                                                                        |
| Water consumption                          | Make water use more sustainable, improve water conservation, reduce water consumption in operations and production.                                                                                                                          |
| <b>Social</b>                              |                                                                                                                                                                                                                                              |
| Employee health and safety                 | Reduce the incidence of occupational accidents, injuries and diseases, implement health and safety measures, promote employee well-being and satisfaction at work, ensure human and labor rights.                                            |
| Employee diversity and gender equality     | Increase the number of women in leadership positions, promote gender equality in all areas of the company, encourage diversity in leadership positions.                                                                                      |
| Sustainable products and customer benefits | Provide sustainable, safe and reliable products and solutions to customers, expand the range of sustainable products, increase sales of sustainable products and revenue from products that improve sustainability and safety for customers. |
| Employee training                          | Increase the number of employee training hours, encourage participation in sustainability-related training, increase employee skill development.                                                                                             |
| Diverse and sustainable supply chain       | Establish a diverse and sustainable supply chain by selecting suppliers that adhere to ethical and sustainable practices and reflect the diversity of the communities they serve.                                                            |

Table A.0 – continued from previous page

|                                                |                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Social responsibility and community engagement | Improve the relationship and dialogue between companies and the communities in which they operate, provide (financial) support to non-profit organizations, foundations, and local initiatives, support disadvantaged groups, reduce social inequalities, implement social responsibility and community engagement programs. |
| <b>Governance</b>                              |                                                                                                                                                                                                                                                                                                                              |
| Business ethics                                | Ensure compliance with the company's business ethics, code of conduct and code of ethics of the company, engage with stakeholders, prevent business ethics violations, including corruption, bribery, fraud or insider trading, provide training to board members, improve ESG-related processes and due diligence.          |
| <b>ESG</b>                                     |                                                                                                                                                                                                                                                                                                                              |
| ESG rating                                     | Improve ESG rating performance.                                                                                                                                                                                                                                                                                              |
| Other ESG assessment and certification         | Improve ESG rating or achieve equivalent ESG assessments or ESG certifications.                                                                                                                                                                                                                                              |

# Appendix B

## Appendix to Chapter II: Examples of KPIs

Below are examples of KPIs that received a value of 1 for each score dimension. The name of the borrower is indicated in parentheses.

### Dimension #1: Strategic relevance

- **KPI:** “The margin of the new credit facility is in fact linked to two strategic targets in the field of energy transitioning and the circular economy which A2A has defined in its 2021-2030 Business Plan and which are included in the recently published Sustainable Finance Framework. The first goal is related to the growth of installed capacity from renewable sources while the second is represented by the increase of recovered materials from treated waste.” (A2A SpA)
- **KPI:** “The indicators are linked to Corbion’s key sustainability initiatives from its Creating Sustainable Growth strategy: Responsible sourcing, Responsible operations and Sustainable ingredient solutions.” (Corbion NV)



## Dimension #2: Materiality

- **KPI:** “The pricing mechanism of the RCF is linked to Stora Enso’s science-based climate targets. Stora Enso commits to reducing absolute scope 1 and 2 greenhouse gas (GHG) emissions from its own operations, as well as scope 3 GHG emissions from its value chain, by 50% by 2030 from the 2019 base-year.” (Stora Enso Oyj). The company belongs to the Basic Materials sector. Comparing this KPI with the SASB standards for this company (see pulp and paper products), we find that reduction of gross global scope 1 emissions is a material issue.
- **KPI:** “Pricing for the facility is based upon the company’s performance against annual intensity reduction targets for its sulfur dioxide (SO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>) emissions.” (Cabot Corp). Comparing this KPI with the SASB standards for this company (see chemicals), we find that the reduction of emissions from air pollutants, including sulfur oxides and nitrogen oxides, is a material issue.

## Dimension #3: Measurability

- **KPI:** “Endesa has committed to increasing the percentage of renewable sources in its total installed power generation capacity in the Iberian Peninsula from 45% at the start of the year to 50% by end December 2021.” (Endesa SA)
- **KPI:** “The Sustainability-Linked financing is linked to the achievement of Enel’s sustainability target to reduce direct greenhouse gas emissions (Scope 1), measured in grams of CO<sub>2</sub>eq per kWh, to equal or less than 148 gCO<sub>2</sub>eq/kWh by 31 December 2023, thereby contributing to the United Nations Sustainable Development Goal (SDG) 13 (Climate Action).” (Enel SpA)

## Dimension #4: Benchmarking

- **KPI:** “The credit margin under the facility will be adjusted based on Maersk’s progress to meet its target of reducing CO<sub>2</sub> emissions per cargo moved by 60%

by 2030, which is significantly more ambitious than the IMO target of 40% by 2030 (all 2008 baseline).” (AP Moller-Maersk A/S)

- **KPI:** “The first target is Ørsted’s science-based target of reducing the carbon emissions from its energy generation and operations (scopes 1-2) to 10 g CO<sub>2</sub>e/kWh by 2025, which is the main lever for achieving carbon neutrality in 2025, and which is aligned with a 1.5 °C climate scenario. The second target is Ørsted’s taxonomy-aligned green investments linked to its announced approx. DKK 350 billion investment programme for 2020-2027, which constitute a significant step in achieving Ørsted’s strategic ambition of reaching approx. 50 GW of installed renewable capacity by 2030.” (Ørsted A/S)

## Dimension #5: Pricing mechanism

- **KPI:** “Under this loan, the margin amount that we are required to pay can be either increased or decreased, by up to 10 basis points per year, to the extent that we are able to meet certain sustainability metrics for any fiscal year beginning with the fiscal year ended December 31, 2021.” (Diana Shipping Inc)
- **KPI:** “Supplier SBT Percentage Applicable Spread Adjustment Amount means, with respect to any period between Sustainability Pricing Adjustment Dates, (a) positive 0.04%, if the Supplier SBT Percentage for such period as set forth in the KPI Metric Report is less than the Supplier SBT Percentage Target for such period, and (b) negative 0.04%, if the Supplier SBT Percentage for such period as set forth in the KPI Metric Report is greater than or equal to the Supplier SBT Percentage Target for such period.” (Moody’s Corp)

## Dimension #6: External review

- **KPI:** “Kinnevik will seek independent and external verification of our actual KPI performance relative to the SPT(s), on an annual basis and in relation to the

Target Observation Date(s). The verification will be conducted by a reviewer with relevant expertise with limited assurance by the reviewer. The verification will be made public on our website by the dates outlined in the transaction specific documentation.” (Kinnevik AB)

- **KPI:** “Such determination and reporting in the ESG Annual Report shall be verified by an independent third party in accordance with the Greenhouse Gas Protocol Corporate Reporting and Accounting Standard (the “ESG Third Party Verification”) and such final, verified reporting will be attached to and reported on the ESG Compliance Certificate as the Sustainability Metric for such Reference Year.” (Ingredion Inc)

## Appendix C

# Appendix to Chapter II: Example of pricing mechanism

To illustrate how SLLs align financial incentives with sustainability goals, we present the following example of an SLL issued to Avangrid in 2018 by a syndicate of lenders.

The baseline applicable margin of the loan is determined based on Avangrid’s credit rating. As described in the loan agreement, this applicable margin may also vary depending on the borrower’s performance against a sustainability target:

“**Applicable Margin**” shall mean for each type of loan, the rate per annum set forth under the relevant column heading below which corresponds with the most current rating of such Borrower’s senior unsecured long-term debt issued by Moody’s and S&P, respectively. Such Applicable Margin may be increased or decreased pursuant to the Applicable Sustainability Adjustment.

| <b>Ratings</b> | <b>Applicable Margin for<br/>Eurodollar Loans</b> | <b>Applicable Margin for<br/>ABR Loans</b> |
|----------------|---------------------------------------------------|--------------------------------------------|
| >A1/A+         | 0.800%                                            | 0.000%                                     |
| A2/A           | 0.900%                                            | 0.000%                                     |
| A3/A-          | 1.000%                                            | 0.000%                                     |
| Baa1/BBB+      | 1.075%                                            | 0.075%                                     |
| Baa2/BBB       | 1.275%                                            | 0.275%                                     |
| Baa3/BBB-      | 1.475%                                            | 0.475%                                     |
| <Baa3/BBB-     | 1.650%                                            | 0.650%                                     |

The margin adjustment resulting from the firm’s sustainability performance is defined as follows in the loan agreement:

“**Applicable Sustainability Adjustment**” means, for any fiscal year (beginning with fiscal year 2018): (a) if the annual Sustainability Amount is greater than or equal to 110% of the Baseline Sustainability Amount, a 0.05% increase in the specified Applicable Margins; and (b) if the annual Sustainability Amount is less than or equal to 90% of the Baseline Sustainability Amount, a 0.05% decrease in the specified Applicable Margins.

The above definition of Applicable Sustainability Adjustment specifies that such adjustment depends on a Sustainability Amount and a Baseline Sustainability Amount, defined as follows:

“**Baseline Sustainability Amount**” means 58.4g CO<sub>2</sub>/kWh, as contained in the opinion of Vigeo Eiris delivered to the Borrowers and furnished to the lenders.

“**Sustainability Amount**” means the greenhouse gas emissions intensity resulting from the Borrowers’ and their Subsidiaries’ operations, calculated in the manner set forth by Global Reporting Initiative 305-4 (previous G4-EN18) based on direct emissions from production facilities divided by the net production, including steam, and expressed as

a ratio of grams of carbon dioxide to kilowatt hour (g CO<sub>2</sub>/kWh).

In summary, this loan agreement incorporates a dynamic pricing mechanism that rewards or penalizes Avangrid's sustainability performance relative to the Baseline Sustainability Amount of 58.4g CO<sub>2</sub>/kWh. The spread charged by the lenders may be adjusted up or down by 5 basis points.

# Appendix D

## Appendix to Chapter III: Description of variables & survey questions

Table D.0: Overview of survey questions.

| Variable                                         | Survey ID | Source                                            |
|--------------------------------------------------|-----------|---------------------------------------------------|
| Module: Demographics                             |           |                                                   |
| Age                                              | (N1)      | Anderson and Robinson (2021), Bauer et al. (2021) |
| Gender                                           | (N2)      |                                                   |
| Party                                            | (N3)      |                                                   |
| Years of education                               | (O1)      |                                                   |
| Income                                           | (O2)      |                                                   |
| Module: Sustainability preferences               |           |                                                   |
| Wahl-o-Mat questions                             | (Q1)      | Wahl-o-Mat                                        |
| Module: Environmental literacy                   |           |                                                   |
| Question on sustainable development              | (R1)      | Filippini et al. (2024b)                          |
| Question on heating                              | (R2)      | Anderson and Robinson (2021)                      |
| Question on CO2 footprint                        | (R3)      | Geiger and Holzhauer (2020)                       |
| Question on temperature                          | (R4)      | Own question                                      |
| Question on forestry                             | (R5)      | Zwickle and Jones (2018)                          |
| Module: Risk, time, social preferences and trust |           |                                                   |
| Risk preferences                                 | (P1)      | Falk et al. (2023)                                |
| Time preferences                                 | (P2)      | Falk et al. (2023)                                |
| Trust                                            | (P3)      | Falk et al. (2023)                                |
| Social preferences                               | (P4)      | Falk et al. (2023)                                |
| Social preferences, costly                       | (P5)      | Falk et al. (2023)                                |
| UG minimal demand                                | (P6)      | Falk et al. (2023)                                |

Continued on next page...

| Variable                                              | Survey ID              | Source                                             |
|-------------------------------------------------------|------------------------|----------------------------------------------------|
| <b>Module: Financial experience</b>                   |                        |                                                    |
| Financial decision maker                              | (S1)                   | Gutsche and Zwergel (2020)                         |
| Checks portfolio                                      | (S2)                   | Modified version from Anderson and Robinson (2021) |
| Talks often about investments                         | (S3)                   | Riedl and Smeets (2017a)                           |
| Current investments                                   | (T1)                   | Gutsche and Zwergel (2020)                         |
| Past investments                                      | (T2)                   | Gutsche and Zwergel (2020)                         |
| <b>Module: Financial expectations of ESG products</b> |                        |                                                    |
| Return expectations                                   | (U1)                   | Riedl and Smeets (2017a), Bauer et al. (2021)      |
| Risk perception                                       | (U2)                   | Riedl and Smeets (2017a), Bauer et al. (2021)      |
| Dimension importance                                  | (U4)                   | Own question                                       |
| Financial scepticism                                  | (U5)                   | Own question                                       |
| <b>Module: Financial literacy</b>                     |                        |                                                    |
| Interest rates                                        | (V1)                   | Lusardi and Mitchell (2014)                        |
| Inflation                                             | (V2)                   | Lusardi and Mitchell (2014)                        |
| Diversification                                       | (V3)                   | Lusardi and Mitchell (2014)                        |
| <b>Module: Sustainable finance literacy – Global</b>  |                        |                                                    |
| Question ESG                                          | (W1)                   | Filippini et al. (2024b)                           |
| Question sustainable financial product                | (W2)                   | Filippini et al. (2024b)                           |
| Question ESG components                               | (W3)                   | Filippini et al. (2024b)                           |
| Question exclusion-based investing                    | (W4)                   | Own question                                       |
| Question best-in-class approach                       | (W5)                   | Own question                                       |
| <b>Module: Sustainable finance literacy – Local</b>   |                        |                                                    |
| Question SFDR Article 6                               | (X1)                   | Own question                                       |
| Question SFDR Article 8                               | (X2)                   | Own question                                       |
| Question SFDR Article 8 social                        | (X3)                   | Own question                                       |
| Question Question Article 9                           | (X4)                   | Own question                                       |
| <b>Module: Perceived impact</b>                       |                        |                                                    |
| Positive contribution                                 | (F2), (H2), (J2), (L2) | Heeb et al. (2022)                                 |

*Remark:* This table contains a brief overview of all key questions grouped into thematic modules. The letters and numbers in parentheses correspond to their respective survey IDs. Sources are provided for relevant variables.



