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Factors influencing the outcomes of online agricultural land lease auctions: Evidence from Ukraine

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Abstract

Ukraine has large and productive agricultural areas that could attract significant volumes of investment. However, this has long been impeded by the lack of a well-functioning transparent free market to sell and rent privately and publicly-owned land. In addition, the country and its land market were severely affected by Russia's 2022 invasion, which led to a sharp economic decline and made significant areas unavailable. Nevertheless, Ukraine is likely to remain one of the world's leading agriculture producers with significant agricultural production and export volumes, and will need to manage farmland efficiently.

Ukraine's land market formed as the country began transforming itself from a centrally planned economy to a market economy in the 1990s. During the first three decades of the transition, 75% of all agricultural land has been privatized, and the rest (or approximately 10.5 million hectares (ha)) remain state-owned. Mandatory ascending-price traditional land auctions were introduced in 2012 to remove the barriers to successful investing, and to facilitate the transfer of rental rights for state-owned agricultural land from the state to private holdings. The auctions, however, lacked transparency and efficiency. To eliminate corruption in land governance and to increase land use efficiency, a pilot project to rent out state-owned agricultural land via online auctions was launched in late 2018. The results of online auctions were publicly disclosed. They became an important source of pricing data available to all market participants. This online auction mechanism was planned to be employed in the future to rent out and sell publicly and privately-owned land.

Before the online auction project began, land market research focused mainly on the emergence and development of the agricultural land market in Ukraine after the dissolution of the Soviet Union, land reforms, privatization, and distribution. Studies also focused on land market efficiency, equity, and productivity during and after the land reforms were implemented, as well as the role of large agricultural producers that were thought to exercise some market power. After the online auction data became available, several papers investigated issues related to land price formation. However, there has been no extensive research on factors that influence land auction outcomes, such as the probability of the plot being rented (i.e. auction success) and the size of the winning bid (i.e. rental rates). This thesis bridges this research gap, comprehensively analyses land auction outcomes, and determines which factors impact them the most. It begins with an investigation of how competition, active bidding, auction design characteristics, and farmland-specific properties influence auction outcomes, employing a mixed-effects model with sample selection. It then explores the occurrence of very small

winning bid amounts in the auctions, and factors that can explain bidding errors, using (heteroscedastic) probit models. Later, it investigates if, over the first year of the project's implementation, regional land management agencies were able to build a positive reputation among agricultural tenants, who could observe the publicly disclosed information about all previous auction outcomes. For this purpose, it uses multiple regression and probit models, a Heckman model with sample selection, and mediation analysis.

The results of the thesis show that competition has the greatest influence on auction outcomes: A higher number of bidders and more active bidding lead to a significantly greater probability of auction success and higher rental rates. Bidders that face low competition are likely to bid below their true valuations. They are also likely to underbid if they have an insufficient amount of time to place a subsequent bid, if bid increments are too small, or if entry fees are cumbersome. Lessors with a better reputation may be associated with a greater probability of future transaction success and a substantial price premium. However, reputation plays an especially important role in auctions that are not very competitive. Trustworthy lessors tend to optimize the amount of effort and preparation costs in the longer term.

Land auctions' efficiency and revenues may be improved if more bidders are invited and a more competitive bidding process is facilitated. More bidders will participate if auction design parameters, like reserve price, bid increments, and entry fee amounts, are optimized. Potential tenants may adjust their willingness to pay in response to information about the positive or negative reputation of lessors. If they already have a good reputation, lessors may optimize the amount of effort they exert in the long term. If their reputation needs improvement, they may consider addressing this by investing more in preparing plots for rent.

List of Publications

The research presented here is based on the following three articles.

Article I (Chapter 2)

Myrna, O. (2023) 'Competition in Online Land Lease Auctions in Ukraine: Reduced-Form Estimation', *Land Use Policy*, 125 (C), 106481. doi: 10.1016/j.landusepol.2022.106481.

Article II (Chapter 3)

Myrna, O. (2022) 'Lower Price Increases, the Bounded Rationality of Bidders, and Underbidding Concerns in Online Agricultural Land Auctions: The Ukrainian Case', *The Journal of Agricultural Economics*, 73, pp. 826–844. doi: 10.1111/1477-9552.12477.

Article III (Chapter 4)

Myrna, O. and Teuber, R. (2024) 'The Role of Lessor Reputation in Land Auctions: Empirical Analysis of Field Data', *The Real Estate Finance Journal*, 40 (4), pp. 173 - 187.

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List of Abbreviations and Acronyms

CI	Confidence intervals
Coef.	Coefficient
Cons.	Constant
Corr.	Correlation
CV	Common values
CVP	Common values paradigm
e.g. / for ex.	*Exempli gratia* (lat.) means "for example"
et al.	*Et alia* (lat.) means "and others"
EU	European Union
EUR	Euro
ex ante	(lat.) before the event
ex post	(lat.) based on analysis of past performance
FAO	The Food and Agriculture Organization of the United Nations
FE	Fixed effects
FPA	First-price auctions
GDP	Gross domestic product
ha	Hectare
i.a.	*Inter alia* (lat.) means "among other things"
i.e.	*Id est* (lat.) means "that is"
ibid.	*Ibidem* (lat.) means "the same person"
IPV	Independent private values
IPVP	Independent private values paradigm
log	Logarithm

Max.	Maximum
Min.	Minimum
N / Nr.	Number of observations
NIS	New Independent States
Prob.	Probability
RE	Random effects
Rob.St.Err.	Robust standard errors
State GeoCadastre	The Ukrainian State Service for Geodesy, Cartography, and Cadastre
SPA	Second-price auction
sq. km.	Squared kilometres
St.Err.	Standard errors
Std.Dev.	Standard Deviation
TOM	Time on the market
UAH	Ukrainian hryvnia
USD	US Dollar
USDA	The United States Department of Agriculture
USSR	The Union of Soviet Socialist Republic

1 General Introduction

1.1 Agricultural land as a scarce and attractive asset

Agricultural land is one of the main factors of food production. It contributes (directly or indirectly) to approximately 90% of food calories (Cassidy *et al.*, 2013) and 80% of protein and fats (livestock production) (Steinfeld *et al.,* 2006). In 2009, agricultural producers worldwide produced enough food for 10 billion people, the world's projected population peak in 2050 (Food and Agriculture Organization of the United Nations, 2009; Holt-Giménez *et al.*, 2012; United Nations, 2019, 2021; Nuveen Natural Capital, 2020; Roser and Rodés-Guirao, 2022). However, in 2019 almost 690 million people remained undernourished (United Nations, 2021). In 2023, more than 345 million people remain food insecure, and around 70% of them live in war-torn countries. Among them, more than 900,000 people worldwide live in famine conditions (World Food Programme, 2023). Economic slowdowns, poverty inequalities, social exclusion, disease outbreaks, pest infestations, and adverse consequences of climate change, including drought and extreme weather events, are holding up global progress against undernourishment (United Nations, 2021). Russia's 2022 invasion of Ukraine disrupted global agricultural commodity markets and created additional pressure on wheat supplies, stocks, and food prices. It emphasized the socio-economic value of agriculture and open trade to achieving food security in vulnerable regions (Hellegers, 2022).

The pressure to reduce emissions of CO_2 to mitigate global climate changes, and the need to substitute or complement gasoline and petroleum diesel with renewable fuels, such as ethanol and biodiesel, have led to a shift in land use away from food production. These demands have intensified the competition for agricultural land, which is also the main input for the production of biofuels (Szklo and Schaeffer, 2010) and creates land scarcity. In 1990, arable land scarcity was observed in nine countries, including the Netherlands, Egypt, and South Korea; by 2025, it is expected to be observed in at least 17 more countries, including vulnerable and more food-insecure nations like Somalia, Bangladesh, Kenya, Mauritania, and Yemen (Sears, 1995). Biodiesel that is derived from oilseeds—soybeans, rapeseed, and sunflower seeds, among others—often receives tax incentives and subsidies at the institutional level, and becomes a more profitable agricultural product than food, driving changes in land use (Szklo and Schaeffer, 2010). Most companies cultivate flexible crops, and choose between food and biofuel markets depending on international market prices (Antonelli *et al.*, 2015; Borras *et al.*, 2013; Hall, 2011).

Agricultural land has long been considered a safe and attractive investment, providing safety and liquidity of capital, safety and regularity of income, ease of management and low management expense. Compared with stocks and shares, its value does not fluctuate rapidly, it is a tangible asset, and it maintains a fair market value (Wheeler and Wheeler, 1953). Farmland can offer high returns with low risk, and is a good inflation hedge (Baker *et al.*, 2014). It can also be a risk-reducing element in investment portfolios. Increased demand for land from non-agricultural buyers attempting to hedge against inflation or to store their wealth was observed during the 2008 financial crisis (Baker *et al.*, 2014; Hüttel *et al.*, 2016; Jauernig *et al.*, 2023; Noland *et al.*, 2011).

Absent socio-economic shocks and crises, the volume and quality of investments depend on the investment climate (Moore and Schmitz, 2008)—the institutional and regulatory environment in which firms operate, defined by the central state (Dollar *et al.*, 2005; Moore and Schmitz, 2008). The investment climate is unfavorable if the government is highly bureaucratic and corrupt, and its provisions or regulations of infrastructure and financial services are inefficient. In this environment, firms cannot obtain reliable services, the returns on potential investments are low and uncertain, and one would not expect much accumulation and growth. In locations with good governance and a favorable business environment, returns and accumulation should be high (Dollar *et al.*, 2005). Furthermore, well-functioning land markets can contribute to rural development by increasing investment incentives, transferring land to more productive producers and increasing productivity, reducing the transaction costs of accessing credit, and increasing credit supply if there is effective demand for credit (Deininger, 2003).

1.2 Ukraine's agriculture

1.2.1 The past and current role of Ukraine's agriculture in global food supply and biofuel production

Immediately after the dissolution of the Soviet Union, agriculture in Ukraine accounted for one-fifth of Gross Domestic Product (GDP) and about 20% of the labor force (Geets (1992) cited in Johnson *et al.* (1994)). Nearly 70% of Ukrainian land was used in agriculture, most of which was arable land (Lerman *et al.*, 1995). The productivity of Ukraine's agriculture was higher than other Soviet republics: Despite having only 15% of the Soviet Union's total arable land resources, Ukraine produced about 24% of all grain, 22% of all meat, and 44% of all sunflowers in the Soviet Union between 1986 and

1990. Nonetheless, compared with the standards of most developed countries, it was "notoriously inefficient" (Johnson *et al.*, 1994; Lerman, 2001).

Currently, the country is a key contributor to global food security, and an important provider of feedstocks for the global biofuel market (Antonelli *et al.*, 2015; Food and Agriculture Organization, 2023; USDA Foreign Agricultural Service, 2022). Before Russia's 2022 invasion, Ukraine was among the top agricultural exporters in the world: the largest exporter of sunflower oil (50%), the third largest exporter of barley (18%), the fourth largest exporter of maize (16%), and the fifth largest exporter of wheat (12%) (European Commission, 2023). The country was also an important exporter of animal-derived products, belonging to the top ten global exporters of poultry (Movchan, 2022), and supplied substantial areas for biofuel feedstock production (Schaffartzik *et al.*, 2014).

The invasion had numerous negative consequences for Ukraine's economy, agricultural production and trade in 2022 and 2023. It resulted in a 29-35% fall in the country's real GDP. Approximately eight million people, or almost 20% of Ukraine's population, immigrated to other countries. The number of internally displaced people has reached 5.9 million as of the end of January 2023. Many professionals were conscripted into the army. High inflation depressed consumption of some food products. Abrupt currency devaluation and depletion of foreign currency reserves made the country dependent on donor aid (Tarassevych, 2023). Approximately 20% of Ukrainian territory was occupied by Russian forces. A substantial area of agricultural land could no longer be cultivated (European Commission, 2023). The supply of fertilizers from Russia and Belarus was disrupted (Statista Research Department, 2022b; Janzen and Zulauf, 2023). Farmers had to shift toward Ukrainian-made alternatives, and switch from grains to oilseeds that are cheaper to grow (The National Bank of Ukraine, 2023).

Due to Russia's blockade of Black Sea ports, Ukraine's agricultural exports fell sharply by over 90% in March, April and May 2022 compared with export volumes in the same months in 2021. From June onwards, export volumes grew, but they were still much lower than the same months in 2021: 79% lower in June, 57% lower in September, and 42% lower in October (European Commission, 2023). As a result, the share of agriculture in Ukraine‘s GDP decreased to 8.2% compared to 10.7% in 2021 (Solohub, 2023; State Statistics Service of Ukraine, 2023). Between 2010 and 2021, the share fluctuated between 7.4% in 2010 and 12% in 2015 (Statista Research Department, 2022a). Agricultural exports dropped by 15% in 2022 to 23.7 billion US dollars. Imports declined by 22% to 5.3 billion US dollars in 2023 (Tarassevych, 2023).

Despite the war, Ukraine is likely to maintain significant volumes of agricultural production and exports (Caprile, 2022; European Commission, 2023; Tarassevych, 2023). It is forecast that Ukrainian farmers will produce 60 million tons of grain in the marketing year 2022/23 and 47.1 million tons in 2023/24, and export 37.4 million tons of grain in 2022/23 and 27.5 million tons of grain in 2023/24 (European Commission, 2023). Trade between Ukraine and its partners will likely be limited by the ability of Ukrainian exports to leave from Black Sea ports. Ukrainian farmers may also have difficulties substituting necessary agricultural inputs that were previously imported from Russia and Belarus, such as fertilizers (Caprile, 2022; Janzen and Zulauf, 2023). Ukraine's agricultural production will likely be affected by its limited ability to use additional agricultural land due to military actions (Janzen and Zulauf, 2023). Potential shortages of agricultural products from Ukraine will likely be compensated for by products from countries like Poland, which has good agricultural and environmental conditions (Bórawski *et al.,* 2022).

Wars and armed conflicts do not only have economic and social consequences, but also negative environmental impacts due to the widespread contamination of soils with chemical and radioactive materials. This often prevents farmland from being used for a long period after the war or conflict ends (Koniuszewski, 2016; Yakovliev and Chumachenko, 2017). In addition, agriculture may be a source of income for people, who fled from the conflict areas to those districts of the affected regions that remained unaffected by the conflict (Baumann *et al.*, 2015). The agricultural sector may play an important role in the process of economic recovery that is central to economic development, reducing poverty, preventing destruction, and tackling violence (Soysa *et al.,* 1999). Facilitating access to land is critical for agricultural production (Hüttel *et al.*, 2016), and therefore, establishing and maintaining a well-functioning agricultural land market during and after the war are important for the development of the agricultural sector.

1.2.2 Land privatization and land market formation in Ukraine

Ukraine's land market formed as the country began transforming itself from a centrally planned economy to a market economy in the 1990s. The first significant land reform started when the 1990 Land Code was approved. It intended to redistribute state-owned lands among individuals, and allowed the leasing of land to agricultural producers, but prohibited buying and selling transactions and private land ownership. The 1992 version of the Land Code recognized state, collective, and individual land ownership (Wegren, 2002) and created the legal framework for the market transition that was initially accompanied by policy uncertainty and sharp declines in production, consumption, and productivity (Csaiki, 1990). Before 1992, few economies of scale, declining technical efficiency in crop production, and considerable variability in technical efficiency between farms were observed. Output levels declined due to increased input prices, decreasing food demand, and continuing state control. High nominal rates, decreased farm income, and uncertainties about the pace of the economic restructuring reduced farm investment. Governments tried to introduce short-term adjustment policies to stabilize farm income and food production, as well as longer-term initiatives to achieve monetary and fiscal stabilization, facilitate trade, and create competitive markets (Johnson *et al.*, 1994).

The need to increase the efficiency and productivity of agriculture motivated further macro-level reforms that aimed to eliminate state controls, liberalize prices, and introduce hard budget constraints. On the sectoral level, these changes included privatization of land, a shift to individual agriculture, and downsizing of farms. Privatization of state-owned land was accomplished by distributing paper shares to individuals, certifying their entitlement to a certain amount of land. To facilitate the transfer of land to new owners, 10% of the agricultural state- and collectively-owned land was allocated to a special "land reserve" that was used to distribute land for private (subsidiary) farming to people who were not members or employees of agricultural enterprises. Members of agricultural enterprises acquired another 15% of available farmland extracted from state and collective agricultural enterprises, for the purpose of private farming. The remaining 75% of farmland was supposed to be transferred to the collective ownership of members of agricultural enterprises, which was seen as a temporary transitional phase between state ownership and individual ownership of land (Wegren, 2002).

By January 1994, more than 80% of land continued to be used by state and collective farms, while over 13% was used by households and private farmers (Wegren, 2002). Over 60% of agricultural land in Ukraine had been transferred from state to collective ownership. Nearly 75% of farms had been reorganized and most of them had allocated land and asset shares to members. The number of independent private farmers in Ukraine exceeded 30,000, with an average farm size of 20 ha. They cultivated less than 2% of all farmland in Ukraine (Lerman, 1995).

In late 1995, further farm restructuring and rural privatization were facilitated by the participation of international actors, such as the International Finance Corporation, the United States Agency for International Development, and the British Know-How Fund. However, the results of their efforts were mixed. The reorganized farms had more economic freedom, more motivated employees, and better performance, but both reorganized and non-reorganized farms were not profitable and lacked productivity (Wegren, 2002).

The 2000 Land Code was significantly more liberal than its earlier versions. It allowed more freedom to conclude lease agreements for agricultural land, inherit land, and transfer land from state to communal ownership. Citizens of Ukraine received the right to privatize an average-sized land share free of charge. The number of landowners who wanted to lease out their land increased significantly. The ban on agricultural land sales remained in place and land transactions were mainly limited to leasing (Wegren, 2002). Such leasing arrangements could be an efficient and flexible way to transfer land to more productive producers, keeping transaction costs low compared with sales (Deininger, 2003).

Land market relations were significantly liberalized after Ukraine adopted the 2002 Land Code. However, it failed to create the necessary conditions for a well-functioning land sales market. Agricultural land sales were still prohibited. About 6.92 million owners of land shares (16% of the population) could not exercise their property rights, reducing the value of their land (Nivyevsky *et al.* (2015); Nizalov *et al.* (2016) cited in Kvartiuk and Herzfeld (2019)). Initially intended as a temporary measure, the moratorium on land sales has been extended many times (Kvartiuk and Herzfeld, 2019) and was finally lifted in July 2021. About 31 million ha of privately owned farmland were supplied to the market (Kvartiuk and Martyn, 2021). The sale of 10.5 million ha of state- and municipally-owned agricultural land remains banned (Plotnikov and Senyshyn, 2022).

The 2012 Land Code introduced mandatory auctioning of public land and stipulated that rental rights for state-owned agricultural land could only be acquired via an English auction procedure. Auctioning was introduced to standardize the procedures of transferring rental rights. Auction organizers received the right to choose a land plot for auction, could influence the use purpose and legal use limitations, and could set the level of the reserve price, entry fees, and other auction characteristics (Kvartiuk *et al.*, 2022). The auctions were criticized for lacking transparency and effectiveness, since they had to be held in person and organized by the Ukrainian State Service for Geodesy, Cartography, and Cadastre (also referred to as the State GeoCadastre). This created potential conflicts of interest and opportunities for manipulation. A reform attempt in 2018 involved providing an option to conduct auctions online on an electronic auction platform that was already used to auction seized property (Deininger *et al.*, 2022).

The investor discourse regarding Ukrainian farmland has been characterized by a strong focus on the fertility of black soil, however, this has not been enough to turn farmland into an attractive asset. Among the main factors that have impeded investments are the moratorium on land sales, and the low profitability of farming. The latter has fallen far below expectations, due to the weather conditions and microclimate, including the availability of water, and competition with other regions where black soil can also be found (Visser, 2017). After the moratorium on land sales was lifted, more than 56,000 sales agreements were concluded covering more than 143,000 ha of land (Plotnikov and Senyshyn, 2022). However, it is not possible to make any clear-cut conclusions, due to the effects of the war on Ukraine's economy and its land market.

1.3 Literature review

Several important studies investigated the issues surrounding Ukraine's land market formation after the country set out to transform itself from the centrally planned to the ideal model of agriculture in market economies that assumes private ownership of land, full transferability of use rights, and predominance of individual farms (Lerman *et al.*, 2002). These articles covered mainly

(i) the emergence and development of the agricultural land market in Ukraine, land reforms, and land privatization (see, for example, Johnson *et al.*, 1994; Lerman, 2001; Wegren, 2002);

(ii) the land market's efficiency and equity during and after the reforms were implemented (see, for example, Koester and Striewe, 1999; Gagalyuk and Valentinov, 2019), and

(iii) the role of large agricultural producers that emerged during the transition and presumably had some market power (see, for example, Deininger *et al.*, 2013; Graubner *et al.,* 2021).

These and other relevant most notable studies are reviewed below. Among the first researchers, Johnson *et al.* (1994) analyzed the market transition in the New Independent States (NIS). On the macro level, they concluded that the reforms were accompanied by policy uncertainty, structural adjustments, and a sharp decline in production, consumption, and productivity. On the farm level, they found that there were few economies of scale, declining technical efficiency in crop production, and considerable variability in technical efficiency between farms.

Lerman *et al.* (1995) further analyzed this structural change on the macro and farm levels. The results of a 1994 survey of farm managers, farm employees, and private farmers showed that Ukrainian reforms related to agricultural land privatization and the creation of shareholding farms were in their early stages. More than 60% of agricultural land in Ukraine had been transferred from state to collective ownership; among the collective and state farms surveyed, nearly 75% had reorganized and most of them had allocated land and asset shares to members. The number of independent private farmers in Ukraine exceeded 30,000; the average farm size was 20 ha. These private farmers cultivated less than 2% of farmland.

Koester and Striewe (1999) also investigated the performance of agriculture in Ukraine during the first decade after independence. Public enterprises were characterized by low liquidity and profitability. Many farms could not cover production costs. The proportion of Ukraine's GDP accounted for by agriculture dropped to 12% in 1996.

Lerman (2001) compared the progress achieved by the countries of the former communist bloc in Central and Eastern Europe and the NIS during the transition, and concluded that despite their common heritage, the reforms in these states diverged significantly from the start. Compared with the NIS, the Central and Eastern European countries achieved better performance following their economic and institutional reforms. There appeared to be a greater readiness among the governments of these countries to implement comprehensive, radical and deep economic and social reforms, including land reforms, individualization and restructuring of agriculture.

Wegren (2002) contrasted the land reforms that were implemented in Ukraine and Russia during the 1990s. His analysis shows that Ukraine followed a more conservative path than Russia, as state farms were not immediately restructured nor privatized, and significant restrictions on the land market were not lifted. However, after 2000, Ukraine seemed to introduce more liberal reforms than Russia, eliminating collective farms.

Swinnen and Heinegg (2002) attempted to explain differences in the procedures and progress of land reforms among the NIS, considering the historical legacies of the countries and their institutions, technology, and politics. They noticed weak demand for land privatization, except in countries and regions where collectivization was imposed only after the Second World War, more radical land reforms and de-collectivization in countries with labor-intensive agricultural systems, and the need for further political and land reforms.

Melnychuk *et al.* (2005) investigated the creation of the agricultural land market in Ukraine. They found that eliminating the state's monopoly on land ownership created the prerequisites for the development of an agricultural land market. However, the moratorium on agricultural land sales interrupted the development of the land market, as well as its infrastructure, including consulting agencies, brokerages, real estate agencies, and insurance companies. Agricultural land transactions in Ukraine were accompanied by bureaucratic land registration procedures, the lack of an integrated registration system for land and real estate rights, as well as little available market information regarding agricultural land prices, land demand and supply.

Lissitsa and Odening (2005) analyzed the performance of individual farms in Ukraine between 1990 and 1999. Their results demonstrate a decline in agricultural production and a 42% reduction in total factor productivity caused by a fall in technical efficiency. Agricultural enterprises that were relatively successful at the start of the transformation process became more successful over the eight-year period, whereas those that were relatively unsuccessful at the start became worse off.

Deininger *et al.* (2013) investigated the performance of large farms with more than 200 ha during the second decade of reforms between 2001 and 2011. They noticed that large farms achieved superior performance. This was attributed to district and farm-specific factors like access to infrastructure and managerial skills, rather than to expected economies of scale.

Gagalyuk and Valentinov (2019) explored how institutional turbulence gives rise to large enterprises called agro-holdings. Membership of an agro-holding may have been a strategy for Ukrainian agricultural enterprises to remain resilient amid severe institutional turbulence during the transition. However, the researchers found no evidence that the remarkable growth of agro-holdings was associated with superior efficiency.

Kvartiuk and Herzfeld (2019) analyzed the impact of the ban on land sales that limited landowners' right to dispose of their agricultural land plots. They concluded that the moratorium on land sales led to large distributional consequences that contradict the definition of land ownership. The ban forced landowners into a situation where they could neither earn a full income from their assets, nor could they transfer plots to others.

Graubner *et al.* (2021) investigated whether agro-holdings could exercise market power in local land markets. They concluded that farms affiliated with an agro-holding possessed (ceteris paribus) more land and set higher land rental prices compared with independent farms. The observed agro-holding farms were larger, they paid higher land rental rates, and could act as price leaders in local land markets.

Lerman and Sedik (2007) provided additional evidence on the performance of Ukraine's small and large farms, using the 2005 farm survey results of the Food and Agriculture Organization of the United Nations. They found no differences in performance and efficiency between individual small farms and large corporate farms established during the transition.

Since the launch of mandatory land auctions for state-owned land rentals, auctioneers have disclosed data that provide reliable new information about state-owned land transactions (Kvartiuk and Herzfeld, 2019). Several articles have analyzed this data, such as Kvartiuk *et al.* (2020), Deininger *et al.* (2022), Kvartiuk *et al.* (2022), Kvartiuk and Martyn (2021), Deininger *et al.* (2022), and Deininger and Ali (2023).

Kvartiuk *et al.* (2020) reviewed the recent land rental price developments in Ukraine. They found that average rental prices for state-owned land have substantially increased between 2013 and 2019. However, the majority of auctions were traditional English auctions and they were not competitive. Consequently, one-fifth of all analysed auctions did not take place because there were not enough participants. During 2018 and 2019, when auctions took place offline and online, land auctions were more competitive and more profitable - average winning bids were two times higher than average minimum bids.

Deininger *et al.* (2022) further analysed the shift to electronic auctions and found that it led to a near-instantaneous doubling of lease revenue. Local governments could have received annual lease revenue of 500 million US dollars if all state-owned land in Ukraine had been auctioned online since 2015. Land allocated competitively and in a decentralized way could improve social, economic, and environmental outcomes.

Kvartiuk *et al.* (2022) examined whether decentralized online auctioning of public agricultural land results in higher land prices compared with traditional auctioning via a centralized agency, and evaluated whether land-use concentration affected auction outcomes. They found that land plots auctioned in a decentralized way generate more revenue for local communities. Land concentration negatively affects land rental rates.

Kvartiuk and Martyn (2021) analyzed land sales transactions after the moratorium on land sales was lifted. They found large differences in land sales activity across Ukraine: Substantially more sales contracts were concluded in central and northern regions, whereas sales markets seemed to be the least active in the eastern and mountainous western oblasts. As of November 2021, the median price was approximately 32,000 Ukrainian hryvnia (UAH) per ha.

Deininger *et al.* (2022) estimated the effects of Russia's war on the area and expected yield of winter crops. Due to the war, they expected the winter crop area to reduce by 0.75 million ha, with 86% of the reduction due to economy-wide effects. Additionally, they expected the winter crop yield to fall by 15% or 4.2 million tons (particularly pronounced for small farms). Taking area and yield reduction together, the war-induced loss of winter crop output was expected to be about 20%.

Deininger and Ali (2023) further analyzed land market performance (registered sales or leases of agricultural and residential land) before and after Russia's invasion. They found that after the invasion the volume of agricultural land sold or leased exceeded that of residential land. The volume later reduced together with a fall in prices of between 15 and 20%, with little sign of speculative land acquisition. Observed mortgage market activity and credit access were below expectations.

Several further issues related to the land market have also been studied. For example, Zinych and Odening (2009) investigated the link between financing and investment in Ukrainian agriculture during the economic transition, using data collected from 529 farms in three Ukrainian regions between 2001 and 2005. They concluded that credit constraints and soft budget constraints significantly influence farms' investment. Credit constraints in Ukraine's agricultural sector were found to be more important than soft budget constraints.

Bojnec *et al.* (2014) further compared farm structures, agricultural financial systems, and government support in Slovenia and Ukraine and found some obvious differences. In Slovenia, family farms are the most common type of farm structure, while in Ukraine large agricultural enterprises play a more significant role. Many small and medium-sized farms in Ukraine need financial support, relying heavily on loans and borrowed capital. Capital market imperfections are one of the major constraints faced by farms in Ukraine, while in Slovenia, government subsidies and off-farm incomes mitigate such imperfections.

Ostapenko *et al.* (2020) analyzed conventional and organic enterprises to identify possibilities for the development of organic agriculture in Ukraine. Their results suggest that organic farming enterprises in Ukraine tend to produce higher output per ha than those engaged in conventional farming. However, the profitability of labor-intensive organic farming, especially in larger companies, remains low, and the share of organic products in Ukraine's agricultural exports remains small.

Shumilo *et al.* (2021) analyzed agricultural land appraisals based on the soil bonitet—a quantitative score representing natural soil fertility. They found that the soil bonitet score does not account for the dynamics of actual crop production on agricultural land, and is not crop-specific. Moreover, land appraisals are not correlated with the actual soil bonitet and should be improved.

1.4 Research aims

Factors that influence the outcomes of land auctions were briefly investigated. Kvartiuk *et al.* (2020), who analyzed them in the context of recent land rental price developments in Ukraine. Kvartiuk *et al.* (2022) and Deininger *et al.* (2022) focused mainly on the investigation of differences between offline and online land lease auctions. However, these studies did not consider several major influencing factors, such as competition and competitive bidding, factors that influence bidding decisions, and the role of lessor reputation.

Auction theory suggests that auction outcomes are mainly determined by competition among bidders and competitive bidding (Milgrom and Weber, 1982, 2000; Salant, 2014). Successful and profitable auctions need a sufficient number of bidders who submit competitive and meaningful bids (Salant, 2014). Inefficient auction design or poor quality of auctioned lots may discourage bidders from participating or placing competitive bids (Avery, 1998; Paarsch and Hong, 2006; Davis *et al.*, 2011; Salant, 2014), and prevent them from revealing their true willingness to pay (Hickman, 2010; Malmendier and Lee, 2011). Therefore, an understanding of the relationship between auction outcomes and the degree of competition, auction design and lot characteristics is very important for the formation of efficient policies (Brannman *et al.*, Klein and Weiss, 1987). Factors that prevent bidders from revealing their bid values, challenge the optimality of actual bidding decisions and the rationality of their behavior need to be investigated to prevent future revenue loss. Knowledge about factors that impact auction outcomes may help market participants to gather relevant information, make well-informed decisions, and improve the certainty and accuracy of their appraisals (Shepherd, 1997; Haynes, 2019).

Bidders may also make their participation and bidding decisions based on information about the lessor's reputation and trustworthiness. They may not be willing to rent land from lessors who have had numerous negative outcomes in the past, or the amount they are willing to pay may be reduced (Bar-Isaac and Tadelis, 2008). It is important to understand the influence of lessor reputation on auction outcomes, in order to improve auction efficiency and increase the revenue that lessors receive from agricultural land.

Therefore, the main research aim of this thesis is to investigate the influence of these factors on auction outcomes, such as the probability of agricultural land plots being rented out via online auction and the size of the winning bid. To achieve the aim of this thesis, three articles have been published:

- Myrna (2023) presented in Chapter 2 of this thesis aims to investigate the influence of online auction competition, active bidding, auction design characteristics, and farmland-specific properties on both auction outcome measures.
- Myrna (2022) presented in Chapter 3 aims to ascertain if factors—auction and property characteristics—that typically explain deviations from the dominant strategy of bidding the true value, can also explain bidding decisions to shade true values in online land auctions.
- Myrna & Teuber (2024) in Chapter 4 aims to analyze whether, over the first year of the project's implementation, regional agencies responsible for agricultural land management were able to build a positive reputation among tenants, who could observe publicly disclosed information about all previous auction outcomes.

1.5 Research hypotheses

The aims of this thesis and the articles mentioned above form the basis of research hypotheses. Myrna (2023) investigates the following hypotheses:

- Competition, measured as the number of bidders and the number of bids placed by each bidder, has a positive effect on the probability of auction success and winning bid amounts (Bajari and Hortacsu, 2003b; Capen *et al.*, 1971; McAfee and McMillan, 1987a; Ong *et al.*, 2005; Paarsch, 1992).
- Higher entry fees and reserve prices lead to higher winning bids, because bidders with higher willingness to pay participate and bid more assertively (Krishna, 2010; Lucking-Reiley, 2000a, 2000b; Lucking-Reiley *et al.*, 2006; Menezes and Monteiro, 2005). They, however, decrease the probability of auction success, because potential bidders with low values are likely to be excluded from the competition (Lucking-Reiley, 2000b; Reiss and Wolak, 2007).
- Bid increment amounts alter bidders' behavior (Hickman, 2010). Large bid increment amounts intimidate bidders and make them less willing to rent the plot, due to a fear of overbidding (Avery, 1998). Bidders shade their bids instead of bidding truthfully, which becomes an additional source of revenue loss (Hickman *et al.*, 2017).
- Plot size impacts auction outcomes, for example, because cultivation of a larger plot is less expensive and more convenient, increasing bidders' willingness to rent and to pay (see, for example, Hüttel *et al.*, 2013; Hüttel *et al.*, 2016a, b).

- The profitability of arable land, grassland and land for organic agriculture differs, leading to a different willingness to pay and different demand (Crowder and Reganold, 2015; Ong *et al.*, 2005; Ritter *et al.,* 2020).
- Better soil quality is associated with higher crop yields and has a positive impact on auction outcomes (Croonenbroeck *et al.*, 2020; Helbing *et al.*, 2017; Ritter *et al.*, 2015).
- Auction outcomes vary spatially and temporally (see, for example, Hüttel *et al.*, 2013; Hüttel *et al.*, 2016a, b).