## Description of variables

In the following, we provide a description of all key variables used in our analyses, as well as the original questionnaire format. Note that the questionnaire was originally conducted in German.

### Main Independent Variables

- *Brochure Treatment*. This dummy variable equals 1 if the participant was given the brochure to read and 0 otherwise.
- *ESG Pref Score*. The average over the seven Wahl-o-Mat questions (Q1). Item 3 is reversed. The questions do not have any numbers associated with the answers. For a convenient interpretation of the lowest category, we use a scale from 0 (“strongly disagree”) to 4 (“strongly agree”).

### Main Dependent Variables - Decision Level

- *Chose ESG*. Dummy variable based on the fund decisions of questions (E2), (G2), (I2), (K2). Equals 1 if the participant chooses an article 8 or 9 fund.
- *Used Criterion*. Dummy variable based on the investment criteria of questions (F1), (H1), (J1), (L1). Equals 1 if the participant indicates that sustainability information played a role in the investment decision.

### Demographics

- *Age*. The natural log of the participants’ self-stated age (N1).
- *Gender*. Answers to the gender question (N2) are split into dummy variables, with “male” as the reference category.
  - *Gender Female*. This dummy variable equals 1 if the participant chooses Female from among the options Female, Male, Non-Binary and Prefer not to say, and 0 if not.

- *Gender Non Binary*. This dummy variable equals 1 if the participant chooses Non Binary from among the options Female, Male, Non-Binary and Prefer not to say, and 0 if not.
- *Party Preference*. Answers to the party preference question (N3) are split into dummy variables, with CDU/CSU as the reference category.
  - *Party SPD*. This dummy variable equals 1 if the participant chooses SPD.
  - *Party Greens*. This dummy variable equals 1 if the participant chooses Bündnis 90 / Die Grünen
  - *Party FDP*. This dummy variable equals 1 if the participant chooses FDP
  - *Party The Left*. This dummy variable equals 1 if the participant chooses Die Linke
  - *Party AfD*. This dummy variable equals 1 if the participant chooses AfD
  - *Party Other*. This dummy variable equals 1 if the participant chooses “Other party”
  - *Party None*. This dummy variable equals 1 if the participant chooses “Would not vote”
  - *Party not eligible*. This dummy variable equals 1 if the participant chooses “I am not eligible”
- *Years of education*. Self-reported highest degree (O1), which we translate into the implied years of education the participant has completed: No degree (yet) = 8 years, elementary school = 9 years, secondary school or Realschule or completed apprenticeship = 11 years, advanced technical college entrance qualification = 12 years, Abitur or “erweiterte Oberschule” with completion of 12th grade (university entrance qualification) = 13 years, bachelor’s degree = 16 years, master’s degree or equivalent = 18 years, doctorate or postdoctoral qualification = 23 years.
- *Income*. Self-reported net monthly household income class (O2). The options start with “less than EUR 500” and “500 to less than EUR 1000”, then move in steps of EUR 1000 until EUR 7000, and the final class is “EUR 7000 or more”.

**Risk Preferences, Time Preferences, Trust and Altruism**

- *Risk Preference.* Answer to the question “How do you see yourself: Are you a person who is generally willing to take risks, or do you try to avoid taking risks” (P1), on a 10-point scale (0 = “Completely unwilling to take risks”; 10 = “Very willing to take risks”) according to the experimentally validated survey module of Falk et al. (2023).
- *Time Preference.* Answer to the question “In comparison to others, are you a person who is generally willing to give up something today in order to benefit from that in the future or are you not willing to do so?” (P2) on a 10-point scale (0 = “Completely unwilling”; 10 = “Very willing to do so”), following Falk et al. (2023).
- *Trust.* Answer to the question “How well does the following statement describe you as a person? As long as I am not convinced otherwise, I assume that people have only the best intentions.” (P3) on a 10-point scale (0 = “Does not describe me at me”; 10 = “Describes me very well”), following Falk et al. (2023).
- *Social Preferences.* Answer to the question “How do you assess your willingness to share with others without expecting anything in return when it comes to charity?” (P4) on a 10-point scale (0 = “Completely unwilling to share”; 10 = “Very willing to share”), following Falk et al. (2023).
- *Social Preferences, costly.* Answer to the question “How do you see yourself: Are you a person who is generally willing to punish unfair behavior even if this is costly?” (P5) on a 10-point scale (0 = “not willing at all”; 10 = “Very willing to punish unfair behavior”), following Falk et al. (2023).
- *UG minimal demand.* The natural log of the minimum demand as player 2 in a hypothetical Ultimatum Game with EUR 100 to share (P6), following Falk et al. (2023).

## **Financial Experience and Signaling**

- *Financial Decision Maker*. Dummy variables based on the answers to the item “Please indicate which of the following statements applies to you personally when it comes to financial matters, e.g. investments.” (S1)
  - *Decides finances with partner*. Dummy variable, equals 1 if a participant gave that answer.
  - *Does not decide about own finances*. Dummy variable, equals 1 if a participant gave that answer.
- *Checks Portfolio*. Answers to the “Checks Portfolio” question (S2) are split into dummy variables, with “weekly” as the reference category, following Anderson and Robinson (2021).
  - *Checks Portfolio 12 times/year*. This dummy variable equals 1 if the participant responds “monthly”.
  - *Checks Portfolio 2-11 times/year*. This dummy variable equals 1 if the participant responds “several times per year but less frequently than monthly”.
  - *Checks Portfolio 1 time/year*. This dummy variable equals 1 if the participant responds “once a year”.
  - *Checks Portfolio <1 time/year*. This dummy variable equals 1 if the participant responds “more rarely”.
  - *Checks Portfolio never*. This dummy variable equals 1 if the participant responds “never”.
  - *Checks Portfolio only when opening/changing*. This dummy variable equals 1 if the participant responds “only when I create a account or change it”.
  - *Has no Portfolio*. This dummy variable equals 1 if the participant responds “I don’t have an investment account”.

For the correlation analyses, we recode this variable into an ordinal variable,

where we join “Has no Portfolio” with “never” and “Checks Portfolio only when opening/changing” with “Checks Portfolio <1 time/year”.

- *Talks often about inv..* Likert scale response to the statement “I often talk about investment with others” (1 fully disagree, . . . , 5 strongly agree) (S3), slightly modifying Riedl and Smeets (2017a).
- *Financial experience..* Counts the numbers of current and past types of investments a participant has or had invested in (T1 and T2), following Gutsche and Zwergel (2020).

### **Literacy**

- *Financial literacy.* The sum of correct answers to the “Big Three” questions (V1-V3), following Lusardi and Mitchell (2014).
- *Environmental literacy.* The sum of correct answers to the five questions from the module “Environmental Literacy” (R1-R5) in Table D. The questions follow Filippini et al. (2024b); Anderson and Robinson (2021); Geiger and Holzhauer (2020); Zwickle and Jones (2018).
- *Sustainable finance literacy.* This variable is the sum of correct answers to the five questions from the modules “Sustainable finance literacy - Global” (W1-W5) and “Sustainable finance literacy - Local” (X1-X4) in Table D. Three of these questions follow Filippini et al. (2024b).

### **Financial Expectations and Perceived Importance**

- *ESG return expectations / ESG risk expectations.* Answers to the questions about return expectations and risk expectations of ESG funds (U1 and U2) are split into dummy variables with “much lower” as the reference category in both cases, following Riedl and Smeets (2017a)
  - *ESG return expectations / ESG risk expectations somewhat lower.* This dummy variable equals 1 if the participant answers “somewhat lower”.

- *ESG return expectations / ESG risk expectations similar*. This dummy variable equals 1 if the participant answers “similar”.
- *ESG return expectations / ESG risk expectations somewhat higher*. This dummy variable equals 1 if the participant answers “somewhat higher”.
- *ESG return expectations / ESG risk expectations much higher*. This dummy variable equals 1 if the participant answers “much higher”.
- *ESG return expectations / ESG risk expectations does not know*. This dummy variable equals 1 if the participant answers “I do not know”.

For the correlation analyses, we recode these variables into ordinal variables, where we code “much lower” as 1, “somewhat lower” as 2, “similar” as 3, “somewhat higher” as 4, and “much higher” as 5.

- *Perceived Importance*. Likert scale response to the statement “How important are the following dimensions to you when investing?” (U4), on a scale from 1 (not important) to 5 (very important).
  - *Importance Returns*.
  - *Importance Risk*.
  - *Importance E*.
  - *Importance S*.
  - *Importance G*.
- *Financial Scepticism*. The average over the 3 questions from module U5, on a scale of 1 to 5, where 1 is “strongly disagree” and 5 is “strongly agree”. Item 2 is reversed.
- *Perceived Impact*. The average of the 4 0-5 Likert scale questions about the perceived impact of the respective investment from modules F2, H2, J2 and L2.

### **Experimenter Demand Effect**

- *Low EDE*. Based on statement (D2). A random subsample of the brochure group gets to read the following statement: “We expect that participants in the experiment who read these instructions will be less likely to invest in sustainable funds than they normally would.”, but does not see statement (D3).
- *High EDE*. Based on statement (D3). A random subsample of the brochure group gets to read the following statement: “We expect that participants in the experiment who read these instructions will be more likely to invest in sustainable funds than they normally would.”, but does not see statement (D2).

Note that for the reference group for this variable, we only show (D1).

### **Technical**

- *Interview time*. The variable represents the natural log of the time spent responding to the survey, excluding the time spent reading the brochure.
- *Use data*. The variable represents the self-stated assessment to the statement “I have given and made my answers and decisions carefully, and to the best of my knowledge, and therefore think that my data should be used for the study” (Y1).

Note that for the two complex linear models in section III.4.2 we had to z-standardize several variables since the downdated VtV matrix of the regression in the first stage of the analysis was not positive definite. This affects the variables Environmental Literacy, Education, Financial Literacy, Perceived impact, Use Data, Risk Preferences, Time Preferences, Social Preferences, Social Preferences, costly, and Financial Experience.



**Welcome to this study on investment decisions conducted by the Justus Liebig University in Giessen. As part of our study, we will ask you to answer some questions and make some financial decisions. It should take you about 30 minutes to complete the survey.**

**You will be paid an allowance of 4.50 pounds (approx. 5.20 euro) for your time. In addition, you will have the opportunity to earn a bonus of approximately 200 euro. We will select 20 people out of all the participants in the study. These 20 people will be paid the bonus on December 1, 2023 (i.e. in about half a year). We will explain the specific details of the bonus payment once you have reached the point in the survey on which the bonus payment is based.**

**The survey contains some attention questions. These will always be recognizable as such if you read the questions carefully, and there will always be clear instructions on how to answer these attention questions. If you answer any of these questions differently from the instructions, we will unfortunately have to decline your participation. In this case, we will give you the opportunity to withdraw your submission yourself (via the Return Submission feature on Prolific) before we reject the submission ourselves after a few days. In either case, you will not receive the allowance and will not be eligible for the bonus payment. We are aware that attention questions are not very popular, but they are necessary to ensure the data quality required for scientific purposes. We thank you for your understanding**

**We ask that you answer all questions truthfully, accurately, and completely. By doing so, you will be making an important contribution to our research. Thank you very much for your assistance.**

**Technical note for Firefox users: If you are taking the survey on your smartphone or tablet using the Firefox browser, in rare cases the survey may not start because you cannot leave this homepage. In this case, please use a different browser.**

**Technical note for Safari users: You may need to press the "Next" button two or even four times to actually get to the next page.**





**A1.** By answering the following questions, you are participating in a study conducted by the Chair of Banking & Finance at Justus Liebig University in Giessen. If you have any questions, please contact Florian Gärtner, at the e-mail address [florian.gaertner@wirtschaft.uni-giessen.de](mailto:florian.gaertner@wirtschaft.uni-giessen.de).

Your participation is voluntary and you can cancel at any time. In addition, you can of course simply not answer individual questions that you do not wish to answer, or select the "No answer" selection option for mandatory questions. Completely dropping out of the study will result in you not receiving any compensation. If, on the other hand, you only fail to answer individual questions, you will still receive full compensation. However, we would like to remind you about the attention questions: of these, you must answer at least one correctly, otherwise we will ask you to withdraw the submission and will not compensate you either.

We only receive the pseudonymized data that Prolific provides us with, as well as the data that you voluntarily provide in the questionnaire. All collected data will only be used for scientific and science communication purposes (i.e. presenting the results to the interested public).

I agree to the use of my data

☐

I do not want my data to be used. I am aware that the study will then stop and I will not receive any compensation.

☐

**B1.**

**C1.** We would like to ask you to carefully read the following brochure. This should take you about 2 minutes. Therefore, we have hidden the "Next" button in this survey for 90 seconds. At the end of this time, it will reappear in the bottom right-hand corner and you will be able to continue with the survey. In the course of the survey, we will ask you a few questions about the content of the brochure.