Myrna (2022) reveals which auction and farmland characteristics are thought to have led to bidding errors and bid shading. The hypotheses are as follows:

- Bidders learn to behave in compliance with the dominant strategy, reducing the probability of bidding errors (Cooper and Fang, 2008; Garratt and Wooders, 2010; Garratt *et al.*, 2012; McGee, 2013).
- Bidders who participate longer develop a personal affinity to an auctioned good, and subsequently overbid rather than shade their bids (Wolf *et al.*, 2005).
- A competitive auction environment makes bidders more prone to overbidding rather than underbidding (Cooper and Fang 2008; Hou *et al.* 2009; Hüttel *et al.* 2013).
- Non-refundable entry costs are seen as 'sunk' and lead to a sunk cost fallacy (Athey and Haile 2007; McAfee *et al.* 2010; Augenblick 2016; Camerer and Weber 1999), whereby bidders are less willing to exit a situation as their financial commitments increase (Camerer and Weber, 1999; Augenblick, 2016).
- If bid increment amounts are not optimal, online auction participants shade their valuations instead of revealing them (Hickman *et al.* (2017), Hickman (2010), Hickman *et al.* (2012).
- Bidding errors can be attributed to intrinsic lot characteristics (Malmendier and Lee, 2011).

Myrna & Teuber (2024) consider the impacts of reputation-related factors on auction outcomes, and the strategies implemented by institutional lessors in response to this. The following hypotheses are investigated:

- A growing ratio of successful to unsuccessful auctions influences the beliefs of a potential tenant about the lessor. A better reputation has a positive impact on auction outcomes (Bar-Isaac and Tadelis, 2008). Lessors expect that the effect of a positive reputation will be sustained over subsequent periods and decrease the amount of effort (Holmström, 1999; Bar-Isaac and Tadelis, 2008).

- Higher preparation costs, a measure of lessor efforts, are expected to have a positive effect on auction outcomes, as they signal to bidders that the plot will not require substantial future expenditure, for example, for its registration (Bar-Isaac and Tadelis, 2008).
- The amount of time a seller or lessor has been in the market impacts auction outcomes, because reputation becomes more refined over time, and provides evidence of the lessor's true nature (*ibid.*).
- A greater number of previous auctions provides a larger volume of publicly known information about lessors and their previous auction outcomes, impacting bidders' decisions and auction outcomes (*ibid.*).
- A greater number of subsequent auctions also impacts bidding decisions, because bidders may implement some forward-looking strategies and participate in upcoming auctions (Anwar *et al.*, 2006; Salant and Cabral, 2019; Zeithammer, 2006).
- Bidding decisions are impacted by the availability of substitutes (Bar-Isaac and Tadelis, 2008). More substitutes are likely to be available in regions with larger amounts of farmland.

1.6 Conceptual and theoretical framework

The following section describes the concepts, theories, data and methodological approaches used in this thesis.

1.6.1 Online auctions

Computer-mediated or online auctions were developed and first implemented in the 1980s. They had many benefits and rapidly grew in popularity. Such auctions are used as efficient coordinating and social mechanisms for setting the prices of properties, efficient procurement mechanisms that may attract offers from numerous potential suppliers, highly visible distribution mechanisms that may attract a considerable number of potential bidders, and efficient allocation mechanisms for properties that are difficult to market through established distribution channels (Klein and O'Keefe, 1999).

Auction platforms may be centralized or decentralized. Centralized actions depend on third-party intermediaries and are often criticized for lacking data integrity, security, transparency, and traceability (Omar *et al.*, 2021). They may be a simple bilateral affair between one bidder and the auctioneer. Alternatively, they may involve collusion between several bidders and the auctioneer to jointly strike a deal, or corruption if the auctioneer is bribed to adjust the auction rules in favor of a bidder

(Lengwiler and Wolfstetter, 2000). Experience from developing and transition countries suggests that corruption is a major obstacle to the growth and development of auction platforms (Compte *et al.*, 2005). Similarly, empirical evidence from Ukraine's land market suggests that corruption was "endemic" in centralized land auctions (Deininger and Ali, 2023: 6). Responsible authorities either endorsed or were unable to resist corrupt practices. This often resulted in land being transferred to private parties below market value and in ways that impeded local development (Deininger *et al.*, 2021: 4). Therefore, online decentralized blockchain-based land auctions were launched in Ukraine in October 2018, to prevent corruption and gain experience of auctioning farmland online (The Cabinet of Ministers of Ukraine, 2017). Decentralized blockchain-based auctions can transform the auction process, eliminating intermediaries, ensuring transparency, traceability, fair bidding among bidders, and security, while reducing transaction costs (Omar *et al.*, 2021).

1.6.2 Agricultural land values

The generally accepted method of land valuation is to determine the normal or expected future income from the property to the landlord after deducting necessary expenses. Land values may be assumed to be private and independent (IPV), because farmers' estimates of land values may differ. Their future incomes and expenses vary depending on different factors, for example, the size of the farm. Small farms may produce higher estimates of the proportion of net farm income attributable to land, because they may include in land values at least part of their income from management and labor wages (Walter, 1946). Larger farms may generate higher incomes while benefiting from economies of scale (Croonenbroeck *et al.*, 2020). Local farmers might be better informed about the potential income generated from the land, and make more accurate appraisals, which could lead to different valuations of land characteristics (e.g., soil quality). Former tenants, who are better informed about a plot's true value, may have the first opportunity to purchase the plot if it is sold (Croonenbroeck *et al.*, 2020).

The prospective purchaser or tenant can compare their estimate of value with the prices being paid by others for comparable properties (Walter, 1946), if this data is available. Thus, in some cases, the assumption that land values are purely private and independent may be relaxed and the presence of commonly known information may also be assumed (Seifert and Hüttel, 2020).

1.6.3 Dominant bidding strategy

The format of blockchain-based land auctions is an English ascending-price auction. The format presumes that the bidder with the highest valuation or willingness to pay wins the auctioned lot, and pays the amount at which the second-to-last bidder dropped out, or a slightly higher amount (Milgrom and Weber, 1982; Haile and Tamer, 2003). The bidder's dominant strategy is to bid on their own valuation if their values are private and independent (Milgrom and Weber, 1982).

1.6.4 Auction results

Auction results may be evaluated from a revenue standpoint, based on the expected selling price, or from an efficiency of allocation standpoint, whereby the object ends up in the hands of the person who values it the most *ex post* (Krishna, 2010). The auctioning of state-owned farmland may be a means of adding rental income to local budgets, promoting business activities or developing a particular sector of the economy, and making sure that the property is used (Salant, 2014). Therefore, auction outcomes may be presented as the probability of the plot being rented and the size of the winning bid. Both auction outcome measures may be impacted by competition among bidders, auction characteristics, and property features (see, for example, Ong *et al.*, 2005).

1.6.5 Exclusion of bidders with low values and bidding errors

We consider an ascending-price online auction with a reserve price and an entry fee. A bidder with a value that is lower than the minimum bid will not find it worthwhile to participate, because if they were to win, they would make a loss from the auction (Paarsch and Hong, 2006; Krishna, 2010). A bidder with a value below the entry fee will also not find it worthwhile to participate (Krishna, 2010). In the presence of both a reserve price and an entry fee, a bidder, who bids their valuation, will find it worthwhile to participate only if the difference between the winning bid (or second highest bid) and the minimum bid at least covers the entry fee (McAfee and McMillan, 1987b; Menezes and Monteiro, 2005; Tan and Yilankaya, 2005; Krishna, 2010).

Although bidders are supposed to stick to the dominant strategy, their deviations from it are often referred to in economic literature as bidding errors (McGee 2013, Garratt and Wooders 2010, Garratt *et al.* 2012, Cooper and Fang 2008). If they do not bid their true value, overbidding or underbidding may occur. In the IPV settings, underbidding will be observed if bidders place bids lower than their true willingness to pay, while overbidding will occur if they place bids higher than their actual willingness to pay (Malmendier and Lee, 2011). Absent information about the true willingness to pay, bidding errors may be observed if bidders fail to follow the dominant strategy during an auction.

In the present case, underbidding was observed if bidders failed to place the highest bid, so that the difference between the winning bid and the minimum bid could at least compensate for the entry fee. The actual observed deviations from theoretically rational bidding behavior imply that bidders either entered the auctions with very low willingness to pay, or some factors existed, such as auction design problems or property particularities that discouraged bidders from submitting higher bids.

1.6.6 Lessor reputation

Seller reputation and trustworthiness are considered to be important intangible assets that influence the behavior of both buyers and sellers, transaction success rates, and final prices (Bar-Isaac and Tadelis, 2008; Bar-Isaac, 2007; Melnik and Alm, 2005; Bergemann and Hörner, 2018; Holmström, 1999; Gilkeson and Reynolds, 2003; Janas and Oljemark, 2021). Bar-Isaac and Tadelis (2008) in their unifying seller reputation framework suggest that potential buyers are expected to learn about the sellers' reputations by observing past transactions. The seller or lessor is expected to be rewarded for having a good reputation based on observations of their previous successful transactions, and punished for having a bad reputation. The online land auction platform under consideration provides detailed information about all past auction outcomes. Potential tenants, who were previously unaware of this information, may use it to form an impression about the regional agency responsible for land management. This information could have an impact on bidding decisions.

Sellers or lessors can also consider this information and increase or decrease their efforts in response to a success or failure, both of which will have an impact upon their future successes and revenues (Bar-Isaac and Tadelis, 2008). The baseline scenario is that good sellers with an infinite time horizon will not sustain a high level of effort, because after buyers learn about a seller's positive reputation, the seller's incentive to exert the same level of effort in subsequent periods diminishes (Holmström, 1999; Bar-Isaac and Tadelis, 2008).

1.7 Data and methodological framework

1.7.1 Online blockchain-based land auctions and collected data

The auctions consisted of several stages: preparation, bidding, and closure. Preparation starts when a state or community agency interested in leasing out an agricultural plot (landowner) submits documentation with the lot description to the local agency responsible for auctioning the land. It contains information about plot dimensions, the use designation of the land, location, cadaster number, a draft rental agreement, minimum bid, bid increment, entry fee, security deposit values, and contact information of the landowner. An auction is scheduled within 30 calendar days after the receipt of the documents. Potential bidders—natural or legal persons, who have indicated their intent and willingness to rent the lot—register on the OpenMarketLand webpage no later than three days before the auction. The online auction platform is run by the state enterprise "System of electronic trade of seized property" in partnership with the State GeoCadaster. All interested bidders pay a non-refundable participation fee (approximately 30 euros) and a security deposit (as a rule, 5% of the reserve price). Prospective bidders may inspect the property. After the application procedure concludes, the person obtains the status of a bidder (The Cabinet of Ministers of Ukraine, 2017).

Bidding starts at a minimum reserve price listed in the announcement. Each subsequent bid must be raised by at least the minimum bid increment. The increment size (as a rule, 0.5% of the reserve price) may vary from auction to auction. Jump bidding is allowed. The bidding ladder is displayed to each auction participant who is logged in. Simultaneous bidding on more than one auction is permitted (The Cabinet of Ministers of Ukraine, 2017).

If a bid higher than the previous one (or the reserve price) is submitted, the auction is extended for an additional three minutes, starting from the submission time stamp of the last bid. If no further bids are submitted within three minutes, the auction closes (The Cabinet of Ministers of Ukraine, 2017). The winning bidder is obligated to sign the protocol electronically within 15 minutes of the auction ending. If the winner does not sign the protocol within a specified period, the auction may be resumed. It is possible to repeatedly auction an unsold plot (The Cabinet of Ministers of Ukraine, 2017).

The successfully concluded auction results are published on the OpenMarketLand webpage. The published information includes details received by the auctioneer from the landowner, as well as the auction results. However, the identities of the bidders and winners are hidden. The final concluded agreement details are kept confidential (The Cabinet of Ministers of Ukraine, 2017).

As of September 2019, 4,890 online land auctions have taken place, corresponding to 97,004.93 ha of agricultural land. Approximately 50,000 ha of land have been rented. The majority of the land lease contracts auctioned have a seven-year duration. Around 150 contracts auctioned were ten-year rental agreements, of which about half were successfully concluded. Some contracts offered a lease of up to 25 years, although these plots largely went unrented and made up a very small share of the sample. The publicly disclosed auction data were collected to serve as a sample for this study.

1.7.2 Methodological approaches used in data analysis

There are two well-known approaches to analyzing auction data: reduced-form estimation, which investigates whether auction theory predictions hold in observational data, and structural estimation, used for conducting comparative institutional design (Gentry *et al.*, 2018: 192-193). Studies that estimate the influence of auction and property characteristics on auction outcomes usually employ a reduced-form approach and estimate the influence of factors using regression analysis (Hüttel *et al.*, 2016; Ong *et al.*, 2005). The same method was also used in this thesis. The estimation relied on several well-known regression models. They are briefly described below. Detailed descriptions of all models and estimation methods are presented in the relevant chapters of the thesis.

1.7.2.1 *A two-stage Heckman model with sample selection (Articles 1 and 3)*

In Myrna (2023); Myrna and Teuber (2024), Heckman's (1979) two-stage estimator was used to estimate the influence of competition, auction and property characteristics (in both articles) and reputation-related variables (in Myrna and Teuber (2024) only) on auction outcomes. In such models, the first-stage regression is a probit regression model for the full sample, to determine the selection of observations for the second-stage regression. The dependent variable of the probit regression was a binary variable indicating auction success, which was assigned a value of 1 for successful auctions, and a value of 0 for unsuccessful auctions. The dependent variable of the second-stage regression represented winning bid amounts that were known only if an auction was successful. The two-stage estimator accounted for the correlation (or covariance) between the two equations' error terms, to correct bias from non-randomly selected samples (Verbeek and Nijman, 1992; Vella, 1998; Verbeek, 2004). The estimation was carried out using maximum likelihood. In Myrna and Teuber (2024), both stages of the Heckman model were estimated separately to check the robustness of the estimated coefficients.

1.7.2.2 *A one-stage heteroscedastic probit regression model (Article 2)*

In Myrna (2022), the estimation of the impact of auction and property characteristics on the propensity to underbid was conducted using a one-stage heteroscedastic probit regression. The dependent variable was given the value of 1 if underbidding was observed—the winning bid exceeded the reserve price by less than the entry fee—and otherwise a value of 0 was assigned. It was modelled as a function of the relevant auction and property characteristics. Heteroscedastic probit regression was chosen to address a non-constant variance across observations that may affect the consistency of the estimators of probit model parameters (Holden, 2011). The model was estimated by maximum likelihood and used a cluster-robust variance-covariance matrix. To check the robustness of the estimated coefficients, two model specifications were estimated.

1.7.2.3 The method of mediation analysis (Article 3)

In Myrna and Teuber (2024), the estimation of one model was carried out using mediation analysis. In the first stage, a multiple regression model with the winning bid amount as a dependent variable was estimated. Per-hectare costs for lot preparation in this model were used as an independent mediator variable. In the second stage, preparation costs were used as a dependent variable. Both were modelled as functions of reputation-related variables, as well as auction and property characteristics. The model was estimated using a quasi-maximum likelihood method that employed the maximum likelihood method to fit the parameters and allowed the residuals of two equations to be correlated (Acock, 2013). The relaxation of the assumption of the error terms' uncorrelatedness results in smaller standard errors and measurement errors are less likely to occur (VanderWeele, 2016).

1.8 Statement of contribution

This work was not a part of any research project. I was the lead author in all cases and relied on the help of my first supervisor. Below I describe my contribution to each article.

Myrna (2022, 2023)

I developed the concepts, research goals and aims, and methodology of both papers, conducted literature reviews, identified the sources of data, collected the samples for estimation, conducted the statistical analysis, and prepared the manuscripts. Prof. Teuber reviewed both manuscripts and provided noteworthy feedback. I prepared the final manuscripts and submitted them to the relevant journals. Prof. Teuber also gave advice on how to respond to the comments, questions and suggestions of anonymous reviewers.

Myrna and Teuber (2024)

I developed the concept, research goals and aims, and methodology of the paper, reviewed relevant literature, described relevant concepts, formulated and estimated regression models, conducted statistical analysis, and wrote the draft manuscript. Prof. Teuber provided noteworthy comments during this process. Both authors discussed the results and reviewed and commented on all versions of it. I prepared the final manuscript and submitted it to the journal. Both authors considered the feedback of the anonymous reviewers, and suggested how the paper could be improved to meet the journal's criteria for publication.

1.9 Outline of the thesis

The remainder of the thesis is structured as follows. Chapter 2 investigates how the competition among bidders, active bidding, and the auction and property characteristics affect auction outcomes. Chapter 3 analyzes the effects of factors that may have prevented bidders from revealing their true willingness to pay and, therefore, prevented auctions from maximizing revenue. Chapter 4 analyzes the role of lessor reputation and investigates if the previous auction outcomes impacted the winning bid amounts and the probability of auction success. It also analyzes how land management agencies responded to increasing numbers of successful or unsuccessful auctions. Chapter 5 discusses the findings and concludes the thesis.

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2 Competition in Online Land Lease Auctions in Ukraine: Reduced-form Estimation

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Abstract

An innovative pilot project to facilitate the transparent transfer of rental rights for publicly owned agricultural land via an ascending-price online auction was launched in Ukraine in October 2018. This paper analyses publicly disclosed auction data and investigates how competition, auction design characteristics, and farmland-specific properties influenced the auction outcomes. This information is factored into the probability of the plot being rented (*i.e.* auction success) and the size of the winning bid (*i.e.* rental rates). The analysis was conducted using an independent private values framework, employing a mixed-effects model with sample selection. Estimation results confirmed that a higher number of bidders and more active bidding lead to a significantly greater probability of auction success and higher rental rates.

Keywords: agricultural land market, competition, land privatization, online auctions

2.1 Introduction

Auctions have often been employed to transfer agricultural land rights from the state to private hands in Central and Eastern Europe (Hartvigsen, 2014). In Ukraine, a pilot project to facilitate the transparent transfer of rental rights for publicly-owned agricultural land via online auctions was launched in October 2018 (Kvartiuk and Herzfeld, 2019). It aimed to replace the old face-to-face auction scheme, to prevent corruption in the field of land relations, to gather experience in auctioning farmland online, and to increase the efficiency of state-owned land management (The Cabinet of Ministers of Ukraine, 2017). This mechanism is also planned to be employed in the future.