If you are having trouble viewing the brochure, you can open or download it in your browser using this link (the link will open a new browser tab).

**D1.** **Investment Decisions**

In the following, you are given three different funds to choose from. You are asked to invest 200 euro in one of these funds. We repeat this situation four times with different funds. After each investment, we will ask you some questions about your investment decision.

The funds are real existing funds of different investment companies. For each fund, you will find a brief overview of the most important information. If you need more information, you can also download the prospectus for each fund.

**D2.** We expect that participants in the experiment who read these instructions will be less likely to invest in sustainable funds than they normally would.



- D3.** We expect that participants in the experiment who read these instructions will be more likely to invest in sustainable funds than they normally would.

**D4.** Bonus payment

Based on your investment decisions, you will participate in a bonus payment structured like a lottery: We use a random number generator to select 20 people from all the participants in the study. For each of these people, we use a random number generator to select exactly one of their four investment decisions, which we then actually implement, i.e. invest accordingly.

After half a year, these 20 people will receive a bonus equal to the value of their investment at that time. To calculate the bonus, we use a simplified net return. This is the raw return achieved by the fund minus the ongoing fund costs for half a year. Other cost factors, such as any performance fees, sales charges, etc., are ignored. For example, if a selected fund has earned 10.5% by December 1, 2023, and has ongoing expenses of 0.5%, the fund will have earned a net return of exactly 10%, and we will therefore pay out 220 euros as a bonus. If, on the other hand, there is a loss of 9.3% and running costs of 0.7%, the net return will be -10%, so we will pay out 180 euros as a bonus.

The maximum payout is 300 euros, even if your investment is worth more on December 1. To compensate, we will also limit your risk of loss by introducing a floor. We will pay out at least 100 euros even if your investment is worth less on the cut-off date. These payouts will be made at the beginning of December as a Prolific bonus.

You will receive your allowance of 4.50 pounds (about 5.20 euro) in any case.

- E1.** You are given 200 Euro to invest in one of the following three funds. These funds are real, actually existing funds. Which of the three funds do you choose?

(If you want more detailed information about the funds, you can download the corresponding fund profiles as .pdf files; the links to these files are below the three images. If you are answering this survey on a cell phone or tablet, you may want to scroll out far enough to see all three funds side by side).

- E2.** Which of the three funds do you choose?

Fund 1: UniNachhaltig Aktien Europa A

Fund 2: UniValueFonds: Europe A

Fund 3: UniDividendenAss -net- A

☐  
☐  
☐

- F1.** What criteria did you use to choose this equity fund? Multiple answers are possible.

Fund name

Risk and return profile (e.g. Morningstar Rating)

Past performance

☐  
☐  
☐



|                                                                                                                                               |                                   |                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|--------------------------|
|                                                                                                                                               | Fund size                         | <input type="checkbox"/> |
|                                                                                                                                               | Most important positions/holdings | <input type="checkbox"/> |
|                                                                                                                                               | Country exposure                  | <input type="checkbox"/> |
|                                                                                                                                               | Industry exposure                 | <input type="checkbox"/> |
| Sustainability information (e.g. text description, SFDR article, carbon footprint, sustainability indicators, ESG fund ratings such as MSCI). |                                   | <input type="checkbox"/> |
|                                                                                                                                               | Costs p.a.                        | <input type="checkbox"/> |
|                                                                                                                                               | Other criteria, namely            | <input type="checkbox"/> |

**F2. Would you say that this investment is more likely to make a positive contribution to societal concerns (e.g. addressing climate change or inclusion and diversity) or less likely to make a contribution at all?**

|                          |                          |                          |                          |                          |                          |                               |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------|
| No<br>contribution       |                          |                          |                          |                          |                          | Very positive<br>contribution |
| 0                        | 1                        | 2                        | 3                        | 4                        | 5                        |                               |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>      |

**G1. You are given 200 Euro to invest in one of the following three funds. These funds are real, actually existing funds. Which of the three funds do you choose?**

(If you want more detailed information about the funds, you can download the corresponding fund profiles as .pdf files; the links to these files are below the three images. If you are answering this survey on a cell phone or tablet, you may want to scroll out far enough to see all three funds side by side).

**G2. Which of the three funds do you choose?**

Fund 1: Deka EURO iSTOXX ex Fin Dividend+ UCITS ETF

Fund 2: Deka EURO STOXX 50® UCITS ETF

Fund 3: Deka EURO STOXX 50® ESG Filtered UCITS ETF

☐  
☐  
☐

**H1. What criteria did you use to choose this equity fund? Multiple answers are possible.**

|                                                                                                                                               |                                                   |                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------------------|
|                                                                                                                                               | Fund name                                         | <input type="checkbox"/> |
|                                                                                                                                               | Risk and return profile (e.g. Morningstar Rating) | <input type="checkbox"/> |
|                                                                                                                                               | Past performance                                  | <input type="checkbox"/> |
|                                                                                                                                               | Fund size                                         | <input type="checkbox"/> |
|                                                                                                                                               | Most important positions/holdings                 | <input type="checkbox"/> |
|                                                                                                                                               | Country exposure                                  | <input type="checkbox"/> |
|                                                                                                                                               | Industry exposure                                 | <input type="checkbox"/> |
| Sustainability information (e.g. text description, SFDR article, carbon footprint, sustainability indicators, ESG fund ratings such as MSCI). |                                                   | <input type="checkbox"/> |
|                                                                                                                                               | Costs p.a.                                        | <input type="checkbox"/> |
|                                                                                                                                               | Other criteria, namely                            | <input type="checkbox"/> |

**H2. Would you say that this investment is more likely to make a positive contribution to societal concerns (e.g. addressing climate change or inclusion and diversity) or less likely to make a contribution at all?**

|                          |                          |                          |                          |                          |                          |                               |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------|
| No<br>contribution       |                          |                          |                          |                          |                          | Very positive<br>contribution |
| 0                        | 1                        | 2                        | 3                        | 4                        | 5                        |                               |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>      |



**I1. You are given 200 euro to invest in one of the following three funds.**

**These funds are real, actually existing funds. Which of the three funds do you choose?**

**(If you want more detailed information about the funds, you can download the corresponding fund profiles as .pdf files; the links to these files are below the three images. If you are answering this survey on a cell phone or tablet, you may want to scroll out far enough to see all three funds side by side).**

**I2. Which of the three funds do you choose?**

Fund 1: Xtrackers MSCI World UCITS ETF 1C

☐

Fund 2: Xtrackers MSCI World ESG UCITS ETF 1C

☐

Fund 3: Xtrackers MSCI World Quality UCITS ETF 1C

☐

**J1. What criteria did you use to choose this equity fund? Multiple answers are possible.**

Fund name

☐

Risk and return profile (e.g. Morningstar Rating)

☐

Past performance

☐

Fund size

☐

Most important positions/holdings

☐

Country exposure

☐

Industry exposure

☐

Sustainability information (e.g. text description, SFDR article, carbon footprint, sustainability indicators, ESG fund ratings such as MSCI).

☐

Costs p.a.

☐

Other criteria, namely

☐

**J2. Would you say that this investment is more likely to make a positive contribution to societal concerns (e.g. addressing climate change or inclusion and diversity) or less likely to make a contribution at all?**

|                          |                          |                          |                          |                          |                          |                            |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------------------------|
| No contribution          |                          |                          |                          |                          |                          | Very positive contribution |
| 0                        | 1                        | 2                        | 3                        | 4                        | 5                        |                            |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |

**K1. You are given 200 euros to invest in one of the following three funds.**

**These funds are real, actually existing funds. Which of the three funds do you choose?**

**(If you want more detailed information about the funds, you can download the corresponding fund profiles as .pdf files; the links to these files are below the three images. If you are answering this survey on a cell phone or tablet, you may want to scroll out far enough to see all three funds side by side).**

**K2. Which of the three funds do you choose?**

Fund 1: JPMorgan Funds - Global Natural Resources A (acc)

☐

Fund 2: Swisscanto (LU) Equity Fund Sustainable Global Water AT

☐

Fund 3: M&G (Lux) IF 1 - Global Listed Infrastructure - EUR A Acc

☐

**L1. What criteria did you use to choose this equity fund? Multiple answers are possible.**

Fund provider

☐



AUZEPY ET AL. (B)

|  |                                                                                                                                               |                      |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
|  | Fund name                                                                                                                                     | <input type="text"/> |
|  | Risk and return profile (e.g. Morningstar Rating)                                                                                             | <input type="text"/> |
|  | Past performance                                                                                                                              | <input type="text"/> |
|  | Fund size                                                                                                                                     | <input type="text"/> |
|  | Most important positions/holdings                                                                                                             | <input type="text"/> |
|  | Country exposure                                                                                                                              | <input type="text"/> |
|  | Industry exposure                                                                                                                             | <input type="text"/> |
|  | Sustainability information (e.g. text description, SFDR article, carbon footprint, sustainability indicators, ESG fund ratings such as MSCI). | <input type="text"/> |
|  | Costs p.a.                                                                                                                                    | <input type="text"/> |
|  | Other criteria, namely                                                                                                                        | <input type="text"/> |

**L2. Would you say that this investment is more likely to make a positive contribution to society's concerns (e.g. combating climate change or inclusion and diversity) or more likely not to make a contribution?**

|                      |                      |                      |                      |                      |                      |                               |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-------------------------------|
| No<br>contribution   |                      |                      |                      |                      |                      | Very positive<br>contribution |
| 0                    | 1                    | 2                    | 3                    | 4                    | 5                    |                               |
| <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/>          |

**M1. To what extent did the information in the brochure shown at the beginning ("General Knowledge: Sustainable Investment") help you to understand the information about the funds shown (e.g. Deka EURO STOXX 50® ESG Filtered)?**

|                        |                      |                      |                      |                      |                      |                      |
|------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| did not help<br>at all |                      |                      |                      |                      |                      | helped a lot         |
| 0                      | 1                    | 2                    | 3                    | 4                    | 5                    |                      |
| <input type="text"/>   | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |

**M2. To what extent did the information in the brochure shown to at the beginning ("General Knowledge: Sustainable Investing") help you in your investment decision regarding the funds shown (e.g. Deka EURO STOXX 50® ESG Filtered)?**

|                        |                      |                      |                      |                      |                      |                      |
|------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| did not help<br>at all |                      |                      |                      |                      |                      | helped a lot         |
| 0                      | 1                    | 2                    | 3                    | 4                    | 5                    |                      |
| <input type="text"/>   | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |

**N1. Please indicate the year you were born.**

|  |                   |                      |
|--|-------------------|----------------------|
|  | prefer not to say | <input type="text"/> |
|  | 2005              | <input type="text"/> |
|  | 2004              | <input type="text"/> |
|  |                   | <input type="text"/> |
|  | 1901              | <input type="text"/> |
|  | 1900              | <input type="text"/> |

(This question is a drop box question which includes each year from 1900 to 2005. To spare the reader several pages of only numbers, we have shortenend this list for presentation purposes)

**N2. What gender do you feel you belong to?**

|                   |                      |
|-------------------|----------------------|
| Male              | <input type="text"/> |
| Female            | <input type="text"/> |
| Non-binary        | <input type="text"/> |
| Prefer not to say | <input type="text"/> |



**N3. If a general election were to be held next Sunday, which party would you most likely vote for with your SECOND VOTE?**

CDU / CSU

☐

SPD

☐

AfD

☐

FDP

☐

Die Linke

☐

Bündnis 90 / Die Grünen

☐

Other party

☐

Would not vote

☐

I am not eligible to vote because I do not have German citizenship

☐

Prefer not to say

☐

**O1. What is your highest level of education?**

**(If you have a different degree, please select the degree that you believe is closest to yours. If you have more than one degree, please select the one you feel is the highest)**

Elementary school / secondary school diploma or polytechnic high school with completion of 8th or 9th grade.

☐

Secondary school diploma, Realschule or Polytechnische Oberschule with 10th grade diploma

☐

Advanced technical college entrance qualification (technical college graduate, etc.)

☐

Abitur or Erweiterte Oberschule with completion of 12th grade (university entrance qualification)

☐

Completed apprenticeship

☐

Bachelor's degree

☐

Master's degree, diploma, state examination or teacher's examination

☐

Doctorate (PhD) or postdoctoral qualification

☐

Other degree

☐

No degree (yet)

☐

Prefer not to say

☐

**O2.**

**What is the total net monthly income of your household (the household includes everyone you live with in the same home, excluding roommates)? This is the amount left over after deducting taxes and social security contributions.**

**If you do not know this amount, please estimate it!**

Less than 500€

☐

500€ to less than 1000€

☐

1000€ to less than 2000€

☐

2000€ to less than 3000€

☐

3000€ to less than 4000€

☐

4000€ to less than 5000€

☐

5000€ to less than 6000€

☐

6000€ to less than 7000€

☐

7000€ or more

☐

Prefer not to say

☐



**P1. How do you see yourself: are you a person who is generally willing to take risks, or do you try to avoid taking risks?**

|                                               |                          |                          |                          |                          |                          |                          |                          |                          |                          |                                        |
|-----------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------------------------------------|
| completely<br>unwilling<br>to take<br>risks 0 | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | very<br>willing<br>to take<br>risks 10 |
| <input type="checkbox"/>                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>               |

**P2. In comparison to others, are you a person who is generally willing to give up something today in order to benefit from that in the future or are you not willing to do so?**

|                                                               |                          |                          |                          |                          |                          |                          |                          |                          |                          |                                                        |
|---------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------------------------------------|
| completely<br>unwilling<br>to give up<br>something<br>today 0 | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | very<br>willing to<br>give up<br>something<br>today 10 |
| <input type="checkbox"/>                                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>                               |

**P3. How well does the following statement describe you as a person?**

**"As long as I am not convinced otherwise, I assume that people have only the best intentions."**

|                                        |                          |                          |                          |                          |                          |                          |                          |                          |                          |                                     |
|----------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|
| does not<br>describe<br>me at all<br>0 | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | describe<br>s me<br>perfectly<br>10 |
| <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            |

**P4. How do you assess your willingness to share with others without expecting anything in return when it comes to charity?**

|                                                                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                                                                              |
|--------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|------------------------------------------------------------------------------|
| not at all<br>willing to<br>share<br>without<br>something in<br>return 0 | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | very willing<br>to share<br>without<br>expecting<br>anything in<br>return 10 |
| <input type="checkbox"/>                                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>                                                     |

**P5. How do you see yourself: Are you a person who is generally willing to punish unfair behavior even if this is costly?**

|                                                                              |                          |                          |                          |                          |                          |                          |                          |                          |                          |                                                                         |
|------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------------------------------------------|
| not willing at<br>all to incur<br>costs to<br>punish<br>unfair<br>behavior 0 | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | very willing<br>to incur<br>costs to<br>punish<br>unfair<br>behavior 10 |
| <input type="checkbox"/>                                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>                                                |



P6.

Imagine the following situation: together with a person whom you do not know you won 100 Euro in a lottery. The rules stipulate the following: One of you has to make a proposal about how to divide the 100 Euro between you two. The other one gets to know the proposal and has to decide between two options. He or she can accept the proposal or reject it.

If he or she accepts the proposal, the money is divided according to the proposal. If he or she rejects the proposal, both receive nothing.

Suppose the other person makes a proposal. You, in turn, must decide whether to accept or reject. What is the minimum amount the other person would have to offer you to make you agree to split?

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

**Q1.** To what extent do you agree with the following statements?

|                                                                                                | strongly disagree        | somewhat disagree        | neither agree nor disagree | somewhat agree           | strongly agree           |
|------------------------------------------------------------------------------------------------|--------------------------|--------------------------|----------------------------|--------------------------|--------------------------|
| Germany should be carbon neutral by 2040 at the latest.                                        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| The planned phase-out of coal-fired power generation in 2038 should be accelerated.            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| The registration of new cars with combustion engines should also be possible in the long term. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| This question is an attention test. Please answer with somewhat disagree.                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| Organic farming should be subsidized to a greater extent than conventional farming.            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| Rail should be prioritized over road when expanding transportation infrastructure.             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| In Germany, all new buildings should be equipped with photovoltaic systems.                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |
| The statutory minimum wage should be increased to at least 13 euros by 2024 the latest.        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> |

**R1.** Which of the following definitions best describes sustainable development?

|                                                                   |                          |
|-------------------------------------------------------------------|--------------------------|
| Ensure universal access to education, health, and social services | <input type="checkbox"/> |
| Meeting today's needs while minimizing environmental impact       | <input type="checkbox"/> |
| Meeting today's needs without compromising future generations     | <input type="checkbox"/> |
| I don't know                                                      | <input type="checkbox"/> |

**R2.** Does the world spend more energy on heating homes or cooling them?

|                                |                          |
|--------------------------------|--------------------------|
| More energy for heating        | <input type="checkbox"/> |
| More energy for cooling        | <input type="checkbox"/> |
| About the same amount for both | <input type="checkbox"/> |
| I don't know                   | <input type="checkbox"/> |

**R3.** Which of the following definitions best describes the carbon footprint of a product?

|                                                                                     |                          |
|-------------------------------------------------------------------------------------|--------------------------|
| The typical coloration of the sky caused by a high concentration of CO <sub>2</sub> | <input type="checkbox"/> |
| The amount of all greenhouse gas emissions over the life cycle of a product         | <input type="checkbox"/> |
| The amount of CO <sub>2</sub> released by a product when it decomposes              | <input type="checkbox"/> |
| The chemical change caused by CO <sub>2</sub> in the atmosphere                     | <input type="checkbox"/> |
| I don't know                                                                        | <input type="checkbox"/> |





**R4. Which of the following phenomena is the main cause of the increase in the Earth's temperature in recent decades?**

- Reduction of the ozone layer (the so-called "ozone hole")
- Increased emission of greenhouse gases (the so-called "greenhouse effect")
- Change in ocean currents, such as "el Niño"
- Change in the tilt of the Earth's axis
- I don't know

☐  
☐  
☐  
☐  
☐

**R5. Which of the following is an example of sustainable forest management?**

- Designating forests as restricted areas for the public
- Never harvest more than the forest can produce in new growth
- Producing lumber for nearby communities to build affordable housing.
- Local communities taking responsibility for forest resources
- I don't know

☐  
☐  
☐  
☐  
☐

**S1. Please indicate which of the following statements applies to you personally when it comes to financial matters, e.g. investments.**

- I decide for myself and/or my household alone
- I decide together with my partner
- I do not decide but someone else does (e.g., partner, parents)

☐  
☐  
☐

**S2. How often do you review your financial portfolio?**

- weekly
- monthly
- several times per year, but less frequently than monthly
- once a year
- more rarely
- never
- only when I create a deposit, or change it
- I don't have a financial deposit

☐  
☐  
☐  
☐  
☐  
☐  
☐  
☐

**S3. To what extent do you agree with this statement: "I often talk with other people about investments."?**

- strongly disagree
- somewhat disagree
- neither agree nor disagree
- somewhat agree
- strongly agree

☐  
☐  
☐  
☐  
☐

**T1. Please indicate in which of the following investment forms you have currently invested your money.**

**(Please select all applicable answers.)**

- Savings book
- Call money account
- Stocks
- Equity funds (including ETFs or index funds)
- Bonds
- Bond funds

☐  
☐  
☐  
☐  
☐  
☐



- Other fixed-interest forms of investment (e.g. mortgage bonds, treasury bonds, savings agreement, time deposit, subordinated loan)
- Other non-fixed-income forms of investment (e.g. warrants, certificates, open-ended real estate funds, closed-end funds, mixed funds)
- Other, not listed forms of investment
- In none of the listed forms of investment

**T2. In addition to the previous answers, please indicate which of these types of investments you have invested money in in the past but no longer do.**

**(Please select all applicable answers.)**

- In none of the listed forms of investment
- Savings book
- Call money account
- Stocks
- Equity funds (including ETFs or index funds)
- Bonds
- Bond funds
- Cooperative shares (Private Equity)
- Other fixed-interest forms of investment (e.g. mortgage bonds, treasury bonds, savings agreement, time deposit, subordinated loan)
- Other non-fixed-income forms of investment (e.g. warrants, certificates, open-ended real estate funds, closed-end funds, mixed funds)
- Other, not listed forms of investment

**U1. How do you estimate the returns of a sustainable investment compared to a conventional investment?**

- much lower
- somewhat lower
- same
- somewhat higher
- much higher
- I don't know

**U2. How do you assess the risk of a sustainable investment compared to a conventional investment?**

- much lower
- somewhat lower
- same
- somewhat higher
- much higher
- I don't know



**U3. At which bank do you have your most important bank account, i.e. the account you use most often? Please ignore this question, as it is only an attention test question. Instead, please answer "other, namely" and enter the number 8 there.**

|                                  |                          |
|----------------------------------|--------------------------|
| Sparkasse                        | <input type="checkbox"/> |
| Volksbanken und Raiffeisenbanken | <input type="checkbox"/> |
| Deutsche Bank                    | <input type="checkbox"/> |
| Postbank                         | <input type="checkbox"/> |
| Commerzbank                      | <input type="checkbox"/> |
| other, namely                    | <input type="checkbox"/> |

other, namely

**U4. How important are the following dimensions to you when investing?**

|                                                         | Not<br>important 1       | 2                        | 3                        | 4                        | Very<br>important 5      |
|---------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| return                                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| risk                                                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| environmental dimension                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| social dimension (for example, fair working conditions) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| governance dimension (for example, no corruption)       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**U5. To what extent do you agree with the following statements?**

|                                                                                                               | strongly<br>disagree     | rather<br>disagree       | neither agree<br>nor disagree | rather agree             | strongly<br>agree        |
|---------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|-------------------------------|--------------------------|--------------------------|
| Sustainable finance products are just greenwashing                                                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> |
| Sustainable finance products help me make a real positive contribution to sustainability                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> |
| At the end of the day, sustainable finance products are not very different from conventional finance products | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> |

**V1. Suppose you had 100 Euro in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?**

|                    |                          |
|--------------------|--------------------------|
| more than 102 Euro | <input type="checkbox"/> |
| exactly 102 Euro   | <input type="checkbox"/> |
| less than 102 Euro | <input type="checkbox"/> |
| I don't know       | <input type="checkbox"/> |

**V2. Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, would you be able to buy more than, exactly the same as, or less than today with the money in this account?**

|                  |                          |
|------------------|--------------------------|
| more             | <input type="checkbox"/> |
| exactly the same | <input type="checkbox"/> |
| less than today  | <input type="checkbox"/> |
| I don't know     | <input type="checkbox"/> |



**V3. Do you agree with the following statement: "Buying a single company stock usually provides a safer return than a stock mutual fund."?**

agree ☐  
disagree ☐  
I don't know ☐

**W1. In the context of sustainable financial investments, the (English) acronym "ESG" is often used. What do you think the abbreviation "ESG" stands for?**

Environmental and Social Goals ☐  
Environmental and Sustainable Goals ☐  
Environmental, Social and Governance ☐  
Environmental, Sustainable and Governance ☐  
I don't know ☐

**W2. Let's say a company has a low environmental footprint but has poor social and employee practices. Would it be possible to call the shares of this company a "sustainable" financial product on the financial markets?**

Yes ☐  
No ☐  
I don't know ☐

**W3. In how many of the 3 ESG components (Environment, Social, Corporate Governance) does a company have to be sustainable in order to be considered a sustainable company on the financial markets?**

only one of the components ☐  
two of the components ☐  
all three components ☐  
I don't know ☐

**W4. Sustainable funds can follow different strategies when selecting stocks. One such strategy is "exclusion-based investing". What does this mean?**

Exclusion-based investing is the process of excluding detrimental companies and business practices. Depending on how sustainability is understood, there are a number of different exclusion criteria that can come into play.

Exclusion-based investing excludes companies that have both the worst ESG rating and the worst financial performance in their industry.

Exclusion-based investing excludes companies that are not on the EU sustainability list under SFDR Article 7.

I don't know ☐

**W5. Sustainable funds can follow different strategies when selecting stocks. One such strategy is the "best-in-class" approach. What does this mean?**

In the best-in-class approach, sustainable funds only include companies that have both the best ESG rating and the best financial performance in their industry.

In the best-in-class approach, sustainable funds only include companies that are leaders in their industry in terms of ESG. This means that an investment in an energy company that operates coal-fired power plants or produces oil, but is also heavily involved in renewable energy, may well be an option

In the best-in-class approach, sustainable funds only include companies that are leaders in their industry in terms of ESG. This means that only investments in companies that operate in highly sustainable industries can be considered.

I don't know ☐

**X1. What are financial products under Article 6?**

These are funds that explicitly consider negative impacts of investment decisions from an environmental, social, or governance perspective

These are funds that do not specifically integrate sustainability considerations into their investment process and could therefore include stocks that are currently excluded from ESG funds, such as tobacco companies or coal producers..

These are funds that take into account six specific sustainability criteria, including CO2 emissions, water management, human rights and corruption

I don't know

☐  
☐  
☐  
☐
**X2. What are financial products under Article 8 ("light green products")?**

These are funds that take into account eight precise sustainability criteria

These are funds that take environmental and/or social factors (subject to good corporate governance) into account when selecting their stocks

These are funds that primarily consider environmental criteria when selecting their stocks. Social characteristics are of secondary importance for Article 8 funds

I don't know

☐  
☐  
☐  
☐
**X3. Can funds that only consider social aspects be classified as financial products under Article 8 ("light green products")?**

Yes

No

I don't know

☐  
☐  
☐
**X4. Which financial products have a sustainable investment strategy contributing to a specific, identifiable environmental or social objective, without doing significant harm to any other sustainability objectives and ensuring good governance practices, for example with respect to employee relations?**

Article 6 financial products

Article 8 financial products

Article 9 financial products

I don't know

☐  
☐  
☐  
☐
**Y1. To what extent do you agree with the following statement?**

**"I have given my answers and made my decisions carefully and to the best of my knowledge, and therefore think that my data should be used for the study".**

**(Note: Your chances of winning the bonus are the same regardless of how you answer this question).**

My data  
should not be  
used at all 1

2

3

4

5

6

7

8

9

My data can  
be used  
without any  
problems 10

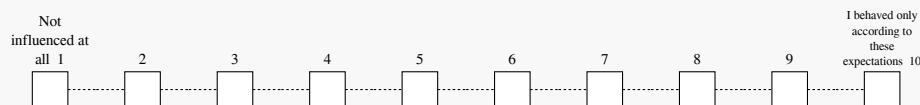
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
**Y2. This study examines the relationship between two variables. Between which two do you think (vague answers are perfectly fine)?**



**Y3.** Subjects in studies often believe that the researchers behind these studies want the subjects to behave in a certain way on some questions or decisions. We don't actually do that, but these expectations about our expectations can still change the subjects' behavior. This poses a problem for us because we want to study the actual research question, not whether our subjects prefer to do what they think we want them to do instead of their "real behavior." In our study, these so-called "experimenter demand effects" could appear in the four investment decisions.