The core format of these auctions is an ascending price or English auction. The process is conducted by an auctioneer who sets a reserve price which bidders may then raise by predetermined bid increments, as long as there compete at least two actual bidders. The auction ends when the other interested bidders have dropped out, and the highest bidder is still interested. The bidder with the highest valuation or willingness to pay wins the auctioned lot and must pay the auctioneer the amount approximately equal to the second highest bid. Thus, the lot is sold at a price largely determined by both buyer competition and the valuations that bidders attach to the object or property (Krishna, 2010). Increased competition in an ascending price auction results in a higher probability of auction success and a higher winning bid, if bidders' valuations are assumed to be independent and private (Bajari and Hortacsu, 2003; Brannman *et al.,* 1987; Milgrom, 1985; Ong *et al.*, 2005; Paarsch, 1992). In turn, failing to comprehend the subtleties of competitive bidding may lead to a loss in revenue and inefficient allocation due to auction failure (Milgrom, 1989; Ong, Lusht and Mak, 2005). Apart from the competition, the auction design – selected by the auctioneer through setting a minimum reserve price, entry fee, and bid increment values – as well as the personal preferences of the winner, the preferences of other bidders, and/or the intrinsic qualities of the lot being sold may also influence the outcome (Milgrom and Weber, 1982; Bulow and Klemperer, 1996).

Existing research dealing with land market auctions employ two main estimation approaches: reduced-form estimation – to measure and test whether auction theory predictions hold in observational data, and the structural estimation of auction data - to deliver the primitives for conducting comparative institutional design (Gentry *et al.*, 2018: 192-193). A reduced-form approach was employed, for instance, in the study by Hüttel *et al.* (2013) in order to investigate how the number of bidders and the share of non-agricultural investors impacted the outcome of land auctions during land privatization in eastern Germany. Hüttel *et al.* (2016b) analyzed how institutional sellers within the privatization process affected price formation in agricultural land markets, using German reunification as the case study. Croonenbroeck *et al.* (2020) applied both methods to investigate asymmetries among bidders that presumably led to non-competitive price formation. Seifert and Hüttel (2020) used structural estimation to test for the existence of a common component in agricultural land valuations and the potential implications of a winner's curse.

The issues surrounding the development of Ukraine's agricultural land market has received attention from economists. However, most studies focus on institutional changes and the role played by agroholdings (see, for ex., Melnychuk *et al.* (2005), Gagalyuk and Valentinov (2019), Graubner *et al.* (2021)). Few studies have addressed the issues related to online farmland lease auctions in Ukraine. Among them, Kvartiuk and Herzfeld (2019) reviewed these auctions within the broader context of land market development, identified a number of the most probable land market reform scenarios, and evaluated them from a welfare economics perspective. They explored how the proposed changes to land relations would affect the traditional business models with varying types of producers, forecasted the general market dynamics, and analyzed the potential effects on agricultural production. Kvartiuk *et al.* (2020) provided an overview of the recent developments in leasing state-owned agricultural land in Ukraine, utilizing the publicly available data on state-owned and communal land auctions. The authors shed some light on the positive relationship between competition and farmland prices, but they did not consider the factors affecting the probability of auction success and the price relation to it in detail. Therefore, a research gap exists.

The following trends were apparent in the auction data released. During the first year of the project, roughly 55% of all land plots auctioned were rented. Successful land auctions with higher rental prices also featured a greater level of competition. Around 30% of the auctions failed because either no participants registered or no bids were placed by registered bidders. The results of the remaining 15% of auctions were nullified due to parties refusing to sign a rental agreement, court decisions, or other legislatively prescribed reasons (The Cabinet of Ministers of Ukraine, 2017). The absence of competition contributed to a high percentage of auction failures which affected the efficiency of allocation such that plots were not rented. Further, low levels of competition led to lower final rental prices, thus impacting the landowner's revenue.

Given this background, this paper aims to investigate the effect of competition on the probability of a plot being rented and the size of the winning bid. It also aims to consider the impact of other auction- and plot-specific characteristics which may affect auction outcomes. A reduced-form approach provides the sufficient analytical means to achieve the aim of this paper. Since one of the aims of the pilot project was to gather experience in auctioning agricultural land electronically, an analysis of the outcomes and the factors which influenced the outcomes can contribute to the ongoing debate about land market efficiency.

Many agricultural land market studies assume that the land valuations used by bidders, *i.e.* the highest price they are willing to pay for an auctioned object or property, are private and independent (see, for ex., Croonenbroeck *et al.*, 2020; Myrna, 2022; Ooi *et al.*, 2006). It means that they derive private values for an object or property from its consumption or use alone and do not assign a value based upon of how much they will earn on the secondary market (Krishna, 2010: 3). The information about other bidders' willingness to pay conveys little useful information about the true value of the auctioned property (Paarsch and Hong, 2006). Private and independent land estimates are based on potential revenue from cultivation which is likely different for each farmer depending upon their crop yield expectations, their individual knowledge and ability, wealth and overall net income flow, and their time and risk preferences (Croonenbroeck *et al.*, 2020). Contrary to this, valuations can be considered common knowledge (CV) in land auctions if bidders are able to derive their valuations from publicly available statistical information that is available at least at an aggregate level or from resale prices (Seifert and Hüttel, 2020).

The estimation in the present paper was conducted within the independent private values paradigm (IPVP) for the following reasons: First, it is assumed that farmers have different operating costs for land cultivation and yield different returns, thus the bidders can have different valuations for the same plot. Second, the auctions were designed for the transfer of rental rights from the state or local community to private hands, and the subleasing of a rented plot was not necessarily foreseen by rental agreements, so bidders could not always assign valuations based upon subsequent lease pricing. In addition, there were few reliable sources of statistical information on aggregate level rental pricing (Kvartiuk, Herzfeld, *et al.*, 2020), and bidders had limited opportunities to form their estimates based on this information. Finally, bidders' estimates are based on farmer-specific land cultivation costs, therefore, the information about competitors' willingness to pay revealed during an auction conveys no useful information about the actual value of the property.

The remainder of the paper is structured as follows: The next section provides a brief description of the land market and online land lease auctions in Ukraine. It is followed by a description of the auction data collected. Then research hypotheses are drawn and a regression model is specified. The main estimation results and findings are discussed and conclusions are then drawn at the end of the paper.

2.2 Land market in Ukraine, collected data, and methodology

2.2.1 The land market in Ukraine and the land leasing process via online auction

The privatization of state-owned agricultural land and land market formation in Ukraine started after the dissolution of the Soviet Union. In three decades, three-fourths of all available farmland has been privatized. The rest, around 10 million hectares (ha), remains state-owned (Kvartiuk and Herzfeld, 2019). Consequently, the supply side is now represented by the following entities: The Ukrainian State Service for Geodesy, Cartography, and Cadaster (often referred to as the State GeoCadaster) and its regional agencies which manage the publicly owned land, the communities who received lands from the State GeoCadaster during the process of decentralization that started in 2014, and private landowners who received their lands in the process of privatization. The demand side is represented by a small number of large agricultural producers who either own or rent large areas of land, on the one hand, and numerous small-scale farms, on the other. A substantial share of land is used by farms between 500 ha and 4,000 ha, which likely represent enterprises established upon the basis of former collective farms. About 18% of the land is cultivated by enterprises (often referred to as "agroholdings") with operational areas of more than 10,000 ha. Small farm owners often face difficulties expanding their farms and competing with large-scale enterprises, largely due to a constrained access to credit (*ibid.*).

To facilitate the transfer of agricultural land rental rights from the state and community level to private hands, online auctions have been used since October 2018. The auction process consists of several stages. Preparation starts when a land managing agency interested in leasing an agricultural plot (landowner) submits documentation with the lot description to the state agency responsible for auctioning (auctioneer).The documents contain information detailing the landowner's contact information, property dimensions, land use designation, location, contract term, cadaster number, normative appraisal and a rental agreement draft, along with the auction specifics including the minimum reserve price, bid increment level, entry fee, security deposit, etc. After receipt of the documents, an auction is scheduled within 30 calendar days. After the electronic auction announcement is published, potential bidders - natural persons or legal entities which have indicated their willingness to rent the lot - can register on the OpenMarketLand webpage no later than three days prior to the auction. The online auction platform was launched by the state enterprise "The system of electronic trade of seized property" in partnership with the State GeoCadaster. Interested bidders then register for the auction(s) and pay the requisite participation fees – a non-refundable entry fee and a security deposit (as a rule, 5% of the reserve price). Before the auction begins, prospective bidders may inspect the property. After the application procedure is over, the person or entity obtains the status of a bidder. The auction begins if at least two bidders are registered, separate from the case of a repeated auction. In a repeated auction, at least one bidder is required to register (The Cabinet of Ministers of Ukraine, 2017).

These online land auctions do not follow a "button auction" model, which is to some extent typical of an English auction, where bidders must reconfirm their continued participation after each round of bidding (the model of a "button auction" is explained in Milgrom and Weber (1982) in detail). Here, bidders do not need to indicate that they are still active when the auction proceeds. Bidding starts at the minimum reserve price, and bidders cannot place bids below this amount. This value is listed in the electronic land auction announcement. The landowner determines the reserve price, and the auctioneer must approve it (The Cabinet of Ministers of Ukraine, 2017). Each subsequent bid must be raised by the minimum bid increment at least, and the increment size may vary from auction to auction. This amount is often determined as 0.5% of the reserve price. Jump bidding and simultaneous bidding on more than one auction is permitted. Each logged-in auction participant is able to view the bidding ladder.

The bidding closes when no subsequent bid is submitted within a certain time interval (after three minutes have passed) after the auction begins. If a bid higher than the previous one (or the reserve price) is submitted, the auction is extended for an additional period of time (three minutes), starting from the submission time stamp of the last bid. If no further bids are submitted within the three minutes, the auction closes and the highest bid is published on the website (such auctions are also termed "soft close" auctions (Duffy and Ünver, 2008)). The winning bidder is then obligated to sign the protocol electronically within 15 minutes after the auction ends. If the winner does not sign the protocol within a specified period, their resulting bid is nullified by the system. Three minutes after a consequent bid nullification, the auction may be resumed. It is possible to repeatedly auction an unsold plot (The Cabinet of Ministers of Ukraine, 2017).

The successfully concluded auction results were published on the OpenMarketLand webpage. The published information includes the documentation which the auctioneer received from the landowner, as well as the auction outcome. The auction is considered successful if it concluded with a signed land rental agreement. For these auctions, the winning bid was also disclosed. Information about the bidders and winners and the final agreement details are kept confidential. The auction is considered a failure if no bidders registered or the registered bidders did not submit a bid equal to or higher than the reserve minimum. The results of the auction can also be cancelled due to the parties refusing to sign a rental agreement, court decisions, or other legislative reasons (*ibid.*).

2.2.2 Data and descriptive statistics

The publicly disclosed auction data was collected to serve as the sample for the present research. Between October 2018 and September 2019, 4,890 online land auctions took place, consisting of 97,004.93 ha of agricultural land. Approximately 50,000 ha of land was rented.

The majority of the land lease contracts auctioned have a seven-year duration. Around 150 contracts auctioned were ten-year rental agreements of which about one half were successfully concluded. Some contracts offered a lease of up to 25 years (mainly for gardening, organic agriculture, and reserve land), nevertheless these plots largely went unrented and made up a very small share of the sample (14 observations out of 4,890 auctions).

Using the collected dataset, a sample for the model estimation was selected. Outliers from the variable representing the plot area below the 1st percentile and above the 99th percentile were removed to drop unusually small and large plots (97 transactions). Additional 197 plots with normative appraisals above 50,000 UAH/ha were also deleted because were likely the plots not solely used for cultivations, were also mistakenly documented, or could represent plots with buildings or infrastructural objects. Some observations were also likely documented by mistake: Five winning bids below the reserve price and 10 successful auctions with only one registered bidder were deleted. Finally, only first-time sales were considered. Therefore, 53 repeated transactions were dropped. The final sample consists of 4,528 land plots, of which 2,547 successful auctions (or 56.25% of all auctions) were held. Failed and cancelled auctions make up 28.36% and 15.39% of the sample respectively. The descriptive statistics for the full sample, the subsample of winning bids, and the subsample of auctions that failed and were nullified are presented in Tables 2.1-2.3.

Table 2-1. Descriptive statistics for the full sample (N=4,528)

Variable	Mean	Median	Std.Dev.	Min.	Max.
Number of bidders	2.388	2.000	1.938	0.000	18.000
Number of bids per bidder	12.066	1.000	30.313	0.000	378.800
Reserve price (UAH/ha) [1]	1366.706	1069.370	1092.203	7.217	20361.99
Entry fee (UAH)	966.327	960.500	27.350	800.000	1003.500
Bid increment (UAH/ha)	6.839	5.361	5.469	0.036	101.810
Area (ha)	16.287	10.983	16.506	0.006	108.102
Soil quality (Index) [2]	63.766	67.290	17.863	19.470	91.330

Table 2-2. Descriptive statistics for the subsample of successful auctions (N=2,547)

Variable	Mean	Median	Std.Dev.	Min.	Max.
Price (UAH/ha)	3445.053	2371.066	3436.417	40.493	27381.07
Number of bidders	2.981	2.000	1.488	2.000	14.000
Number of bids per bidder	21.028	3.500	37.822	0.200	378.800
Reserve price (UAH/ha)	1403.861	1205.956	1023.345	23.000	8540.010
Entry fee (UAH)	964.732	960.500	27.525	800.000	1003.500
Bid increment (UAH/ha)	7.024	6.030	5.128	0.115	42.700
Area (ha)	17.156	12.000	16.567	0.614	108.102
Soil quality (Index)	64.405	66.690	17.028	19.470	91.330

Table 2-3. Descriptive statistics for the subsample of auctions that failed or were nullified (N=1,981)

Variable	Mean	Median	Std.Dev.	Min.	Max.
Number of bidders	1.625	1.000	2.168	0.000	18.000
Number of bids per bidder	0.543	0.000	5.020	0.000	84.200
Reserve price (UAH/ha)	1318.935	872.719	1173.356	7.217	20361.99
Entry fee (UAH)	968.378	960.500	26.994	800.00	1003.500
Bid increment (UAH/ha)	6.602	4.388	5.871	0.036	101.810
Area (ha)	15.170	9.952	16.364	0.600	100.00
Soil quality (Index)	62.946	67.520	18.855	19.470	91.330

Source: Author's tabulation based on OpenMarketLand data (2018-2019).

As follows from the data, the auctions were characterized by a relatively low level of competition. On average, two bidders participated per auction and 12 bids were placed by each bidder per auction.

[1] All bids are listed in Ukrainian Hryvnias (UAH), 1 Euro corresponded to approximately 30 UAH (The National Bank of Ukraine, 2019).

[2] No integrated index (similar to an *Ackerzahl* that is widely used in Germany) that captures updated and comprehensive assessment of soil quality is used in Ukraine. Instead, the existing soil quality assessment procedure is rather complicated, while its outcome includes a list of subject-specific indicators that are difficult to utilize in econometric models. The presented soil quality index can be considered only as an approximation. The assessment was made by agricultural groups and subgroups of soils. The evaluation criterion is the average long-term yield of a group of cereals without taking the costs into account. Soils with the highest cereal yield were evaluated with 100 points (The Ukrainian Academy of Sciences, 1978; Grachev, 2019).

Successful auctions were slightly more competitive with roughly three rivals for each lot and each of them placing 21 bids on average. The average number of bidders and the average number of bids placed per auction fluctuated over time as can be seen in Figure A1 in Appendix A.

Winning bids (only observable for successful auctions) ranged between 40.49 and 27,381.07 UAH/ha (see Table 2.2). The average winning bid (3,445.05 UAH/ha or about 115 Euro/ha) was more than 2.5 times higher than the average reserve price. A median value of the reserve price was 3 times higher than the winning bid. The average rental rates also fluctuated over time (see Figure 1). They decreased in November 2018, then increased until January 2019, then decreased through to June 2019, and fluctuated over the final three months.

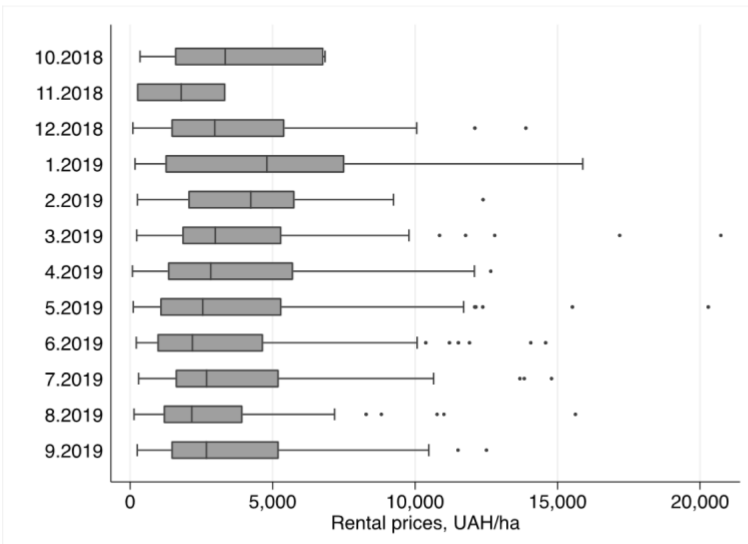

Figure 2-1. Temporal evolution of average rental prices in UAH/ha.