Please think about these decisions. In making these decisions, did you feel that we wished you had made certain investment decisions? If so, which ones?

**Y4.** How much do you think this expectation of what we would want influenced your decision?



**Y5.** Do you have any other comments regarding our study?

**This is the end of the study. Thank you for your participation. Your contribution is very valuable.**

**Contact: [florian.gaertner@wirtschaft.uni-giessen.de](mailto:florian.gaertner@wirtschaft.uni-giessen.de)**

## Appendix E

### Appendix to Chapter III: Screenshots of funds & brochure

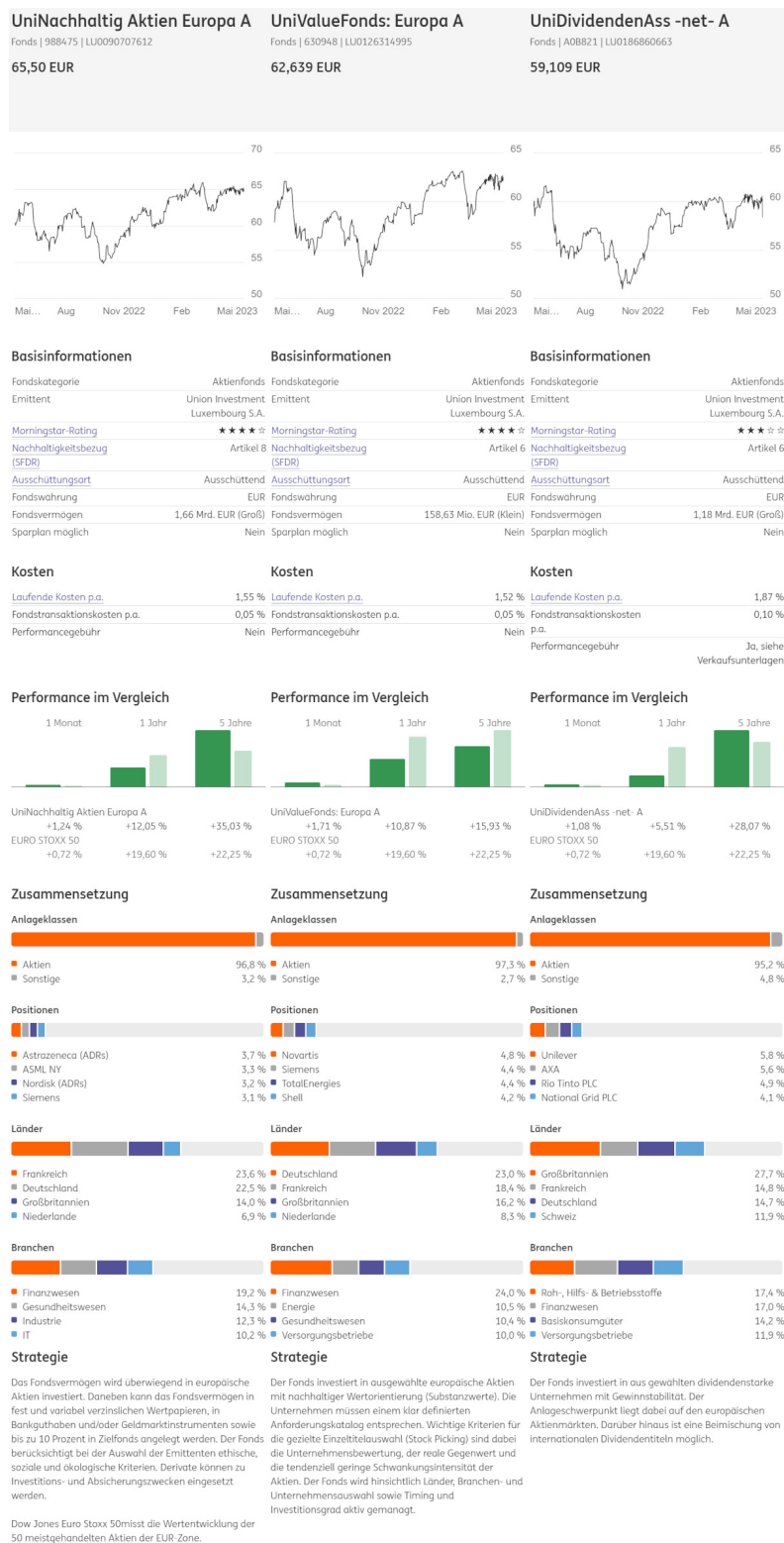
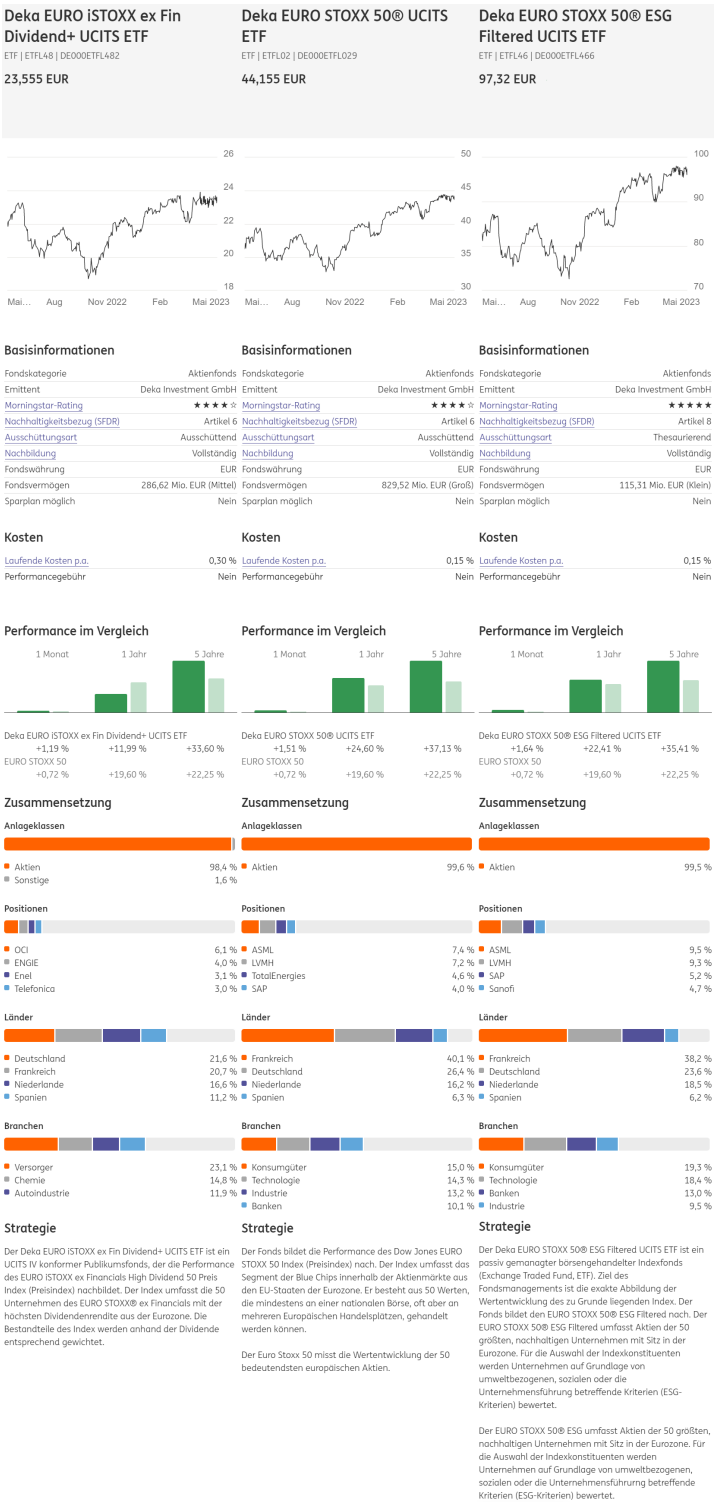


Figure E.1





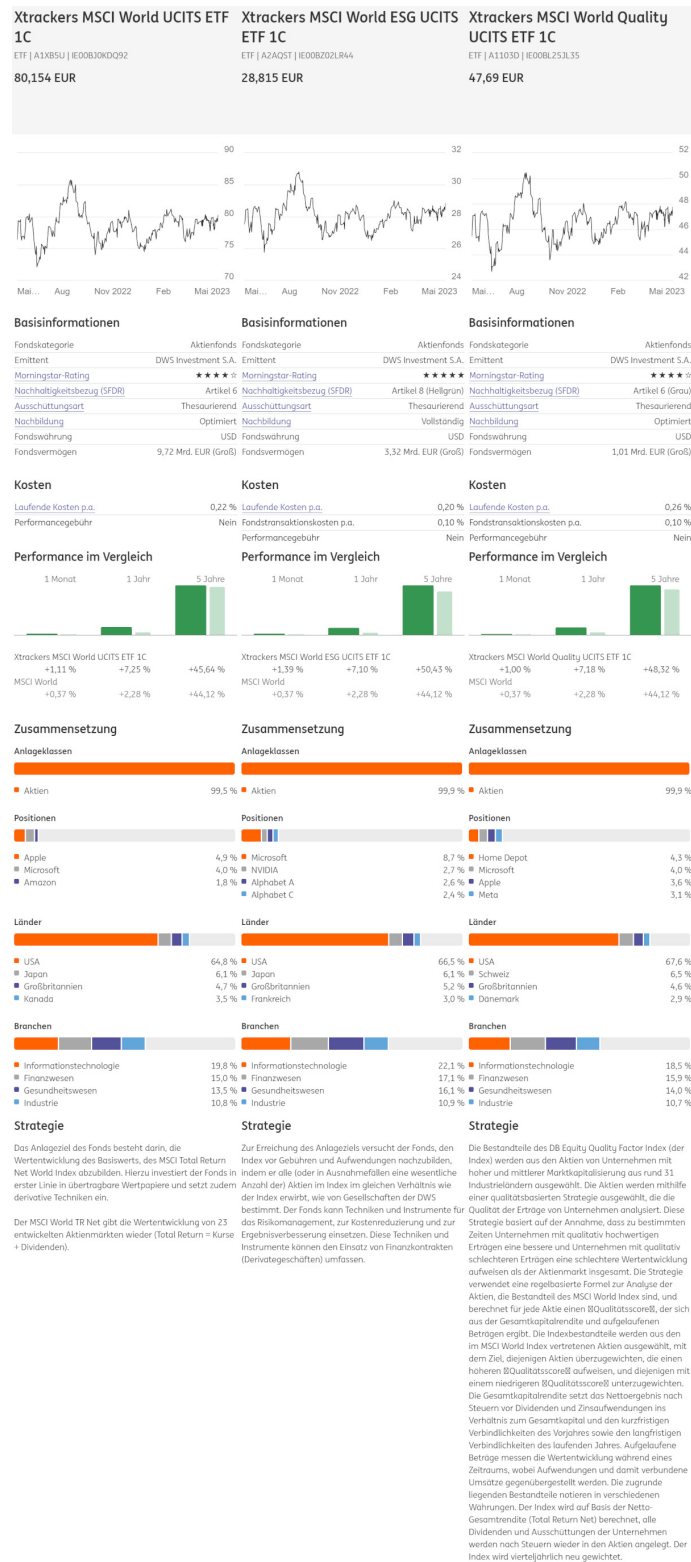


Figure E.3

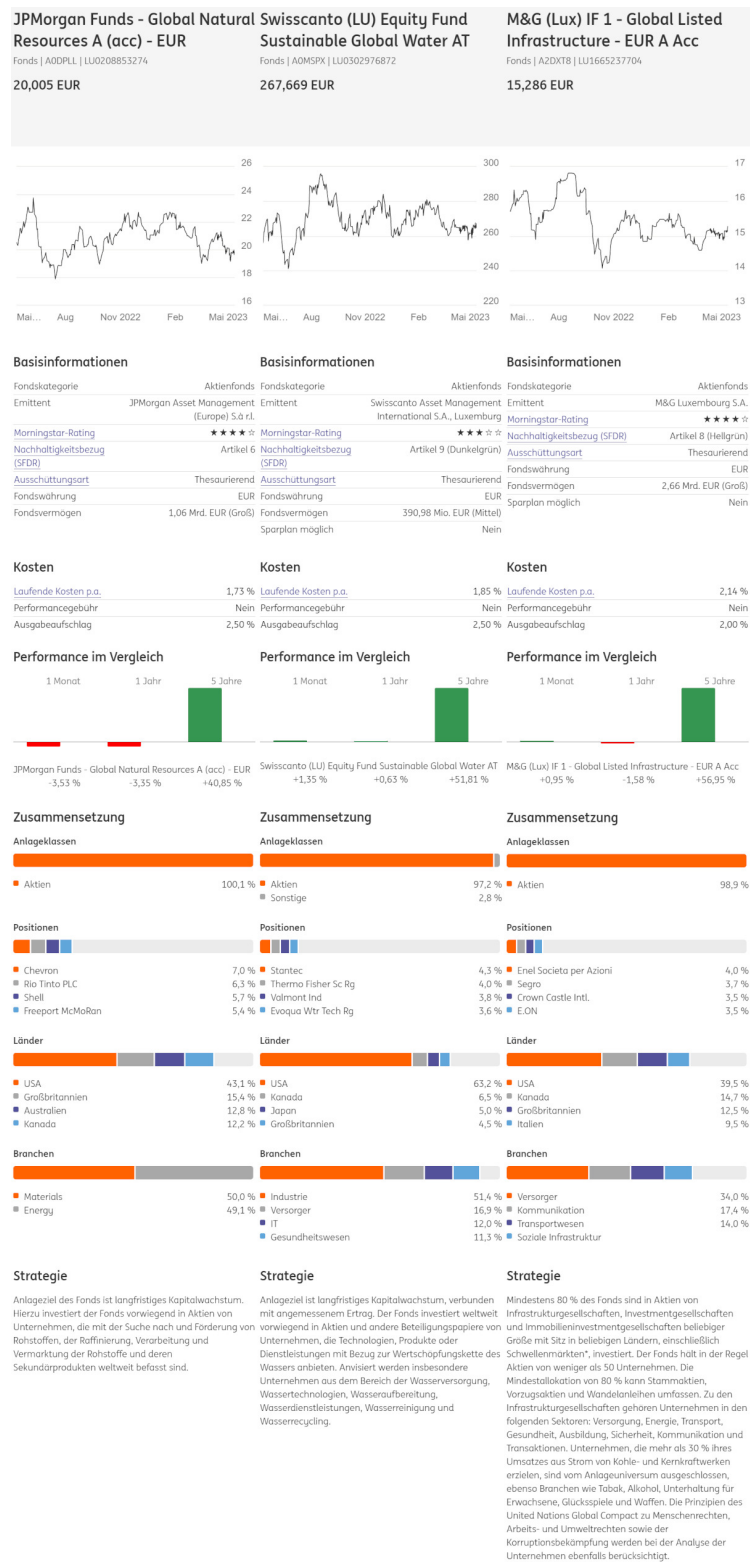


Figure E.4

## OBJECTIVE OF THIS BROCHURE

Dear Participants,

Sustainability is on everyone's lips these days. But what does it have to do with our financial investments? In this brochure, you will learn what sustainability means when it comes to investing. In particular, you will learn about the criteria and investment strategies that are at play in the composition of sustainable funds and ETFs. Most importantly, it will help you make more informed investment decisions. Enjoy the reading!

Best regards,

Christina E. Bannier

Alix Auzepy

Florian Gärtner

## WHO WE ARE



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## General Knowledge: Sustainable Investments



## ESG – WHAT IS IT?

Anyone interested in sustainable investing will repeatedly come across the so-called ESG criteria. The acronym stands for "**Environmental, Social and Governance**".

These three generic terms have become widely accepted by professional investors, such as pension funds or asset managers, as **important criteria for classifying sustainable investments**. ESG refers to three key areas of responsibility that can be assessed in order to determine the sustainability performance of a company.

**FOR A COMPANY TO BE CONSIDERED A SUSTAINABLE COMPANY ON THE FINANCIAL MARKETS, IT MUST PERFORM WELL IN ONE OF THESE AREAS - OR PREFERABLY ALL THREE.**

However, there is **no universally accepted definition of sustainability**: A "green finish" does not always mean that a financial product is truly sustainable. Rather, one must carefully examine the product and its composition, for example, the individual companies in a fund. In general, a company can be considered sustainable on the financial markets if it performs well in one of the ESG areas - or preferably in all three.

Sustainability features may vary significantly from one financial product to another. Investors should therefore be aware of the **specific investment criteria and strategy applied before investing in a fund and ETF**.

## THREE CENTRAL CRITERIA

### Environmental



This area includes companies that are, for example, characterized by their adoption of environmentally friendly production processes, efficient utilization of raw materials, waste reduction efforts, and a focus on minimizing greenhouse gas emissions. Additionally, companies that make significant investments in renewable energy sources and technologies geared towards combating climate change tend to achieve high scores in this crucial category.

### Social



This area includes companies that set high standards for the rights and well-being of their employees. This includes maintaining strict policies against child labor and avoiding any form of discrimination based on gender, ethnicity or other minority characteristics. Companies that score high in this area provide fair compensation to their employees. They also actively engage with their suppliers to ensure compliance with the necessary standards and promote a responsible and inclusive working environment throughout their supply chain.

### Governance



Companies with good corporate governance reject corruption and ensure independence and transparency in their decision-making. They place a high priority on compliance with legal requirements and create a supportive environment for whistleblowers. The sustainability strategy is integrated into their management and undergoes regular review by the company's supervisory bodies.

## SUSTAINABLE FUNDS AND ETFs

How do sustainable funds or ETFs actually select their stocks? What benchmarks and criteria do they use, and what methods do they employ?

A common strategy of sustainable funds is to **exclude harmful companies and business practices**. Depending on how sustainability is understood, different exclusion criteria may come into play. Here are some examples:

- **Fossil energy:** This includes various business activities related to coal and oil. Special processes such as fracking or the use of oil sands may also be excluded.
- **Nuclear power:** This often includes not only the operation of nuclear power plants, but also the production of nuclear components and uranium mining.
- **Armaments and weapons:** This category includes, for example, manufacturers of controversial weapons and suppliers of critical components.
- **Disregard for human and labor rights:** Companies may be excluded if trade union rights are not respected, if children are used as labor, or if forced labor is used.
- **Business ethics:** This refers to unethical or criminal business practices such as corruption, tax evasion and money laundering. Companies with serious violations in these areas may be excluded.

### A COMMON STRATEGY OF FUND COMPANIES IS THE EXCLUSION OF HARMFUL COMPANIES AND BUSINESS PRACTICES.

Certain **thresholds** are often used when applying exclusion criteria. This means, for example, that a company can generate up to 5% of its revenue from fossil fuels without violating the specific exclusion criteria applied by the fund.

In addition to the use of exclusion criteria (as “negative” criteria), “**positive**” criteria are also used in the composition of sustainable funds. The positive criteria are based on three additional strategies, among others: ESG integration, best in class and theme selection.

## THREE ADDITIONAL STRATEGIES

### ESG integration



ESG integration is an investment strategy that entails including companies in a fund's composition based on specific minimum thresholds related to financially significant ESG factors. This approach involves overweighting stocks of companies with robust ESG practices and underweighting those with poor ESG performance. To evaluate these thresholds, ESG ratings or similar scores are commonly used.

### Best-in-class



The best-in-class strategy focuses on including companies in a portfolio that are industry leaders in specific sustainability areas. This means selecting companies that excel in environmental, social, and governance practices, even if they operate in traditionally unsustainable sectors, as long as they are at the forefront of positive change in their industry. For example, investing in an energy company that operates coal-fired power plants might be an option if it also has a strong commitment to renewable energy.

### Theme selection



Thematic investing is an investment strategy where funds select companies based on specific themes or problem areas they focus on, such as renewable energies, water, health, and other relevant sectors. By targeting companies aligned with these themes, the funds aim to capitalize on emerging trends and innovations within these areas.

## REGULATION IN THE E.U.

The multitude of terms and strategies surrounding sustainable investing can be confusing for investors. However, the European Union has taken a step towards providing clarity and transparency with the introduction of the **Sustainable Finance Disclosure Regulation (SFDR)** in 2021.

This regulation mandates asset managers, banks, and fund companies to categorize financial products like funds and ETFs into one of the **three following categories**:

- **Article 6 funds:** These funds take into consideration ESG factors and sustainability risks in their investment decisions. However, they do not explicitly promote or market their specific environmental or social features.
- **Article 8 funds:** In contrast to Article 6 funds, Article 8 funds not only consider and integrate ESG factors and sustainability risks into their investment strategies but also actively advertise their environmental or social features.
- **Article 9 funds:** Article 9 funds are specifically designed to pursue sustainable investment objectives with measurable impacts.

The SFDR facilitates investor decision-making by requiring funds to **document** their sustainability objectives and policies in fund brochures and on their websites.

## THREE CENTRAL ARTICLES

### Article 6 funds: Traditional financial products



Classification under Article 6 signifies that ESG considerations are not the primary focus of the investment strategy. As part of the disclosure requirements, Article 6 funds must describe how sustainability risks could potentially influence their investment policy and impact their financial position. If sustainability risks are not considered relevant, they must provide a clear explanation for this decision.

### Article 8 funds: Light green products



Classification under Article 8 indicates that the funds not only consider, but also actively promote, sustainability features in its investment policy, alongside financial objectives. These products are required to disclose how they incorporate environmental and/or social features, while also ensuring good corporate governance practices.

### Article 9 funds: Dark green products



Classification under Article 9 indicates that the funds have a clearly defined sustainable investment objective. They must explicitly state an environmental, social or similar objective. These funds also seek to reduce negative impacts on other environmental or social considerations. In addition, they are must transparently disclose how they ensure the achievement of their sustainable investment objective.

### KEY TAKEAWAYS

- Sustainable funds are funds that use ESG criteria in their stock selection. ESG stands for the dimensions: **Environmental, Social & Governance**. These criteria are critical to evaluating a company's sustainability performance.
- Although these criteria are commonly used, there is **no binding or universally accepted definition of sustainability**, which means that sustainability characteristics can vary greatly from one financial product to another. Differences may arise due to how the individual dimensions are measured and weighted.
- In the context of sustainable funds, the selection criteria and sustainability characteristics for the inclusion of companies in the fund are determined by the **fund's strategy**. It is common for the fund strategy to have an **emphasis on certain ESG criteria** to the **detriment of other sustainability aspects**.
- It is therefore **not necessary** for a company to have an equally good performance in all three dimensions - environment, social and governance - in order to be considered sustainable by the financial markets. A single dimension may be sufficient.
- In practice, there are **various approaches** to how sustainable funds make their selection decisions based on ESG criteria. These include exclusion procedures, ESG integration, best-in-class approach and theme selection.
- The EU Sustainable Finance Disclosure Regulation (SFDR) requires asset managers and fund companies to classify their financial products into sustainability categories known as **Article 6 (traditional financial products)**, **Article 8 (light green financial products)** and **Article 9 (dark green financial products)**. The aim is to create transparency about the actual extent to which ESG criteria are taken into account in the investment strategy and the pursuit of sustainability goals.





# Appendix F

## Appendix to Chapter IV

- **Individual Shareholder:** Hi. My name is David Sims. I own 15 shares. And as has been mentioned before we've had a good last three or four years and made about \$8.8 billion profit since 2008. And, yes, as you have said before, Mr. Hay, you have paid taxes. This company has paid taxes in accordance with the law. Everything you have done has been in accordance with federal tax policy, yet even though we have I think the fact that this company has had a net remittance from the government of \$174 million in taxes, not only didn't we pay anything, but the government has paid, I think that's against the intent of federal tax policy. And even though you didn't break the law and even though you have invested a lot of money to build new plants and that's why you have written off taxes, had a tax write off, I think that's not – that's against the intent and it's really not right. A company with this large earnings should pay its fair share and you should not, we should not ask for a rate hike from the rate payers, from the electricity users until we start paying a reasonable share of taxes. Thank you.
- **(Former) Employee:** I'm Gary Patton. I'm a 21-year employee with The Home Depot out of Greenville, South Carolina. I appreciate the last question that was asked, and I wanted to ask you something specific also. I'm having a hard time figuring it out completely. How is the implementation of the Affordable Care Act which should be fully implemented in January I believe of next year affecting us

employees here with The Home Depot in our deductions, our medical coverage, and all of that, can you foresee or share with me in layman's terms how that might be affecting us? (...).

My name is Len Corky. I'm a Baxter retiree and I have Baxter stock. I was with Baxter from 1955 to 1986. I have a suggestion that Baxter consider the use of solar panels and we can – it would be good PR because we can boast that we can save the lives of people, but we're also improving the environment by using a less contaminating source of energy. Thank you.

- **Trade Union:** Good morning. My name's Michael Hogan. I'm a labor organizer for the International Brotherhood of Teamsters. I work in Boston, Massachusetts. And I have two questions, Mr. Chairman. My first question - and if I can pose it this way - I've met with some of your front-line workers in my home state and there's a problem when some of the workers are afraid to organize because they're afraid that your supervisors or your managers, through their intimidation and the fear that they make their employees feel, they're afraid that they'll lose their job. So, what I'd like to see today is a commitment from you, that you'd sit down with our general president, James P. Hoffa and negotiate a neutrality agreement so that, in the future, any workers that may feel suppressed or angered or that they have some problems, that if they come to a labor organization such as ours, that they may organize without fear of losing their jobs.
- **Asset Manager:** Luke Berman, portfolio manager and shareholder, just some brief comments and questions. First, congratulations to your move to a new high-tech HQ, for the hands-down number one premium quantitative financial company in the world. As compared to other stocks, our stock, MHFI, have outperformed the general broad spectrum of stocks in the averages and then in our peer category group. In fact, MHFI is one of the only iconic companies which has not had revenue or earnings problems this year and has fully recovered its momentum moving now to higher highs up to the general market malaise in February and this deep decline that we had. You stated that we are primarily

finished with restructuring the move up to the J.D. Power sales completed later in the fall. As we now seem to be at an inflection point in the economy and the stock market, it will be harder to achieve double-digit earnings gains unless the extrapolate – extrapolated economic expansion by the Federal Reserve continues which has two different interest rate increases projected for 2016. Now that you have a firm handle on the pulse of the Company, do you – how do you expect the organic growth to materialize that it'd be very difficult over the next few years?