Source: Author's calculation, based on OpenMarketLand data (2018-2019).

Tables 2.1-2.3 also shows that over the entire period, the highest reserve price was 20,361.99 UAH/ha, with the mean value at approximately 1366.71 UAH/ha and a median value of 1069.37 UAH/ha. The entry fees varied between 800 UAH and 1003.50 UAH. The average entry fee and its median value were almost equal in all subsamples. The value of the minimum bid increment varied between 0.04 UAH/ha and 101.81 UAH/ha with an average value of 6.84 UAH/ha and a median value of 5.36 UAH/ha. The average increment value for successful auctions was only 0.19 UAH/ha higher. The mean and median increment values were also almost equal in all samples.

Tables 2.1-2.3 show that the size of auctioned plots ranged between 0.01 and 108.1 ha. The average rented plot size was 17.16 ha. It was greater than the average unrented plot size by almost 2 ha. Average soil quality varied between 19.47 and 91.33, with a mean of 62.95-64.41 in three samples. The values indicate a generally high level of productivity for the agricultural land auctioned.

Soil quality is closely related to and primarily determined by plot location. The data contains information about auctioned plots situated in all of Ukraine's 24 regions and 369 districts. Map B1 in Appendix B shows the percentage of concluded contracts on the district level. The percentages range between about one-fifth of auctions being successful in districts that belong to the southern region of Zaporizhzhya, to more than two-thirds being successful in districts that belong to the northern, western and eastern regions. The average rental prices also differed between districts (see Maps B2 in Appendix B). More expensive land rental pricing is concentrated in the central regions of the country. Regions with higher rental rates were often characterized by a greater level of auction competition (see Maps B3 and B4 in Appendix B).

The parcels auctioned represent a variety of land use designations. Arable land constitutes the largest share of auctioned agricultural land (84% of all parcels available and of plots rented, 85% of plots that were not rented), as can be seen in Table 2.4. Almost 10% of the offered and rented plots were grassland and plots neighboring electrical networks. About 5.74% of auctions (6.32% of successful auctions and 5% of failed and nullified auctions) had rental pre-conditions that the land be used for organic agriculture, gardens or reserves.

Table 2-4. Transaction shares by farmland purpose

Group	*Full sample*		*Winning bids only*		*Cancelled and failed auctions*	
	Number of plots	Share (%)	Number of plots	Share (%)	Number of plots	Share (%)
Arable land	3826	84.50	2139	83.98	1687	85.16
Grassland	442	9.76	247	9.70	195	9.84
Other purpose	260	5.74	161	6.32	99	5.00
Total:	4,528	100.00	2,547	100.00	1,981	100.00

Source: Author's tabulation based on OpenMarketLand data (2018-2019).

A testing phase was conducted during the first months of the project's implementation. It was used for technical optimization, thus only a few auctions took place during October-November 2018 (see Table 2.5.). During this period, the auctioneer, landowners and bidders could gain respective experience. The growing popularity of online auctions was observed after the successful testing phase.

The number of auctions per month increased from 10 in October 2018 to 842 in September 2019. Similarly, the total number of failed and cancelled auctions increased (OpenMarketLand, 2018-2019).

Table 2-5. Number of observations per month

Month	Number of plots auctioned	Share in the total number of auctions, %	Number of successful auctions	Share in the total number of successful auctions, %	Number of cancelled and failed auctions	Share in the total number of cancelled and failed auctions, %
10.2018	10	0.22	9	0.35	1	0.05
11.2018	6	0.13	3	0.12	3	0.15
12.2018	266	5.87	167	6.56	99	5.00
1.2019	168	3.71	90	3.53	78	3.94
2.2019	150	3.31	82	3.22	68	3.43
3.2019	561	12.39	355	13.94	206	10.40
4.2019	432	9.54	241	9.46	191	9.64
5.2019	517	11.42	294	11.54	223	11.26
6.2019	502	11.09	303	11.90	199	10.05
7.2019	485	10.71	257	10.09	228	11.51
8.2019	589	13.01	299	11.74	290	14.64
9.2019	842	18.60	447	17.55	395	19.94
Total:	4,528	100.00	2,547	100.00	1,981	100.00

Source: Author's tabulation based on OpenMarketLand data (2018-2019).

2.2.3 Research hypotheses and specification of the empirical model

Many studies assume that auction characteristics and property features affect the probability of auction success and the size of the winning bid (see, for ex., Ong *et al.*, 2005). If ascending price auctions are treated under the IPVP, the price should increase monotonically as the number of bidders increase (Paarsch, 1992; Bajari and Hortacsu, 2003b). The effect of competition can also be measured by the number of bids placed by each bidder: A greater number of bids should also have a positive price effect (Capen *et al.,* 1971; Ong *et al.*, 2005). In addition, a larger number of bidders and bids should positively affect the probability of a plot being rented (McAfee and McMillan, 1987; Ong *et al.*, 2005).

Entry fees and reserve prices are intended to exclude bidders who have valuations below these amounts (Krishna, 2010). However, those who participate have higher valuations and are expected to bid more assertively (Lucking-Reiley, 2000a, 2000b; Lucking-Reiley *et al.*, 2006; Menezes and Monteiro, 2005). Therefore, it is expected that both instruments lead to higher winning bids. In turn, reserve prices and entry fees set too high may also dissuade potential bidders from entering the competition (Lucking-Reiley, 2000b; Reiss and Wolak, 2007). This may increase the probability of auction failure.

Bid increments can substantially alter bidders behavior (Hickman, 2010): They may engage in bid shading instead of revealing their actual valuation, which may become an additional source of revenue loss (Hickman *et al.*, 2017). It may be expected that larger bid increments may have a negative effect on winning bids. Large price increases are seen as such that they may intimidate competitors (Avery, 1998). So, one may assume that if bidders see a large sum for each bid increment, they may become less willing to rent a plot – fearing to overpay.

There is a good deal of land market research dedicated to estimating the effect of plot size on land pricing, yet this relationship is ambiguous (Hüttel *et al.*, 2016a, b). Some studies (see, for ex., Hüttel *et al.*, 2013; Hüttel *et al.*, 2016a, b) argue that arable land cultivation and other farming activities are better facilitated if there is one large plot at the farmer's disposal, thereby reducing transaction and machinery costs and resulting in a willingness to pay more for land. Maddison (2000) suggests that the per-hectare price may be independent from plot size but found no conclusive evidence for this hypothesis. Ritter *et al.* (2020) concluded that one can expect a negative size-price relationship for very small and very large plots and a positive relationship for medium-sized plots. Absent a consensus among these studies, a theoretical prediction regarding the price-size relationship is challenging. In turn, Xu *et al.* (1993) suggest that buying or renting a larger plot usually implies having access to greater financial resources and may be of lower demand. So, it is assumed that larger plots are more likely to remain unsold.

Land use designations are likely to have influenced final rental prices. This follows the premise (see, for ex., Ritter *et al.*, 2020) that arable land is expected to have a higher price compared to grassland, due to a lower profitability rate on the latter. Following the same logic, organic farming is associated with higher profitability when compared to conventional agriculture, but tend to have lower yields. In addition, land suitable for organic agriculture is scarcer globally (Crowder and Reganold, 2015), so it was assumed that organic agricultural farmland may also be more expensive than arable land, however, this effect is to be determined. In turn, it is difficult to predict the exact effect which land use designations have upon the probability of an auction being successful, because there is no study that estimates the effects. However, it seems reasonable to capture this effect too, because different property characteristics may affect the probability of auction success (Ong *et al.*, 2005).

Soil quality is a common indicator of farmland productivity in land market research. Better soil quality is associated with higher crop yields which has a positive impact on farmland prices (Croonenbroeck *et al.*, 2020; Helbing *et al.*, 2017; Ritter *et al.*, 2015, to name a few). More productive land is also assumed to have higher demand. Thus, higher soil quality is expected to have a positive effect on the probability of auction success.

The collected auction data was analyzed, employing a reduced-form approach that allows for testing whether theoretical predictions hold for the observational data (Gentry *et al.*, 2018). To come up with consistent and efficient parameter estimates a mixed-effects model with endogenous sample selection was chosen, because of the following reasons. First, since successful auctions constitute only 55% of the sample, non-random selectivity can be a serious issue leading to biased coefficient estimates (Verbeek, 2004; Kyriazidou, 2007). For ex., non-random sample selection may be attributed to the presence of a binding reserve price that led to a truncated distribution of bids: Only bidders who have valuations exceeding the reserve price participate in the auction (Paarsch and Hong, 2006: 61-62). To correct for this bias, Heckman (1979) developed a two-stage estimator. In its first stage, the equation coefficients that determine selection are estimated using a probit regression model for the full sample. The dependent variable of the selection equation equals 1 if the dependent variable of the equation of interest is observed, and 0 if it is unobserved (Verbeek, 2004: 229). The important parameter which makes a two-stage estimator different from the estimation of a regression model and a probit model independently is the correlation coefficient (or covariance) between the two equations' error terms (Verbeek, 2004: 229). Therefore, the second stage is complicated by the standard errors that have to be adjusted to account for the first step estimation (Vella, 1998).

In the works of Verbeek and Nijman (1992) and Kyriazidou (2007), Heckman's two-stage estimator was extended to account for the panel data structure and the presence of potential unobserved heterogeneity. The extended models with sample selection require two correction terms to be included in the equation of interest corresponding to the conditional terms of the panel-level error terms and observation-level errors in the equation of interest given the selection. The parameters for these correction terms are the covariances between panel-level errors in both equations and between their observation-level errors respectively (Verbeek and Nijman, 1992).

Second, the data used for the estimation is comprised of the transactions which are treated as pseudo-panel data consisting of a series of independent non-overlapping cross-sections (such data structures are common for real estate transactions (see, for ex., Baltagi *et al.* (2013)). The sample does not contain auctioned land plots situated in all Ukrainian districts (see, for ex., Map B1 in Appendix B). Thus, it is assumed that administrative units are randomly selected from a larger population. Moreover, there may be some unobserved district-specific factors and characteristics leading to a lack of independence among plots within the same settlement. Therefore, the between-district variability was modeled as a random effect. A random-effects regression model with endogenous sample selection for pseudo-panels is an extension for the same estimator for balanced panels (Wooldridge, 2013, 2019), but the order of observations included in the panels is being ignored and the panels' length can vary, allowing for the random effects transformation parameter to vary (Wooldridge, 2019).

Third, the possible omitted variable bias that is often seen as another serious issue in hedonic models (Kuminoff *et al.*, 2010) was addressed by adding time and spatial fixed effects. The time dummies were used to account for the observed temporal variation of prices and auction outcomes. Evidence for the suitable applicability of fixed time effects in random-effects regression models to account for the potential presence of a time trend can be found in the works by Bell *et al.* (2019) and Bell and Jones (2014). The first three months of auctions were chosen as a reference category, because the testing phase was characterized by a limited number of auctions. To capture the effect of regional factors, like the structure of the regional economy, its infrastructure, and neighborhood characteristics (Nilsson and Johansson, 2013), spatial fixed effects (region-level dummy variables) were added to both stages of the model. Spatial fixed effects in hedonic models efficiently "absorb the bias from omitted variables" (Kuminoff *et al.*, 2010: 158-159) and have to be specified at a relatively coarse scale (Abbott and Klaiber, 2011). The reference region is the central Ukrainian region of Cherkasy, which has above-average land rental prices and an average share of successful auctions when compared with other regions. Table 2.6 summarizes the hypotheses used in the model, defines and introduces notations for the variables.

Table 2-6. Hypotheses and definition of variables

Characteristic	Notation	The hypothetical effect of the variable on	
		The probability of auction success	Rental rate
Dependent variables			
Auction success	$Outcome_{in}$		
Final per-hectare price	P_{in}		
Independent variables			
Auction specific characteristic			
Number of bidders	$Bidders_{\mathrm{in}}$	Positive	Positive
Number of bids per bidder	$Bids_{\mathrm{in}}$	Positive	Positive
Entry fee	$\mathrm{E_{in}}$	Negative	Positive
Reserve price	RP_{in}	Negative	Positive
Bid increment	$\mathrm{I_{in}}$	Little evidence, negative is assumed	Negative
Plot-specific characteristics			
Plot area	$\mathrm{A_{in}}$	Negative	No consensus among studies
Land use purpose	$Landuse_{kin}$		
Arable land		Reference	
Grassland		No evidence	Lower than arable land
Other land, including the land for organic agriculture		No evidence	Higher than arable land
Soil quality	$\mathrm{Q_{in}}$	Positive	Positive
Month	$Month_{min}$	Temporal variation is assumed	
Location	$Region_{jin}$	Spatial dependencies are assumed	

The selection process is modelled in Equation 1. It contains all variables listed in Table 2.6 which are used as selection covariates:

$$Outcome_{in} = 1(\alpha_1 Bidders_{\mathrm{in}} + \alpha_2 Bids_{\mathrm{in}} + \alpha_3 E_{in} + \alpha_4\, RP_{in} + \alpha_5 I_{in} + \alpha_6\, A_{in} + \alpha_7 Q_{in} + \sum_k \zeta_k\, Landuse_{kin} + \sum_j \eta_j\, Region_{jin} + \sum_m \kappa_m\, Month_{min} + u_{1in} > 0) \quad (1)$$

where $Outcome_{in}$ takes a value of 1 if a winning bid is observed, and a value of 0 if no winning bid is observed, and $\alpha_1$to α_7, ζ_k, η_j, κ_m are regression coefficients to be estimated, u_{1in} is a composite error term that consists of a panel-level error term and observation-level errors. The index i refers to districts and n denotes plots within the respective district.

The equation of interest is given by:

$$\log(P_{in}) = \beta_1 Bidders_{\text{in}} + \beta_2 Bidders_{in}^2 + \beta_3 Bids_{\text{in}} + \beta_4 E_{in} + \beta_5 \log(RP_{in}) + \beta_6\ I_{in} + \beta_7 \log(A_{in}) + \beta_8 Q_{in} + \sum_k \gamma_k\, Landuse_{kin} + \sum_j \delta_j\, Region_{jin} + \sum_m \theta_m\, Month_{min} + u_{2in} \quad (2)$$

where β_1 to β_8, γ_k, δ_j, θ_m are regression coefficients to be estimated and u_{2in} is a composite error term.

For model identification the selection equation of a two-stage model should contain more independent variables than the equation of interest (Clougherty *et al.*, 2015; Mulligan and Rubinstein, 2008; Schwiebert, 2012) or by functional form (Escanciano *et al.*, 2016; Lewbel, 2019). Escanciano *et al.* (2016) suggest that the latter "does not require an exclusion restriction for identification, since identification is obtained by parameterization of the joint error distribution in the selection and outcome equations". It allows parameters to be identified and accurately estimated. In addition, Tables 2.1-2.3 indicate that some variables in the sample (for ex., the one that represents the number of bids per bidder has a mean value of 21 and the median of 3.5 for successful auctions) have skewed distributions. It prevents assuming a normal distribution (Altman and Bland, 1995). In this case, a (logarithmic) transformation may be needed to make them normally distributed (Altman and Bland, 1996).

To avoid functional misspecification, a multivariate Box-Cox procedure was applied. Variables "final per-hectare price", "reserve price", and "plot area" were entered log-transformed in Equation 2. The variable "number of bidders" is entered into Equation 2 in linear and quadratic forms to allow for a non-linear relationship. Heteroskedasticity-consistent standard errors (White, 1980) allowed for increasing the efficiency of the parameter estimates.

2.3 Main estimation results and discussion

The estimation results are shown below. Table 2.7 presents the results for the selection equation, proceeded by the estimated coefficients for the equation of interest reported in Table 2.8. The respective correlation coefficients, number of observations, and results of a Wald test presented at the end of Table 2.8 are reported for both tables. The selected auction- and farmland-specific variables influence the agricultural land rental prices and the probability of an auction's success as indicated by their statistically significant coefficients of the Wald test. The correlation coefficients between the two equations' panel-level error terms and between the observation-level errors in all models are significantly different from zero. It justifies the use of the model that corrects the possible selection bias.

The estimation results show that competition significantly impacts auction outcomes: If an additional bidder registers, the probability of auction success increases and the resulting price increases by 41.4%. Similar results were found for arable land (40.4%) and grassland (54.8%). The quadratic term of the number of bidders reflects a slight reduction in the expected positive effect if the number of bidders increases further. The increase in the number of bids is also associated with a higher chance of an auction being successful, and each additional bid leads to a 0.8% price increase. This generally meets the expectations. Analogous results have also been reported by other land auction-related studies (Ong, Lusht and Mak, 2005; Hüttel *et al.*, 2013; Croonenbroeck, Odening and Hüttel, 2020).

The estimation shows that the relationship between per-hectare reserve prices and winning bids is positive: A 1% higher reserve price is associated with a 0.68-0.69% higher final price. Its effect on the probability of auction success is not significant in all three models. The positive price effect complies with the theory and meets the expectations, because bidders with low valuations are assumed to be excluded (Krishna, 2010). Larger entry fee values have no significant effect on prices and on the probability of auction success.