- **Analyst:** All right, Mike Mayo, Wall Street analyst. What a difference a year makes. Again, I come to these Annual Meetings, it's the only chance – once a year chance so I can ask questions of the Independent Directors, and have the Independent Directors be publicly held accountable. So James hopefully, you can give an answer to my question. If Erskine Bowles can also respond, that would be great too. But my question is, what is the degree of confidence that Morgan Stanley can transition from restructuring to growth and why? And on the one hand the good news, since last year, you mentioned, revenue is flat, profits of \$1 billion. That's good. Consensus Wall Street estimates have you meeting your financial target – your ROE target, this year. That's good. And certainly the stock price has gone from \$26 to over \$40 since last year's Annual Meeting. But the issue is, the restructuring seems to be in the later stages. Company-specific factors propel growth. They seem to be in the later stages. And there are some headwinds that you know about in terms of fixed revenues way above your target range, it'll probably be coming down. Your equity market share, you're a victim of your success. How much more share can you get? And then your wealth management assets have been showing kind of sluggish growth over time. You've made it work through the restructuring, but the restructuring is in late stages. How do you get that revenue growth to propel your earnings growth going forward? And how confident can you be in getting that?
- **Public Asset Manager:** My name is Cindy Ernberg and I'm here as the deputy to California State Controller, John Chiang. I'd like to speak briefly to the elec-

tion of board of directors, which I didn't have an opportunity to speak on earlier. The controller does support the election of directors this year, but with reservations, as he has some concerns regarding the company's long-term strategy to sustain its performance and the board's role in improving the Company's image with the public, with its own investors, and with regulators. Controller Chiang is a trustee of the California Public Employees' Retirement System and the California State Teachers' Retirement System, the nation's first and second largest public pension funds, with over \$400 billion in assets. Together, these funds own \$4 billion of Exxon Mobil. So many Californians have a substantial financial stake in the Company's long-term success. The board's most important role to provide independent oversight of management is compromised, we believe, when the CEO serves as chairman of the board. Combining these two roles has interfered with effective communications between shareowners and directors and has likely affected the Company's at least former positions in statements on climate change. Shareholders are happy today, but, frankly, until Mr. Tillerson's presentation, we hadn't seen the Company having a sustainable strategy for maintaining its high earnings. As Mr. Tillerson's presently surprising remarks acknowledge, the Company is under pressure like no other time in its history to meet growing global energy demands, but to do it in a less carbon intensive way. While we support the candidates this year, by next year, the controller hopes to see evidence that the board is improving relationships with its shareholders, really positioning itself to reduce emissions, and earning our support by overseeing management. And as you continue to think about new members, are you seeking expertise with these challenges that I mentioned? Thank you for your time.

- **Religious Asset Manager:** My name is John Wilson. I'm with Christian Brothers Investment Services we're a shareholder of ExxonMobil. I want to follow-up on the question that was just asked and point to the fact that the Sarbanes-Oxley law strengthens requirements, the corporation has disclosed to shareholders in Securities filings, risk controls for material issues. Now our company has acknowledged that greenhouse gases cause global warming and that action is needed to prevent

harm to the ecosystem. We differ with you in that we believe that it is a material risk to our business. In fact there are many uncertainties surrounding the future of an energy demand. Every day in the news we hear of new [inaudible] for new laws, regulations and technologies designed to reduce our reliance on oil and gas. Our ability to predict future demand for oil is clearly in doubt. Surely this is a material issue for shareholders of an oil company. Yet the company confidently predicts that oil and gas will continue to supply 60% of the world energy needs up until 2030, even as demand grows, and derives all of its strategic decisions from this particular prediction. No where does the company explain to shareholders what it plans to do if the future does not turn out exactly as it expects. In contrast, many of our competitors have reported their strategies to respond to climate change. Nowhere has ExxonMobil reported on any scenario planning to manage these risks. So my question is for Mr. Houghton and for the auditors, what risk controls has the company established to mitigate the risk of climate change and how can shareholders evaluate the effectiveness of these controls? Thank you.

- **NGO:** Hello. My name is Susan Okie, and I'm here on behalf of People for the Ethical Treatment of Animals, and our more than 2 million members and supporters worldwide. Our members are all consumers who strongly object to the cruel treatment of animals. ExxonMobil has worked well with PETA on animal testing issues over the past few years and I hope we'll have the same cooperative and productive relationship on this animal and entertainment issue. Last year, ExxonMobil pledged \$1.25 million in funding over the next five years for educational materials that promote the Iditarod to school children. The Iditarod, as many of you know, is a 1,150 mile course over which dogs are forced to run more than 100 miles per day for almost two weeks straight. The dogs must pull heavy sleds through some of the worst weather conditions on the planet and, as a result, they routinely die on the course. Many dogs used in the Iditarod suffer from pulled muscles, stress fractures, diarrhea, dehydration, intestinal viruses, or bleeding stomach ulcers. Mushers ride, eat, and sleep on the sleds while the dogs continue to run. One dog collapsed and died from gastric ulcers during

this year's Junior Iditarod. And in 2009, six dogs died, including two who were believed to have frozen to death. The Iditarod Trail Committee rarely punishes abusive mushers, even those who have been caught beating exhausted dogs in order to keep them running. Mushers participate in the race because of the prize money, not because they believe the dogs enjoy it. Dogs used in the Iditarod are treated as if they are outdoor equipment. They aren't allowed inside the house with the family and then never get to play a game of catch. The vast majority of dogs who are used to pull sleds live at the end of a very short chain. Their entire world can be measured in a few muddy feet. Iditarod sponsorship and prize money has declined over the past few years and, in an attempt to increase support, event organizers have shamelessly marketed this punishing ordeal as an event that benefits dogs. And now, one that benefits students as well. ExxonMobil could easily fund educational materials for students across the country that excludes the Iditarod. My question is this. Can consumers hear that ExxonMobil will commit to refusing to renew its sponsorship of the Iditarod, a dwindling industry that promotes and causes egregious animal suffering?

- **Religious Organization:** Yes, it is. My name is Michael Crosby. I'm an Capuchin Franciscan Friar from Milwaukee. And I wasn't planning on asking the question, just presenting a resolution. But there was a young man that raised a question that has been a question with us, I know you're international and not domestic, but our ministries are highly invested among poor people in Detroit and Milwaukee through the most economically depressed areas. And the data does show that in economically depressed less educated communities, there's a higher rate of smoking. I think his question was related to that on a global basis and I don't think you were able – I was not able – but you didn't answer another element of his question. How do you deal with that fact if it is a fact globally, are less educated, poor people tend to be outside, I know data for the United States, it is, but what is it for outside in your market, are the majority of your smokers, less educated, poor, I just would like to know the data that's all? Would you have data on it?.

- **Proxy:** Mark Nickerson, proxy holder. With the growth you've seen in retail volume, do you anticipate rolling out more weekly options, for example, Tuesday and Thursday S&P option? Or making the universal settlement times for C, B options for buy options instead of different – Wednesdays, Fridays?

# Appendix G

## Appendix to Chapter IV

- **ENV:** 2-degree, abatement, acidification, agriculture, air, align, aligning, alignment, alternative, animal, animals, annihilation, arctic, atmosphere, aware, awareness, batteries, battery, below, biodiversity, biofuel, biofuels, biological, biomass, biphenyls, building, buildings, burn, burning, capture, car, carbon, carbon-free, carbon-intensive, carbon-neutral, carbon-related, cars, catastrophe, catastrophes, catastrophic, CDP, celsius, chain, change, chemical, chemicals, chronic, circular, clean, clean-energy, cleaner, cleanup, climate, climate-change, climate-friendly, climate-related, CO<sub>2</sub>, CO<sub>2</sub>-emitter, CO<sub>2</sub>-footprint, coal, coastal, combustion, commitment, conservancy, conservation, conserve, consumption, contaminat, contaminated, contamination, COP, COP21, curb, curbing, cyclones, decarbonize, deforestation, degradation, degrade, degrees, diesel, dioxide, dirty, disasters, disclosure, disposal, drill, drilling, drought, eco-activis, ecocide, eco-friendly, ecological, ecosystem, ecosystems, efficiency, efficient, electric, electricity, electrify, emission, emissions, emit, energy, energy-efficiency, energy-efficient, environment, environmental, epa, erosion, ETS, exploration, externalities, extraction, fire, fires, flood, flooding, floods, footprint, forest, fossil, fracturing, freshwater, fuel, fuel-efficient, fuel-eficien, fuels, future, gas, gases, generation, generations, geothermal, ghg, ghgs, glacial, global, goal, goals, goas, green, greener, greenwashing, greenhouse, greenpeace, green-tech, GRI, grid, groundwater, habitat, hazardous, heat, heatwave, heatwaves, householding, hurricane, hurricanes, hybrid, hydraulic, hy-



dro, hydroelectric, ice, IEA, impact, impacts, innovation, intensity, Kyoto, land, leak, lithium, low-carbon, melting, metals, methane, minerals, mitigate, mitigation, mobility, natural, nature, negative, net, net-zero, neutral, neutrality, nitrogen, nitrous, non-renewable, nuclear, ocean, oil, oxide, ozone, packaging, Paris, pesticide, pesticides, petrol, petroleum, planet, planetary, plants, plastic, poison, poisoned, pollut, pollutants, pollute, polluted, pollution, positive, power, precipitation, preservation, prevention, PRI, produce, production, protect, protecting, protection, rain, rainforest, recycl, recycle, recycling, reduce, reducing, reduction, refineries, refinery, reforestation, renewable, resilience, resource, resource-efficient, resources, resource-saving, responsible, rise, SBTI, scarce, scarcity, scenario, SDG, sea, smoke-free, snow, snowmelt, soil, solar, sourcing, species, storage, storm, storm-related, storms, sulfur, sustainability, sustainable, target, targets, taxonomy, TCFD, technologies, technology, temperature, temperatures, threat, threatened, tidal, toxic, traceability, transformation, transition, transitioning, transport, transportation, UN, upcycl, utilities, vehicle, vehicles, vulnerability, vulnerable, warming, waste, waste-reduced, wastes, waste-to-energy, water, water-saving, wave, waves, weather-related, welfare, wetland, wetlands, wilderness, wildlife, wind, wind, wood, zero, zero-carbon

- **SOC:** abortion, abus, abuse, access, accessibility, accident, accidents, accountability, addiction, addictive, advocacy, affordable, african-american, aid, aids, alleviate, antidiscrimination, anti-racism, anti-union, asian, assault, assistance, bargaining, benevolent, black, black americans, blacks, blue-collar, bribe, brutality, cancer, care, caregiver, caring, charit, charitable, charities, charity, child, childbirth, childcare, children, citizen, citizens, citizenship, civic, civil, colleagues, collective, communit, communities, community, compassion, conditions, conflict, conflicts, contract, contractor, contractors, corruption, cultural, custody, data, death, deaths, decent, democracy, demographic, departure, departures, deportation, die, died, dignity, disabilities, disability, disabled, disadvantaged, discriminate, discriminated, discriminating, discrimination, dislocated, dismissal, dismissals, disparity, displace, diverse, diversity, divide, domestic, donate, do-

nated, donates, donating, donation, donations, donors, drinkable, drug, educate, educated, educates, educating, education, educational, elder, elderly, empathy, employ, employee, employee-friendly, employees, employer, employment, empower, empowerment, endowment, endowments, entrepreneurship, epidemic, equal, equality, equity, ethic, ethical, ethnic, ethnically, ethnicities, ethnicity, exhausted, exhaustion, exploitation, expression, fair, fairness, families, family, female, females, forced, freedom, friendly, fundamental, gap, gay, gays, gender, genders, genero, genocide, gift, gifts, gun, harassment, harmony, hate, health, health-care, healthier, healthy, hire, hired, hires, hiring, hispanic, hispanic-american, hiv, homeless, homelessness, homosexual, hours, housing, human, humanit, humanitarian, humanity, humankind, hunger, ill, illness, ilo, immigra, immigrant, immigrants, immigration, inclusion, inclusive, income, indigenous, inequal, inequality, injuries, injury, integrity, intoxication, intoxications, job, jobs, judicial, justice, labor, labour, latino, latinos, layoff, layoffs, learning, lesbian, lesbians, lgbt, lgbtq, lgbtq+, life, life-transforming, literacy, livelihood, lives, living, local, low-income, low-paying, low-wage, malnutrition, mankind, marginalized, marriage, maternity, medicaid, medicare, medicine, medicines, mental, microcredit, microfinance, microfnance, migrant, migrants, migration, minorit, minorities, minority, moral, multiculturalism, nations, nondiscrimination, nonprofit, non-profit, non-violence, nourish, occupation, occupational, opportunities, oppression, orientation, origin, overtime, paid, pandemic, parental, peace, pension, people, philanthropic, philanthropy, police, poor, poorest, population, populations, poverty, prejudice, prevention, privacy, profiling, profits, profit-sharing, promote, pro-social, prosperity, protection, protest, protests, public, quality, race, racial, racism, racist, refugee, refugee, refugees, religion, religious, respect, restructure, restructuring, retiree, retirees, retiring, right, rights, robotization, safe, safety, satisfaction, scholarships, second-class, security, servitude, sex, sexism, sexual, sick, sickness, skill, skilled, skills, skin, slave, slavery, slaves, social, socially, societal, society, solidarity, sourcing, staffing, standardization, stress, strike, strikes, suicide, suicides, teaching, teamwork, traceable, trade, trafficking, training, transgender, trans-

parenthood, underpaid, underprivileged, underrepresented, unemployment, unfair, union, unionization, universal, unrest, veteran, veteran-owned, veterans, violate, violence, vocational, volunteer, vulnerable, wage, wages, war, welfare, well-being, well-being, wellness, woman, women, women-owned, worker, worker-friendly, workers, workforce, working, work-life, workplace, workplace, workplaces, young, youth