Table 2-7. Estimation results for the selection equation

	Model 1 (full sample)		Model 2 (arable land)		Model 3(grassland)	
	Coef.	**Rob. Std. Err.**	**Coef.**	**Rob. Std. Err.**	**Coef.**	**Rob. Std. Err.**
Dependent variable = outcome (1 if the price is observed, 0 if otherwise)						
Auction characteristics						
Number of bidders	**0.176**	**0.037**	**0.167**	**0.038**	**0.339**	**0.092**
Number of bids	**0.115**	**0.022**	**0.119**	**0.025**	-	-
Entry fee (UAH)	-0.003	0.002	-0.002	0.002	-0.004	0.004
Reserve price (UAH/ha)	0.001	0.000	0.001	0.000	-0.000	0.000
Minimal bid increment (UAH/ha)	**-0.112**	**0.032**	**-0.113**	**0.034**	-	-
Farmland characteristics						
Area (ha)	**-0.006**	**0.002**	**-0.006**	**0.002**	-0.006	0.005
Soil quality (Index)	0.001	0.003	0.003	0.004	-0.029	0.011
Farmland purpose factor variable						
Arable land	*Reference*		-	-	-	-
Grassland	0.037	0.123	-	-	-	-
Other farmland	-0.003	0.151	-	-	-	-
Monthly variables						
October, November, December 2018	*Reference*		*Reference*		*Reference*	
January 2019	-0.233	0.227	-0.114	0.253	-	-
February 2019	**-0.431**	**0.199**	**-0.492**	**0.204**	-	-
March 2019	0.057	0.166	0.064	0.184	-	-
April 2019	-0.007	0.182	-0.044	0.197	-	-
May 2019	0.186	0.175	0.100	0.186	-	-
June 2019	0.285	0.165	0.273	0.172	-	-
July 2019	0.111	0.184	0.009	0.194	-	-
August 2019	0.195	0.211	0.215	0.218	-	-
September 2019	-0.070	0.225	-0.102	0.238	-	-
Regional variables						
Cherkasy	*Reference*		*Reference*		*Reference*	
Chernihiv	0.258	0.239	0.318	0.255	-0.230	0.678
Chernivtsi	0.019	0.270	0.275	0.305	-	-
Dnipro	-0.200	0.174	-0.237	0.194	-0.077	0.500
Donetsk	0.322	0.207	0.373	0.233	0.411	0.514
Ivano-Frankivsk	-0.071	0.205	0.051	0.204	-	-
Kharkiv	-0.205	0.367	-0.206	0.392	-0.286	0.479
Kherson	0.330	0.205	**0.481**	**0.231**	-0.045	0.595
Khmelnytskyi	0.008	0.201	0.111	0.210	-0.725	0.772
Kyiv	-0.019	0.315	0.109	0.315	-	-
Kirovohrad	**-0.606**	**0.225**	**-0.710**	**0.256**	0.079	0.474
Lviv	-0.105	0.240	0.179	0.264	-	-
Luhansk	**1.124**	**0.315**	**1.267**	**0.355**	-	-
Mykolaiv	0.048	0.168	0.039	0.191	**1.490**	**0.644**
Odesa	**0.602**	**0.181**	**0.649**	**0.185**	-	-
Poltava	-0.352	0.384	-0.126	0.409	-0.151	0.701
Rivne	0.397	0.270	0.536	0.279	-	-
Sumy	0.442	0.259	**0.537**	**0.266**	0.791	0.794
Ternopil	0.399	0.217	0.480	0.249	0.993	0.567
Transcarpathia	0.296	0.290	0.273	0.321	-	-
Vinnytsya	0.209	0.240	0.292	0.281	0.551	0.665
Volyn	**0.594**	**0.219**	**0.723**	**0.233**	-	-
Zaporizhzhya	**-0.708**	**0.383**	**-0.650**	**0.399**	-	-
Zhytomyr	-0.231	0.278	-0.130	0.284	-	-
Cons.	1.665	1.860	1.187	1.984	5.018	3.985

Note: Statistically significant coefficients are highlighted ($p < 0.05$).

Table 2-8. Estimation results for the equation of interest

	Model 1 (full sample)		Model 2 (arable land)		Model 3 (grassland)	
	Coef.	**Rob. Std. Err.**	**Coef.**	**Rob. Std. Err.**	**Coef.**	**Rob. Std. Err.**
Dependent variable = price (UAH/ha, log)						
Auction characteristics						
Number of bidders	**0.414**	**0.046**	**0.404**	**0.049**	**0.548**	**0.066**
Number of bidders (squared)	**-0.024**	**0.004**	**-0.023**	**0.005**	-	-
Number of bids	**0.008**	**0.001**	**0.008**	**0.001**	-	-
Entry fee (UAH)	0.002	0.001	0.002	0.001	0.002	0.003
Reserve price (UAH/ha, log)	**0.676**	**0.064**	**0.687**	**0.069**	**0.674**	**0.117**
Minimal bid increment (UAH/ha)	0.007	0.011	0.008	0.011	-	-
Farmland characteristics						
Area (ha, log)	0.013	0.015	0.019	0.014	-0.068	0.098
Soil quality (Index)	**0.003**	**0.002**	**0.004**	**0.002**	0.005	0.005
Farmland purpose factor variable						
Arable land	*Reference*		-	-	-	-
Grassland	-0.019	0.065	-	-	-	-
Other farmland	0.005	0.070	-	-	-	-
Monthly variables						
October, November, December 2018	*Reference*		*Reference*		*Reference*	
January 2019	**0.185**	**0.080**	**0.190**	**0.080**	-	-
February 2019	**0.266**	**0.099**	**0.323**	**0.092**	-	-
March 2019	0.127	0.070	**0.156**	**0.072**	-	-
April 2019	0.088	0.075	0.132	0.079	-	-
May 2019	0.142	0.075	**0.170**	**0.079**	-	-
June 2019	0.001	0.077	0.020	0.078	-	-
July 2019	0.146	0.090	**0.215**	**0.098**	-	-
August 2019	-0.015	0.096	-0.009	0.096	-	-
September 2019	0.068	0.096	0.105	0.099	-	-
Regional variables						
Cherkasy	*Reference*		*Reference*		*Reference*	
Chernihiv	0.004	0.127	-0.022	0.130	-	-
Chernivtsi	0.163	0.160	0.073	0.168	-	-
Dnipro	-0.031	0.101	-0.022	0.099	-	-
Donetsk	**-0.211**	**0.106**	-0.201	0.116	-	-
Ivano-Frankivsk	0.020	0.114	-0.026	0.113	-	-
Kharkiv	0.013	0.133	-0.006	0.136	-	-
Kherson	-0.121	0.112	-0.189	0.118	-	-
Khmelnytskyi	0.045	0.125	0.016	0.128	-	-
Kyiv	0.128	0.173	0.089	0.175	-	-
Kirovohrad	0.163	0.104	0.188	0.116	-	-
Lviv	0.216	0.126	0.163	0.129	-	-
Luhansk	-0.067	0.113	-0.090	0.128	-	-
Mykolaiv	0.084	0.106	0.051	0.109	-	-
Odesa	**-0.206**	**0.098**	**-0.229**	**0.099**	-	-
Poltava	0.212	0.135	0.144	0.147	-	-
Rivne	-0.096	0.143	-0.145	0.148	-	-
Sumy	-0.064	0.103	-0.078	0.110	-	-
Ternopil	0.185	0.143	0.061	0.134	-	-
Transcarpathia	-0.144	0.159	-0.186	0.191	-	-
Vinnytsya	0.164	0.136	0.122	0.129	-	-
Volyn	-0.168	0.131	-0.184	0.134	-	-
Zaporizhzhya	0.225	0.157	0.194	0.157	-	-
Zhytomyr	0.152	0.141	0.122	0.142	-	-
Cons.	-0.550	0.961	-0.111	0.964	**4.147**	**0.704**
Corr. between panel-level error terms	**-0.913**	**0.021**	**-0.905**	**0.023**	**-0.688**	**0.157**
Corr. between observation-level errors	**-0.600**	**0.149**	**-0.647**	**0.141**	**-0.588**	**0.270**
Number of observations	4,528		3,826		444	
i.a. selected observations	2,547		2,139		242	
Wald chi2 / Prob > chi2	2359.67	**0.000**	**2025.04**	**0.000**	**-**	**-**

Note: Statistically significant coefficients are highlighted ($p < 0.05$).

Larger bid increments have a negative effect on the probability of auction success, yet have no significant price effect. The negative effect larger bid increments have on the probability of auction success complies with the hypothesis. Large increments could intimidate potential bidders and deter them from entering or bidding, as Avery (1998) suggest. If they enter, the bidding could potentially exceed private individual valuations and result in overbidding or the submission of a very high bid. Once the winner realizes that winning the auction in question did not constitute an optimal outcome, they might refuse to sign a contract (Hou *et al.* (2009), Hüttel *et al.* (2013)). This would lead to both revenue loss, land misallocation and would necessitate a repeated auction.

The estimation results revealed a negative relationship between the probability of auction success and plot size. This result may be explained by the fact that larger plots are in lower demand due to the budget constraints of bidders, as results published by Xu *et al.* (1993) indicate. Furthermore, there is evidence that for each unit higher in the soil quality index, a 0.3-0.4% higher per-hectare rental rate is expected. The findings meet the expectations: Cultivating more fertile soil is associated with higher crop yields, higher annual net returns, and higher demand for land, as numerous land market studies conclude (see, for ex., Croonenbroeck *et al.*, 2020; Myrna *et al.*, 2019; Ritter *et al.*, 2019, 2015).

Price fluctuations over time also exist, which is in line with expectations. Compared to the first three months, average prices went up in January, February, March, May, and July slightly. However, one cannot speak about a distinct increasing time trend and the coefficients may reflect the presence of intra-annual changes in market conditions. No significant effect of time on the probability of auction success was observed, apart from February, where the probability of auction success decreased compared with the first three months. Moreover, the months, when higher prices are observed, are not necessarily the months, when more successful auctions took place.

The results further confirm that the location of auctioned land matters. Compared with the central region of Cherkasy, the average rental rates in two rather industrial than agricultural south-eastern regions of Donetsk and Odesa were lower. The estimated effects are in line with other land market studies that attribute differences in land prices to structural variations in the regional economy and the role agriculture plays in it (Nilsson and Johansson, 2013), existing infrastructure, and other factors being of consequence (Hüttel *et al.*, 2013). Auctioned plots located in different regions have a different probability of being rented, as confirmed by significant coefficients in up to eight regions out of the 24 regions considered. In comparison to Cherkasy, where approximately 51,5% of auctions were successful, higher probabilities of auction success were found in the four south-eastern regions of

Kherson, Luhansk, Mykolaiv and Odesa, in one western regions of Volyn, and one northern region of Sumy. The probability of auction success was lower in the regions of Zaporizhzhya and Kirovohrad.

2.4 Conclusions and limitations

Factors influencing online auction outcomes and the role of competition has hitherto been largely overlooked by researchers addressing the development of Ukraine's land market. The aim of this paper has been to bridge this gap, analyse the auction results, and investigate the central hypothesis that greater competition positively impacts the probability of auction success and leads to higher winning bids. The impacts which other auction- and plot-specific characteristics have on auction outcomes have also been factored into consideration. Considering this case, this paper seeks to contribute to the discussion about the importance of competitive bidding in online auctions. The research persuasively confirms that the number of bidders and the number of bids placed per auction are useful measures of auction competition. Some interesting results related to the effect of auction design characteristics which have before been overlooked were found, such as the effect of minimum bid increments on the probability of auction success. Furthermore, the empirical paper results contribute to the ongoing, deeply rooted and lively debate about the design of Ukraine's land market and how to improve its efficiently. This discussion was started after the dissolution of the Soviet Union and has gained momentum in the last few years in light of the process of agricultural land market liberalization. Transferring public property rights through an auction is not a new phenomenon. It has been argued by Krishna (2010) that one of the most important uses of auctions has been to facilitate the transfer of assets from public to private hands in Eastern Europe and the former Soviet Union. However, transferring farmland rental rights via online auction represents an interesting institutional innovation that needs not only to be efficiently implemented but also to be thoroughly conceptualized.

The results of this paper reveal the main factors influencing auction outcomes. Competition has the most pronounced positive impact upon auction outcomes. Higher winning bids may also be achieved by means of setting higher per-hectare reserve prices. However, auction theory suggests that this auction design parameter may also introduce inefficiencies by deterring the entry of bidders with a lower willingness to pay. Therefore, if landowners want to ensure that the land is cultivated instead of generating higher revenues from the lease agreement, they will not find it reasonable to set larger reserve prices. In the opposite case, these amounts may be set higher to increase auction revenues.

Bidders and landowners may consider that higher prices are to be expected if land is more fertile and that regions where agriculture plays an important role in the structure of the regional economy (mainly located in central Ukraine) tend to have higher land rental prices. However, these regions are not necessarily those, where farmers are willing to rent public agricultural land by means of online auctions. Some temporal variation in auction outcomes was also observed. This suggests that some intra-annual market changes may have affected the pricing. However, they were not significant enough to speak about a distinct time trend. Besides, the greater the size of the plot is associated with the lower probability of a successful auction outcome.

The existence of three important limitations of this study should not be ignored. First, the reduced-form approach only allowed the paper to examine the main hypothesis, and to gain a broader perspective of online land lease auctions in Ukraine and its functional environment. Second, the publicly disclosed auction data does not include information about the identities of bidders. Absent this information, symmetry among bidders was assumed and the estimations could not account for the presence of some market power exercised by agroholdings over small farmers and former cooperatives. Land market studies suggest that buyer asymmetries may arise from the size of a firm, their production constraints, and/or the possession of better information (Croonenbroeck *et al.*, 2020) and may affect farmland prices (Curtiss *et al.*, 2013). Third, it was also assumed that bidders' valuations are independent and private. Under certain circumstances the land values could also be considered under the common values framework (Seifert and Hüttel, 2020). These aspects need to be addressed in future research.

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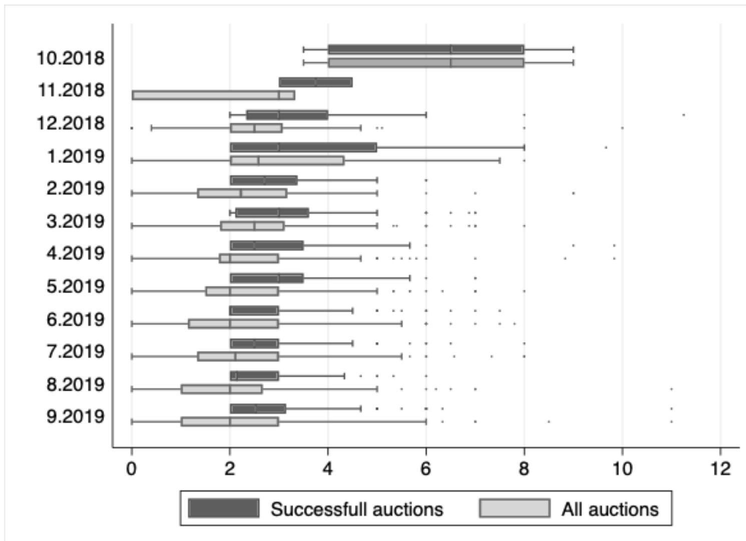
Appendix A

(a) average number of bidders



(b) average number of bids per bidder

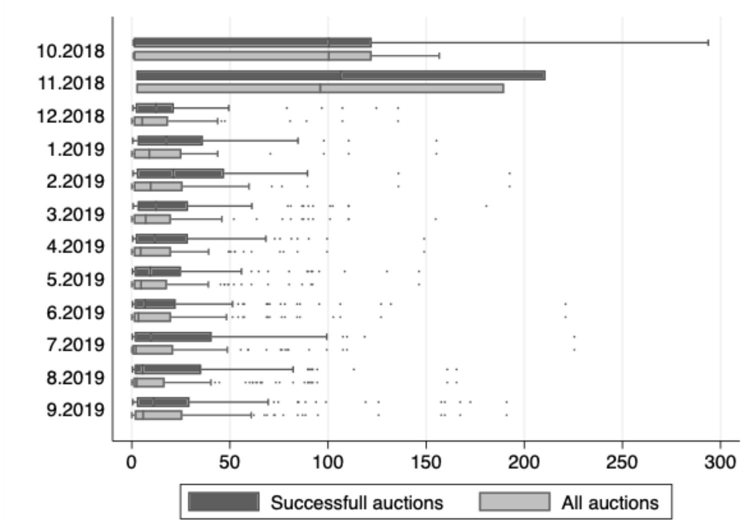
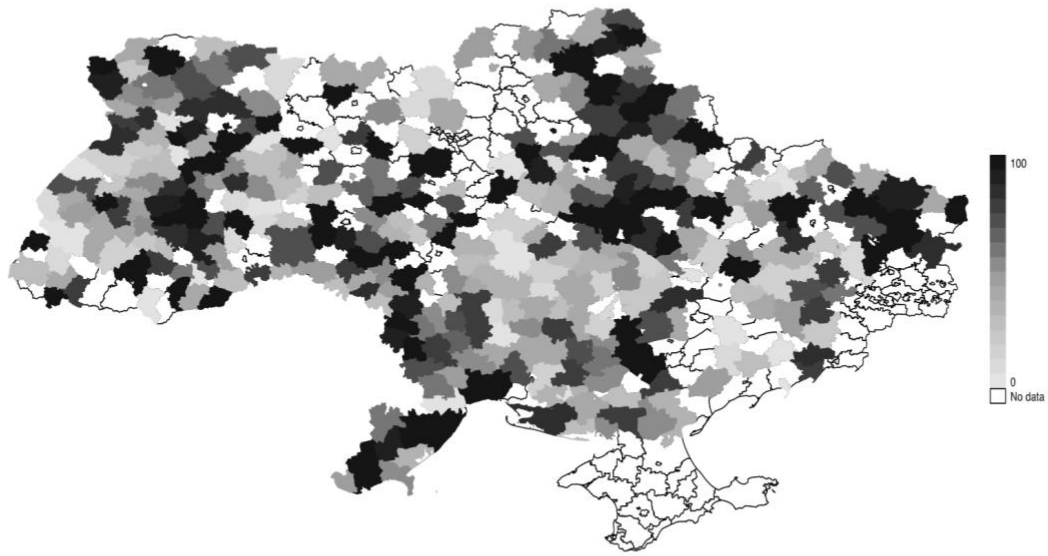


Figure A 2-1. Dynamics of auction competition measured (a) by the average number of bidders per auction and (b) by the average number of bids per bidder.