- **GOV:** accountability, accounting, agenda, anti-competitive, anti-corruption, anti-voting, antivoting, audit, audited, auditing, auditor, auditors, audits, authority, autonomy, award, awarded, awarding, awards, ballot, ballots, board, bonus, bonuses, bribery, bureaucracy, bylaw, bylaws, cash-bonus, cast, censorship, CEO, CFO, chairman, charter, charters, checks, clawback, collusion, committee, committees, compensate, compensated, compensates, compensating, compensation, compliance, composition, conduct, conflict, conflicts, conformity, constitution, contributions, control, controlling, controls, corrupt, corruption, coso, cost-benefit, cuts, decentralization, decision-making, delegation, diligence, director, directors, disclose, disclosed, discloses, disclosing, disclosure, disclosures, dividend, dividends, duty, elect, elected, electing, election, elections, elects, embezzlement, empowerment, enforcement, engagement, equity, ethics, evasion, executive, expert, expertise, extortion, federalism, fee, feedback, fees, fiduciary, fiscal, fraud, fraudulent, governance, governing, grassroots, guidelines, hotline, incentive, incentives, independence, independent, influence, influences, influencing, inform, information-sharing, innovation, insider, insiders, inspector, inspectors, integrity, interdependence, internal, investor, investors, laundering, leadership, legitimacy, litigation, litigations, lobbied, lobbies, lobby, lobbying, lobbyist, lobbyists, long-term, malus, management, meritocracy, misappropriation, misconduct, monitor, monitoring, monitors, nepotism, networking, nominate, nominated, nomination, nominations, nominee, nominees, non-executive, non-financial, norm, norms, notice, oligarchy, oversee, overseeing, oversees, oversight, ownership, parachute, parachutes, pay, pay-for-performance, paying, payout, payouts, pay-to-play, performance, pill, planning, poison, policy, policy-making, power, presentation, pre-

sentations, presidency, press, principles, privatization, procedure, procedures, procurement, proponent, proponents, proposal, proposals, pro-shareholder, proxies, proxy, qualification, qualifications, quorum, quota, recruit, recruiting, recruitment, reform, regulation, regulatory, remuneration, report, reporting, reports, representation, reputation, reputational, resign, resignation, resigned, responsibility, retain, retainer, retainers, retaining, retention, retirement, revenue, review, reviewed, reviewing, reviews, reward, rewarding, rewards, risk-management, rotation, rule, rules, salary, sanction, sanctions, say-on-pay, scrutiny, secrecy, security, self-determination, self-governance, separation, shareholder, shareholders, shares, short-term, sovereignty, spending, stability, stakeholder, stakeholders, statement, statements, statute, subsidiarity, succession, supervision, supervisory, talent, talented, talents, tax, taxes, tenure, track-record, training, transparency, transparent, vacancies, vacancy, vested, vesting, vests, violation, vote, voted, votes, voting, voting rights, whistleblower, whistleblowers, whistleblowing

# Appendix H

## Appendix to Chapter VII

|                 | Expo<br>sures | Scenario          | Projections  | Balance sheet       | Horizon                        | Credit risk                 | Market risk                                    | Operational risk                                                            |
|-----------------|---------------|-------------------|--------------|---------------------|--------------------------------|-----------------------------|------------------------------------------------|-----------------------------------------------------------------------------|
| Transition risk | Global        | Short-term stress | Baseline     | Static              | 3 years<br>(2022-2024)         | Corporate loans & mortgages | Bonds & stocks issued by NFCs (parent company) | Operational and reputational risks assessed via a qualitative questionnaire |
|                 |               |                   | Stress       |                     |                                |                             |                                                |                                                                             |
|                 |               | Long-term paths   | Orderly      | Dynamic             | 30 years<br>(2030, 2040, 2050) | Corporate loans & mortgages |                                                |                                                                             |
|                 |               |                   | Disorderly   |                     |                                |                             |                                                |                                                                             |
|                 |               |                   | Hot house    |                     |                                |                             |                                                |                                                                             |
|                 |               | Physical risk     | EU countries | Drought & heat risk | Baseline                       | Static                      | 1 year<br>(2022)                               |                                                                             |
| Stress          |               |                   |              |                     |                                |                             |                                                |                                                                             |
| Flood risk      | Baseline      |                   |              | Static              | 1 year<br>(2022)               | Mortgages & CRE loans       |                                                |                                                                             |
|                 | Stress        |                   |              |                     |                                |                             |                                                |                                                                             |

Figure H.1: Scenarios and risk types of the 2022 ECB climate risk stress test. Figure adapted from ECB (2022a). Note: CRE stands for commercial real estate. NFC refers to non-financial corporation.

Table H.1: Overview of climate scenarios developed by the NGFS and the ECB for stress testing purposes.

| Organization | Scenario name                    | Scenario category   | Time horizon      | Average warming | Policy reaction         | Technology change           | Carbon dioxide removal | Regional policy variation | Overall description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------|----------------------------------|---------------------|-------------------|-----------------|-------------------------|-----------------------------|------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NGFS         | Net zero 2050                    | Orderly             | Until 2100        | 1.4°C           | Immediate and smooth    | Fast change                 | Medium-high use        | Medium variation          | Net zero 2050 limits global warming to 1.5°C through stringent climate policies and innovation, reaching global net zero CO2 emissions around 2050. Jurisdictions such as the US, EU, UK, Canada, Australia and Japan reach net zero for all GHGs by this point Physical risks are relatively low but transition risks are high.                                                                                                                                                                                                                                                                                 |
| NGFS         | Below 2°C                        | Orderly             | Until 2100        | 1.6°C           | Immediate and smooth    | Moderate change             | Medium-high use        | Low variation             | Below 2°C gradually increases the stringency of climate policies, giving a 67% chance of limiting global warming to below 2°C. The scenario assumes that climate policies are introduced immediately and become gradually more stringent though not as high as in the net zero 2050 scenario. Physical and transition risks are both relatively low.                                                                                                                                                                                                                                                             |
| NGFS         | Delayed transition               | Disorderly          | Until 2100        | 1.6°C           | Delayed                 | Slow/fast change            | Low-medium use         | High variation            | Delayed transition assumes annual emissions do not decrease until 2030. Strong policies are needed to limit warming to below 2°C. This scenario assumes new climate policies are not introduced until 2030 and the level of action differs across countries and regions based on currently implemented policies. Higher transition and physical risks than in the net zero 2050 and below 2°C scenarios.                                                                                                                                                                                                         |
| NGFS         | Fragmented world                 | Too-little too-late | Until 2100        | 2.3°C           | Delayed and fragmented  | First slow, then fragmented | Low-medium use         | High variation            | The Fragmented world scenario assumes delayed and divergent climate policy ambition globally, leading to high transition risks in some countries and high physical risks everywhere due to the overall ineffectiveness of the transition. Countries without zero targets follow current policies, while others reach them partially.                                                                                                                                                                                                                                                                             |
| NGFS         | Current policies                 | Hot house world     | Until 2100        | 3°C             | None – current policies | Slow change                 | Low use                | Low variation             | Current policies assumes that only currently implemented policies are preserved, leading to severe physical risks. Emissions grow until 2080 leading to about 3°C of warming. Irreversible changes like higher sea level rise.                                                                                                                                                                                                                                                                                                                                                                                   |
| ECB          | Long-term orderly transition     | Orderly             | 30 yrs/until 2050 | 1.4°C           | Immediate and smooth    | Fast change                 | Medium-high use        | Medium variation          | The orderly scenario assumes that climate policies are introduced early and gradually become more stringent. It is based on the NGFS net zero 2050 scenario and includes stringent climate policies and innovation, with net zero carbon emissions reached around 2050. Both physical and transition risks are relatively limited. The smooth and gradual nature of the transition ensures that the costs resulting from the energy transition are minimized, while restricting global warming to only 1.5°C helps mitigate physical risks.                                                                      |
| ECB          | Long-term disorderly transition  | Disorderly          | 30 yrs/until 2050 | below 2°C       | Delayed                 | Slow/fast change            | Low-medium use         | High variation            | The disorderly scenario explores higher transition risks due to delays in the implementation of policies. It is based on the NGFS delayed transition scenario, which assumes new climate policies are not introduced until 2030. Strong policy actions are needed to limit warming to below 2°C. This leads to higher transition risks than in the orderly transition scenario. Physical risks are also higher, as the delay in implementing policies leads to a greater increase in temperature and a rise in the frequency and magnitude of extreme weather events.                                            |
| ECB          | Hot house world                  | Hot house world     | 30 yrs/until 2050 | 3°C             | None – current policies | Slow change                 | Low use                | Low variation             | The hot house world scenario assumes that no new climate policies are implemented. The scenario calibration is based on the NGFS current policies scenario. Even though European emissions decline in this scenario, global emissions grow until 2080, leading to about 3°C of warming. Transition risks are negligible. The absence of transition costs is more than offset by the adverse impact of extreme physical risks on the economy. The physical damages arising during 2050-2080 are frontloaded to 2040 and 2050 to limit the scenario horizon to 2050 while still including relevant physical risks. |
| ECB          | Short-term disorderly transition | Disorderly          | 3 yrs/until 2024  | 1.7°C           | Immediate               | Slow/fast change            | Low-medium use         | High variation            | The short-term disorderly transition risk scenario assesses institutions' short-term vulnerabilities triggered by a sharp, abrupt increase in the price of carbon emissions. The calibration of the scenario is based on the NGFS delayed transition scenario. To focus on a short-term horizon, the carbon price increase is frontloaded to 2022, 2023 and 2024.                                                                                                                                                                                                                                                |
| ECB          | Drought and heat risk scenario   | n.a.                | 1 year            | n.a.            | n.a.                    | n.a.                        | n.a.                   | n.a.                      | This scenario models the economic effects of a severe drought and heatwave, which is assumed to hit Europe. The calibration is based on NGFS estimates for labor productivity shocks due to heat stress across relevant countries until 2050. To limit the scope of the exercise, the scenario only models the shocks to sectoral gross value added growth. Given the one-year time horizon, a 100% pass-through of a labor productivity shock to GDP is assumed.                                                                                                                                                |
| ECB          | Flood risk scenario              | n.a.                | 1 year            | n.a.            | n.a.                    | n.a.                        | n.a.                   | n.a.                      | Severe floods are assumed to take place across Europe. Flood risk is heterogeneous across Europe and can differ significantly even within a few kilometers. Therefore, the flood risk scenario accounts for within-country variation in risks. A flood risk map at the NUTS3 level is constructed.                                                                                                                                                                                                                                                                                                               |

*Remark:* This table presents key features related to the scenario narratives and their macro-financial risk assumptions. Green means “low risk”, yellow means “medium risk”, red means “high risk”. Based on and adapted from ECB (2022a) (see p.13-18); NGFS (2023b) (see p.21); NGFS (2024b). Note that the overall scenario descriptions follow the terminology used by NGFS and the ECB in the referenced sources.

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# Affidavit

Ich erkläre hiermit, dass ich die vorgelegten und nachfolgend aufgelisteten Aufsätze selbstständig und nur mit den Hilfen angefertigt habe, die im jeweiligen Aufsatz angegeben oder zusätzlich in der nachfolgenden Liste aufgeführt sind. In der Zusammenarbeit mit den angeführten Koautoren war ich mindestens anteilig beteiligt. Bei den von mir durchgeführten und in den Aufsätzen erwähnten Untersuchungen habe ich die Grundsätze guter wissenschaftlicher Praxis, wie sie in der Satzung der Justus-Liebig-Universität Gießen zur Sicherung guter wissenschaftlicher Praxis niedergelegt sind, eingehalten.

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Alix Auzepy, 21. Januar 2025

## Submitted Papers:

1. Auzepy, A., Bannier, C. E. and Martin, F. (2023), ‘Are sustainability-linked loans designed to effectively incentivize corporate sustainability? A framework for review’, *Financial Management*, 52(4), 643–675.
2. Auzepy, A., Bannier C. E. and Gärtner F. (2023), ‘Looking beyond ESG preferences: The role of sustainable finance literacy in sustainable investing’, Working Paper.
3. Auzepy, A., Bannier, C. E. and Martin, F. (2024), ‘Raising their voices: Share-

holder soft engagement on ESG issues at annual general meetings’, Working Paper.

4. Auzepy, A., Bannier, C. E., Bofinger, Y. and Rock B. (2022), ‘Carbon footprints and equity risk assessments’, Working Paper.
5. Auzepy, A., Tönjes, E., Lenz, D. and Funk, C. (2023), ‘Evaluating TCFD reporting — A new application of zero-shot analysis to climate-related financial disclosures’, PLOS ONE 18(11), e0288052.
6. Auzepy, A., Bannier, C. E. (forthcoming), ‘Climate risk integration in bank risk management and capital requirements. An interview-based analysis of approaches and challenges’, Springer Gabler.