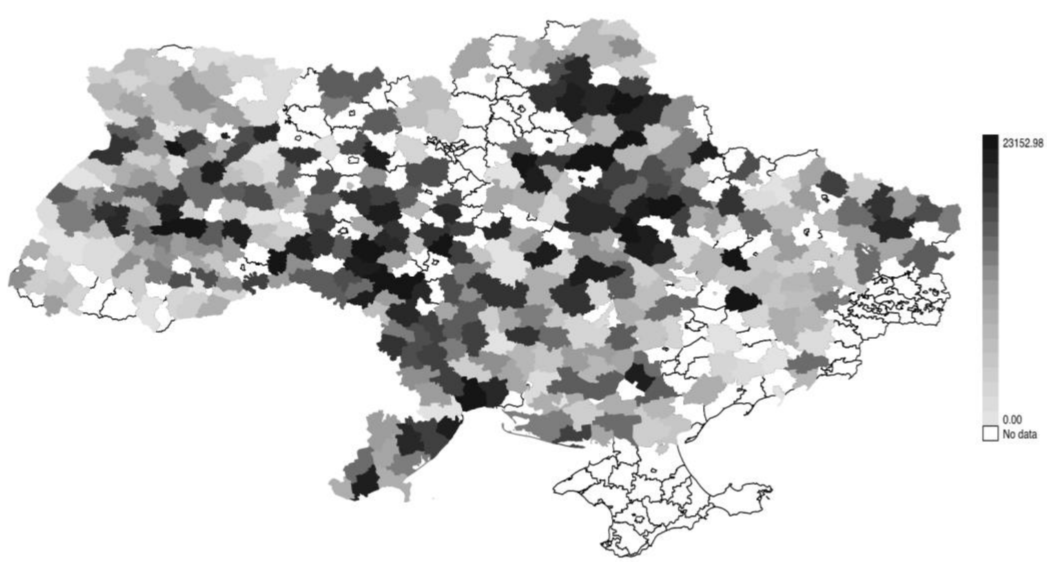
Source: Author's calculation, based on OpenMarketLand data (2018-2019).

Appendix B



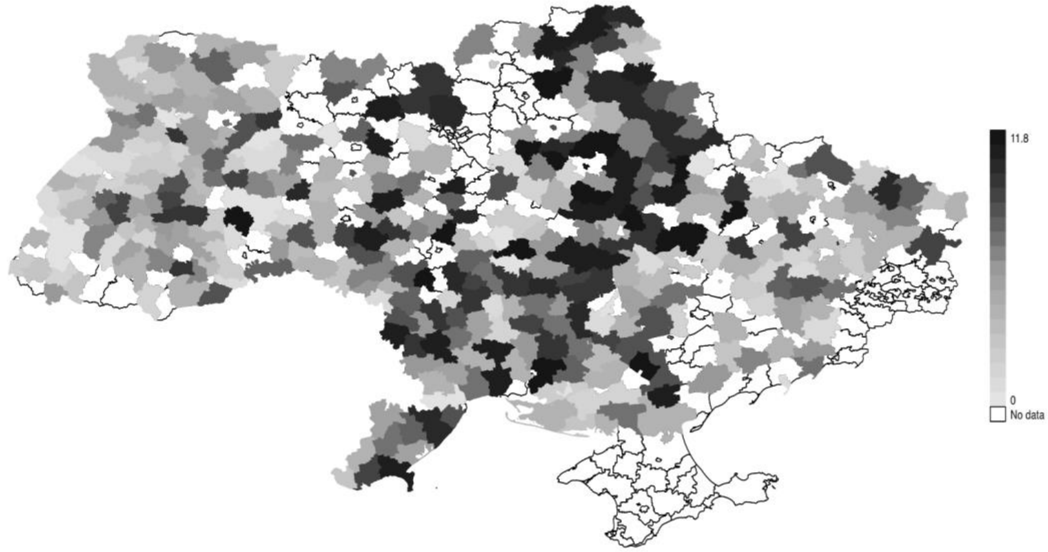
Map B 2-1. Share of successful auctions of all online agricultural land lease auctions conducted in Ukraine between October 2018 and September 2019, by district.

Source: Author's calculation and presentation based on OpenMarketLand data (2018-2019).



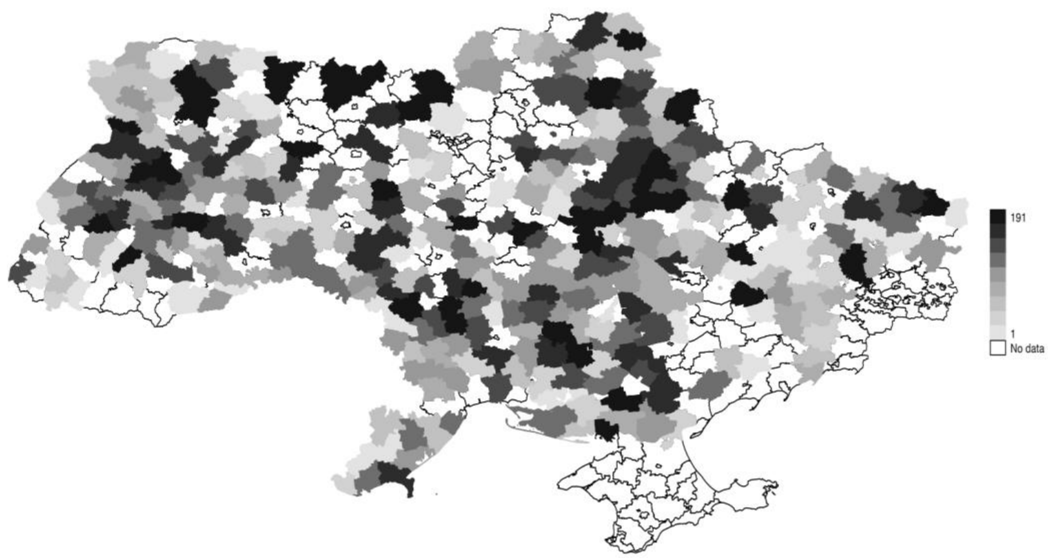
Map B 2-2. District-level average per-hectare prices (UAH/ha).

Source: Author's calculation and presentation based on OpenMarketLand data (2018-2019).



Map B 2-3. District-level average number of bidders per auction

Source: Author's calculation and presentation based on OpenMarketLand data (2018-2019).



Map B 2-4. District-level average number of bids submitted per bidder per auction.

Source: Author's calculation and presentation based on OpenMarketLand data (2018-2019).

3 Lower Price Increases, the Bounded Rationality of Bidders, and Underbidding Concerns in Online Agricultural Land Auctions: the Ukrainian Case

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Abstract

Auction theory suggests that bidders follow a dominant strategy that is to submit the highest bid equal to the bidder's true valuation in an ascending price auction with independent and private values (Milgrom and Weber, 1982). Bidders in real-world auctions may deviate from this strategy, resulting in either underbidding – submitting bids lower than the valuation - or overbidding - bidding an amount in excess of the real value. This study utilizes data collected from online agricultural land lease auctions in Ukraine that took place between October 2018 and September 2019 to analyse the occurrence of minimal price increases, which indicate underbidding. It investigates if factors – auction and property characteristics – that typically explain deviations from the dominant strategy – can also explain bidding behaviours in land lease auctions. The estimation using a heteroscedastic probit model reveals that underbidding could reasonably be attributed to low competition, insufficient time to place a subsequent bid, very small bid increments, and cumbersome entry fees.

Key words: online land lease auction, underbidding, bidding behaviour, agricultural rental prices.

3.1 Introduction

Agricultural land rights are often transferred from the state to private holdings via auction (Hartvigsen 2014). Several important issues surrounding the bidding on agricultural land sale auctions have been analysed by economists. Among the first, Colwell and Yavaş (1994) investigated a special form of farmland sale auctions, when large plots are first broken into small parcels and each parcel is auctioned separately, and then they are subsequently reassembled and auctioned as a whole parcel. Later, Hüttel *et al.* (2013) investigated if an auction mechanism used in eastern Germany during land privatization significantly affected the price of farmland sold. Croonenbroeck *et al.* (2020) investigated asymmetries among foreign and local bidders that may result in non-competitive price formation. In the most recent study by Seifert and Hüttel (2020), bidder valuations were tested for the presence of a common component that may affect bidding behaviour and auction revenues. Bidders were assumed to either have access to commonly known pricing information from the secondary market or reliable publicly available statistical information about land prices.

Although the abovementioned studies have covered several important issues related to bidding on farmland sale auctions, none of them investigated bidding in land lease auctions. The need to study land lease auctions separately is motivated by the fact that they entail several characteristics that may affect bidding behaviour not characterized by land sale auctions. Grenadier (1995: 299) referring to Miller and Upton (1976) suggests that "leasing an asset is a purchase of the use of the asset over a specified period of time. Thus, leasing provides a mechanism for the separation of ownership from use, with the lessee receiving the benefits of use and the lessor receiving the value of the lease payments plus the residual value of the asset." Based on this approach, the first obvious distinctive feature of land tenancy compared with land sales is the contract term: In contrast to land sale auctions that are used to determine a one-time transaction price, land lease auctions are used to determine not only a spot price but also a sequence of future payments (Hüttel *et al.* 2016) that may affect the behaviour of both bidders and landowners. Landowners who wish to lease a parcel via auction will find it very important to identify the least capitally constrained tenant to ensure that the tenant will be able to pay the agreed upon rental payments despite any possible production variations - especially if their access to credit and insurance is limited (Deininger and Feder 2001). Besides, landowners will find important to ensure that the tenant cultivates the plot in a profitable and sustainable way, invests in land preservation, and the residual value of the plot at the end of the term of the tenancy agreement remains high. Second, compared to land sales, rental markets are associated with positive externalities by facilitating the acquisition of agricultural knowledge by the tenant and adaptation to changing labour availability (Deininger and Feder 2001). They may increase bidders' certainty in land valuations. The third distinctive feature is either the presence or absence of a secondary market. Unlike land sale auctions, where non-farmers may purchase a plot with the intent of reselling (Seifert and Hüttel 2020), subleasing plots may not be allowed. On the one hand, it imposes an information constraint on bidders in lease auctions: They cannot formulate their valuations based upon resale pricing. On the other hand, non-farmers will no longer be interested in leasing land via auction, and tenants are more likely to rent a plot for cultivation. Hence, bidders are expected to derive their land valuations exclusively from their expected returns from agricultural activities. Last but not least, land plots are rarely perfect substitutes, as the location, size and productivity may vary (Hüttel *et al.* 2016). So, farmers who often lease additional plots to expand their existing farm are likely to be interested in a particular plot located nearby. For them, not winning a specific plot may be more consequential than for non-farmers, who purchase land to resell it.

This paper analyses the agricultural land lease auctions that took place in Ukraine between October 2018 and September 2019. The auctions use an ascending price online auction scheme with a reserve price and an entry fee. Online auctions usually share important features of an English auction (Garratt *et al.* 2012) and are equivalent to a second-price auction (SPA) under the independent private values paradigm (IPVP) (Milgrom 1989). It means that each potential bidder is assumed to have a privately and independently drawn valuation of an auctioned good which is equal to the maximum amount they are willing to pay (Krishna, 2010). The seller uses an auction to identify the bidder with the highest valuation (Paarsch and Hong, 2006). The bidder's dominant strategy is to bid their own private valuation (Milgrom and Weber, 1982). If a seller sets a minimum bid and a non-refundable entry fee, potential bidders will then find it optimal to participate only if the difference between their true valuation and the minimum bid compensates for the entry costs (McAfee and McMillan, 1987b; Tan and Yilankaya, 2005).

The empirical evidence from experimental and real auctions shows that bidders may often depart from the dominant bidding strategy (Kagel and Levin 1993). In the experiments described in the studies by Kagel and Levin (1993) and Garratt *et al.* (2012), all of the bidders study-wide were pre-assigned their private valuations before the auction began. If bidders failed to follow the dominant strategy during an auction, it can be assumed that bidding errors occurred. Bidding errors in real-world auctions were considered mostly under the common values paradigm (CVP) (Bajari and Hortacsu, 2003b, 2003a). That means that the value of the object was assumed to be the same for all bidders (Paarsch and Hong 2006: 26). In these cases, the winning bids were analysed in light of posted - "take-it-or-leave-it" - pricing (Paarsch and Hong 2006: 55) of the product in question or the comparative value of a similar good (Bajari and Hortacsu, 2003b). The related studies suggest that bidding errors may occur in both directions, such as overbidding - bidding an amount that is higher than the actual willingness to pay -

and underbidding - bidding a very low amount compared to the valuation (Malmendier and Lee, 2011). In online auctions, the share of bidders who overbid and the share of those who underbid may reach about 40% each, or bidding errors of one or the other kind may prevail (*ibid.*).

Economists have found few factors that influence a bidder's decision to behave in compliance with the dominant strategy. McGee (2013), Garratt and Wooders (2010), Garratt *et al.* (2012), and Cooper and Fang (2008) investigated the capability of bidders to apply a dominant strategy derived from the knowledge they gained from past auction outcomes. However, they found that the scope of this effect is limited.

The factors leading to deviation from the dominant strategy are more numerous. For ex., Wolf *et al.* (2005) suggest that bidders may develop a personal affinity to an auctioned good the longer they participate and subsequently overbid. A competitive auction environment is considered as one that makes bidders more prone to overbidding rather than underbidding (Cooper and Fang 2008; Hou *et al.* 2009; Hüttel *et al.* 2013). Non-refundable entry costs can often be seen as 'sunk' that may lead to a sunk cost fallacy (Athey and Haile 2007; McAfee *et al.* 2010; Augenblick 2016; Camerer and Weber 1999), where bidders are less willing to exit a situation as their financial commitments increase (Camerer and Weber, 1999; Augenblick, 2016). Hickman *et al.* (2017), Hickman (2010), and Hickman *et al.* (2012) suggest that due to incremental bidding, online auction participants may shade their valuations instead of revealing them. Malmendier and Lee (2011) expected that bidding errors could also be explained by intrinsic lot characteristics, but found narrow empirical evidence supporting this hypothesis.

There are several additional factors leading to bidding errors in real estate auctions. Dotzour *et al.* (1998) attributed overbidding to the information constraints that bidders face and suggested that bidders may overbid for property if they are unaware of the prices and/or availability of other comparable properties being offered for sale. Gwin *et al.* (2005) showed that bidders consistently overbid, if they want to secure the land for development. Chang *et al.* (2007) suggest that overbidding can happen when a developer wants to obtain property in a specific geographical location where they already have an ongoing project. Tse *et al.* (2011) found that any sort of increasing uncertainty motivates bidders to reduce their bids.

The publicly disclosed auction data from agricultural land lease auctions in Ukraine reveals that deviations from the optimal bidding strategy in the form of very low price offers - such that the difference between the minimum bid and the winning bid was less than the actual entry costs - were observed in almost one half of the successfully completed auctions. The actual observed bidding behaviour deviations from the theoretically rational one imply that bidders in these auctions entered the auction with either a very low willingness to pay and/or some factors exist, such as auction design problems or property particularities, that discourage bidders from submitting higher bids. This paper investigates if the common causes of underbidding in SPAs may be helpful in explaining low winning bids in land auctions. The effects of these causes on the propensity to underbid were analysed by means of several specifications of a heteroscedastic probit model.

We use the IPVP for the following reasons: First, it is assumed that farmers' valuations are based on their estimated earnings from land cultivation - which differ for each farmer. Furthermore, the information about other bidders' valuations conveys limited information about property value. Second, the subleasing of a rented plot may not be allowed by rental agreements, thereby ruling out the possibility of further rent and any referential price the property may have on the secondary real estate market. Finally, there are very few reliable sources of statistical information in Ukraine on aggregate level rental pricing which could have been used by bidders as a reference to form their valuations, and this information is not necessarily available to all bidders (Kvartiuk, Herzfeld, *et al.*, 2020).

We contribute to the discussion about agricultural land lease auction efficiency. For farmers, underbidding may increase their risk of not winning the property (Seifert and Strecker 2003), where there may be no other suitable plot. In addition, finding a substitute may be associated with further search costs. The farmer subsequently might need to rent several remote plots to expand production, and this may increase land cultivation costs (Hüttel *et al.* 2016). For landowners, underbidding is also problematic resulting in revenue losses (Krishna, 2010). Any problems that may prevent the landowner from identifying the bidder with highest valuation, including those associated with land auction design, may affect the efficiency of allocation (*ibid.*).

The remainder of this paper proceeds as follows: Section 2 describes *the* theoretical background related to rational bidding behaviour in an ascending price auction under the IPVP with a minimum bid and an entry fee corresponding to the Ukrainian land lease auctions. Section 3 provides an institutional background related to online land lease auctions and describes the auction data. It presents the methodology, core empirical results, and discussion. Section 4 concludes.

3.2 Theoretical background: dominant bidding strategy and the optimality of participation

3.2.1 Bidding behaviour in a SPA

As mentioned above, the online agricultural land auctions in Ukraine have adopted an open ascending price auction scheme with a predetermined reserve price, entry fee and incremental bidding. At least two well-known models for ascending price auctions exist, namely the clock model of Milgrom and Weber (1982) and an incomplete model of English auctions of Haile and Tamer (2003) that extends its arguments. They provide a useful framework for the present analysis. The Milgrom-Weber clock model assumes a "button" auction: An auction process is conducted by an auctioneer who begins the auction with announcing a minimum bid which is then raised by bidders. After each round the bidders must confirm that they are still participating. When the price exceeds their valuations, they drop out the auction. The bidding continues as long as at least two actual bidders are participating and closes when one of the two remaining bidders drops out. The remaining bidder wins the auctioned lot. An open ascending bid (or English) auction and a sealed-bid second-price (or Vickrey) auction are considered to be strategically equivalent if bidder valuations are assumed to be private and independent (The reasoning for why the IPVP is appropriate is provided in on-line Appendix A). The dominant strategy of the bidder i is to bid b_i that is equal to the bidder's valuation v_i (Krishna, 2010). It can be formally expressed as follows:

$$b_i = \beta(v_i) = v_i\,, \quad i = 1, \dots, N \qquad (1)$$

(Paarsch and Hong, 2006).

Given these bids, bidder's payoffs are:

$$\Pi_i = \begin{cases} v_i - max_{j \neq i} b_j \; if \; b_i > max_{j \neq i} b_j \\ \quad 0 \;\; if \; b_i < \; max_{j \neq i} b_j \end{cases} \qquad (2)$$

where $max_{j \neq i} b_j$ ($j = 1, \dots, M$) denotes the highest bid submitted by other bidders (Krishna, 2010).

They can be described as follows. If a bidder i submits the highest bid, then his/her profit will be $v_i - max_{j \neq i} b_j$. If he/she does not win the auction, the profit will be zero. The bidder i wins, if all other bidders submit lower bids. In an exceptional case $b_i = max_{j \neq i} b_j$ the object or property goes to each winning bidder with equal probability (*ibid.*).

Haile and Tamer (2003) extended the clock model, allowing for a free-form bidding process: Bidders are not required to indicate if they are still active during the auction and may submit a bid larger by one bid increment or place a jump bid. The model is based on two assumptions about bidders: First, they do not place bids above their valuations and second, they do not allow a competitor to win at a price they would still be willing to pay. Both assumptions are consistent with the dominant strategy of "button" and second-price auctions (Paarsch and Hong, 2006). However, according to the model of Haile and Tamer (2003), the second-highest bid may not necessarily be equal to the second-highest valuation. Instead, the second-highest valuation may be bounded by the winning bid plus one bid increment. If the latter were not true, some other competitor whose valuation is the second highest, would have beaten the existing highest bid (Paarsch and Hong, 2006).

It is implied in the first assumption of the extended model that bidders do not overbid. The second assumption is motivated by the idea that bidders observe and respond to the current bid with higher bid of their own (McAfee and McMillan 1987) and they do not miss opportunities to make a profit (Haile and Tamer, 2003). Therefore, they will not underbid if it leads to losing the auction. If they do, the object may then go to the bidder with a lower valuation, thus affecting the efficiency of allocation. Moreover, it does not cost bidder i much to bid a bit higher because the winning price is determined by the last bid of the nearest competitor (Paarsch and Hong, 2006). This provides additional arguments that underbidding is not optimal.

3.2.2 Exclusion principle

McAfee and McMillan (1987) suggest that the optimal selling mechanism for the owner of an item is to sell it to the bidder with the highest valuation, if this valuation is above a set cut-off price. The cut-off price should be strictly above the seller's own valuation that is revealed through the minimum bid (also called a positive reserve price) $r > 0$. A bidder with value v_i that is lower than the minimum bid r will not find it worthwhile to participate (and often they are not allowed), because if he/she wins, it is not possible to make a positive profit from the auction. Therefore, it is usually assumed that only those potential bidders who had valuations exceeding the reserve price participate. The bidders' equilibrium strategy becomes

$$\beta(v_i) = v_i \; if \; v_i \geq r \quad (3)$$

(Paarsch and Hong, 2006; Krishna, 2010).

The exclusion of bidders with low values has implications upon the efficiency of an auction. If the seller attaches no value to the object, *i.e.* $r = 0$, the object will be sold to the bidder with the highest value thereby ensuring efficient allocation (Krishna, 2010). A positive reserve price $r > 0$ leads to a trade-off that the seller must confront: The higher reserve price will increase revenue when only one bidder participates and will also raise the probability that the object remains unsold, if no registered bidder has a valuation that exceeds the reserve price $v_i > r$ (Haile and Tamer, 2003).

The auctioneer may also charge a non-refundable entry fee e. Similar to a bidder with value v_i that is below the positive reserve price ($v_i < r$), a bidder with a value below an entry fee ($v_i < e$) will also not find it worthwhile to participate (Krishna, 2010). Moreover, if an auctioneer uses both instruments – a reserve price and an entry fee – the bidder's strategy becomes

$$\beta(v_i) = v_i \; if \; (v_i - r) \geq e \tag{4}$$

According to Equation 4, a bidder i, who bids his/her valuation, will find it worthwhile to participate only if the difference between the winning bid and minimum bid can at least cover the entry fee (McAfee and McMillan, 1987b; Menezes and Monteiro, 2005; Tan and Yilankaya, 2005; Krishna, 2010).

Although bidders are supposed to stick to the dominant strategy, their deviations from it are often referred to in economic literature as bidding errors (McGee 2013, Garratt and Wooders 2010, Garratt *et al.* 2012, Cooper and Fang 2008). Potential bidding errors and factors that influence their occurrence are described in Section 3.1.3.

3.3 Empirical analysis

3.3.1 Description of land auctions and the auction data

3.3.1.1 Electronic land auctions in Ukraine

Land privatization in Ukraine started after the dissolution of the Soviet Union. The distribution of the state-owned agricultural land was done by granting land certificates in the 1990s. It facilitated the transfer of about 31 million hectares (ha) or three quarters of all farmland to private ownership. In 2001, a moratorium on land sales restricted the private landowners' right to sell the farmland they received. Absent a land sales market, land relations have developed on a lease/rental basis. The transfer of land rental rights for privately owned land was conducted through private negotiations. Their details were neither systematically collected nor publicly disclosed. Rental rights for agricultural state-owned land could only be transferred via a traditional English auction, according to the 2012 Land Code. It was intended to improve transparency of state-owned land rental process. The auctions gradually gained in popularity and in 2018, the Ukrainian State Service for Geodesy, Cartography, and Cadastre (also referred to as the State GeoCadastre) conducted around 1,500 successful auctions (Kvartiuk, Herzfeld, *et al.*, 2020).

One of the Ukrainian decentralization reforms launched in 2014 aimed at increasing the efficiency of managing state-owned land. Responsible regional and/or community agencies were given the right to manage local state- or community-owned land. An online auction project to facilitate the transfer of land rental rights from the state and communities to private hands was launched in October 2018 (The Cabinet of Ministers of Ukraine, 2017; Kvartiuk and Herzfeld, 2019). This project aimed to replace the traditional English auction scheme, to prevent corruption, and to gain experience in auctioning farmland electronically (The Cabinet of Ministers of Ukraine, 2017). The publicly disclosed auction data has become a unique source of information about state-owned land transaction prices in Ukraine (Kvartiuk, Herzfeld, *et al.*, 2020). The online auctions will also be used in the future for the transfer of state-owned land rental rights as well as the sale of privately-owned agricultural land after the ban on selling land was lifted in July 2021 (The Verkhovna Rada of Ukraine, 2020).

The online auction process proceeds in several stages. It starts when the auctioneer receives documentation with the property description from the regional or community agency that owns the parcel and is interested in renting it out. In these documents the contact information of the landowner, property characteristics (its dimensions, land use designation, location, cadastre number, normative appraisal, contract term, rental agreement draft, etc.), and auction-specific characteristics (the minimum bid, bid increment, entry fee) are detailed. The auctioneer announces an auction after the receipt of the documents and publishes an announcement on the OpenMarketLand webpage, an online auction platform run by the state enterprise "The system of electronic trade of seized property" in partnership with the State GeoCadastre. Regional, district and community agencies also publish announcements on their webpages. Potential bidders have to register within 30 calendar days and may inspect the property. During the registration, paying an entry fee is required. The amount is calculated at 50% of the state determined subsistence-level income on the publication date of the land auction announcement and may not exceed it. Potential bidders acquire the status of a bidder after they successfully register. Each lot is auctioned separately (The Cabinet of Ministers of Ukraine, 2017).

The auction starts at the prescheduled announced date and is conducted within one business day. The first bid placed (price offer) must be equal to or higher than the reserve price. The landowners are free to set the reserve price at an amount they consider appropriate. As an unofficial rule, the reserve price is calculated at 8-10% of the normative land appraisal.[3] Each subsequent bid must be raised by at least one minimal bid increment. The bid increment amount is usually 0.5% of the reserve price. The bidding ends when no bidder is willing to increase the price within the set time interval (after three minutes have passed) after the auction begins. If a subsequent bid higher than the previous one (or the reserve price) is placed, the auction is extended for additional three minutes. Such auctions are termed "soft close" (Duffy and Ünver, 2008). If no further bid is submitted, the bidding closes and the winning bid is published on the webpage. The winner is obligated to sign the protocol electronically within 15 minutes after the auction closes. If he/she does not sign the protocol within a specified period, the highest bid is cancelled by the system and the auction may be resumed. An unsold plot may be auctioned repeatedly (The Cabinet of Ministers of Ukraine, 2017).

The successful auction results are published on the OpenMarketLand website. The published information includes the land- and auction-specific information received from the landowner before the auction, as well as the winning bid. The auction is considered successful, if it is concluded with a signed land rental agreement. It is considered a failure if no rental agreement is signed. The private information about bidders and winners and the final concluded agreement details may not be published (The Cabinet of Ministers of Ukraine, 2017). The results from the successful electronic land auctions that took place between October 2018 and September 2019 are described below.

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[3] Normative valuations are derived in accordance with the prescribed procedure in the Ukrainian Legal Code "On Land Evaluation" of 11 December 2003, and with the Decree of the Cabinet of Ministers of Ukraine "On approval of the methodology of normative monetary valuation of agricultural land" of 16 November 2016. The valuation represents capitalized income from the plot, determined according to established and approved norms (The Cabinet of Ministers of Ukraine, 2016). One may reasonably suggest that normative appraisals are considered public information that may be used by bidders to form their valuations. However, the methodology of normative land appraisals was adopted to calculate land prices not formed by market forces. Therefore, the appraisal may not necessarily reflect the economic value of a certain plot (Kvartiuk, Herzfeld, *et al.*, 2020). The appraisals are calculated based upon a relatively old economic land assessment conducted in 1988 (The Cabinet of Ministers of Ukraine, 2016). The methodology is based on assigned rental income, which is generated only through the production of cereals and overlooks many other factors, such as the selling price of cereals, production cost per hectare, profitability, technological innovations and so on (*ibid.*). The appraisals may be used by bidders to get an impression of the plot's land cultivation productivity and profitability, but they can hardly be used by farmers when forming their private land valuations, because in real life farmers will not use the same technology and grow the same products.

3.3.1.2 Data and descriptive statistics

The initial sample collected consisted of 2,670 successful auctions. To increase the homogeneity of the data, outliers below the 5th percentile and above the 95th percentile were removed to drop the unusually small and large per-hectare prices. These adjustments led to deleting 265 observations. Six winning bids below the reserve price were also removed. They were likely documented by mistake.

The auction data contains plots with different land use designations, namely arable land, grassland, and farmland used for other purposes. Arable land constitutes the largest share of auctioned agricultural land (about 84% of plots rented). Nearly 10% of the rented plots were grassland. About 6% of auctions had rental preconditions that the land be used for organic agriculture, gardens or reserves. To further increase homogeneity of the data, only arable land plots and grassland were selected. This resulted in deleting 152 further observations. The final sample consists of 2,247 observations with 90% representing arable land. All bids are in Ukrainian currency, Hryvnia (UAH). At the time of data collection, 1 Euro corresponded to approximately 30 UAH (The National Bank of Ukraine, 2019).

Every observation in the sample includes the information about the winning bid, number of actual bidders, reserve price, entry fee, bid increment, average time spent by each bidder, month the auction took place, location, plot area, land use designation, contract term, and if a plot is auctioned for the second time (see Table 3.1). A maximum of twelve bidders participated in an auction. The average number of actual bidders fluctuated between two and three bidders per auction, tending to decrease to two bidders at the end of the observed period – which is the minimum number of bidders required for an auction to take place according to the respective law. In a repeated auction only one actual bidder is required for a plot to be rented out (The Cabinet of Ministers of Ukraine, 2017). The average land lease per-hectare price amounts to approximately 3,303 UAH/ha. It ranges from 79 UAH/ha to 33,985 UAH/ha. The per-hectare minimum bid varies between 23 UAH/ha and 11,293 UAH/ha with a mean value of approximately 1,461 UAH/ha. The average participation costs amounted to 965 UAH and ranged between 800 UAH and 1,003.5 UAH. The amount of bid increment varies between 0.12 UAH/ha and 56.48 UAH/ha with an average value of 7.31 UAH/ha. On average, each bidder spent approximately 7.43 minutes in auction. Twenty-nine auctions or about 1% of the sample were repeated auctions. Leased plots are on average 16.6 ha. Their area ranges from 0.6 ha to 159 ha. The majority of the land lease contracts auctioned had a seven-year term. Forty-nine successfully concluded contracts were ten-year rental agreements. All contracts may be extended up to 50 years - the maximum allowable land lease term according to the Land Code (The Verkhovna Rada of Ukraine, 2002).

Table 3-1. Descriptive statistics and definition of variables (N=2,247)

Variable	Notation	Mean	Std.Dev.	Min	Max	Remarks
Per-hectare winning bid, UAH/ha	price_ha	3303.23	3171.23	78.93	33985.48	
Number of actual bidders	nr_bidders	2.89	1.32	1.00	12.00	
Per-hectare reserve price, UAH/ha	reserve_price_ha	1461.47	1172.20	23.00	11292.76	Also called here a minimum bid
Entry fee, UAH	entry_fee	964.72	27.78	800.00	1003.50	Also called here entry/participation costs
Minimum bid increment, UAH/ha	increment_ha	7.31	5.87	0.12	56.48	
Average time spend by each bidder, minutes	duration_min	7.43	13.18	0.27	153.50	
Repeated auctions	repeated	0.01		0.00	1.00	Dummy variable=1 if a plot is auctioned for the second time
Contract term, years	length	7.07	0.438	7.00	10.00	
Plot area, ha	area_ha	16.61	15.73	0.65	158.69	
Grassland	grassland	0.10		0.00	1.00	Dummy variable=1 if a plot is grassland
Month	month			1.00	12.00	The variable indicates the respective month from October 2018 to September 2019, when auctions took place
Physiographic regions	natural_area			0.00	6.00	The variable indicates the respective physiographic region to which the plot belongs (see Table 2b and Tables B1 and B2 in on-line Appendix B).
Underbids	underbid	0.46		0.00	1.00	Dummy variable =1 if a winning bid is below the equilibrium bid level
Underbids	underbid_2	0.44		0.00	1.00	Dummy variable =1 if a winning bid plus one increment is below the equilibrium bid level

Source: Author's representation based on OpenMarketLand data (2018-2019).

Table 2a shows the growing number of successful auctions over time. A testing phase was conducted during the first months of the project's implementation. It was used mainly for technical optimization, and it allowed the auctioneer, landowners, and bidders to gain experience. The number of successful auctions per month increased from 9 in October 2018 to 404 in September 2019. This tendency holds for both groups of considered land.

Table 3-2. Number of plots rented via online auction per month for two groups of land (N=2,247).

month	Freq.	Percent	Cum.	Freq.	Percent	Cum.
	Arable land			*Grassland*		
Oct.-Dec. 2018	156	7.72	7.72	9	4.00	4.00
Jan. 19	74	3.66	11.37	4	1.78	5.78
Feb. 19	78	3.86	15.23	1	0.44	6.22
Mar. 19	283	14.00	29.23	37	16.44	22.67
Apr. 19	185	9.15	38.38	23	10.22	32.89
May 19	233	11.52	49.90	15	6.67	39.56
Jun. 19	238	11.77	61.67	23	10.22	49.78
Jul. 19	190	9.40	71.07	13	5.78	55.56
Aug.19	246	12.17	83.23	35	15.56	71.11
Sept.19	339	16.77	100.00	65	28.89	100.00

Source: Author's representation based on OpenMarketLand data (2018-2019)

The territory of Ukraine consists of several physiographic regions: Forest-Steppe and Steppe (incl. Donbas), Polissia, the Carpathian Mountains, and the Crimean Peninsula.[4] The topsoil, climate and vegetation vary regionally. Table 2b illustrates the absolute number of successful auctions per physiographic region. The majority of successful auctions took place in Forest-Steppe and Steppe regions. They have the largest area of available agricultural land and the best soil quality. The auctions that took place in Central and Eastern Polissia represent the smallest share.

[4] The sample includes no observations from the Crimea.

Table 3-3. Number of plots rented via online auction per physiographic region for two groups of land (N=2,247).

natural_area	Freq.	Percent	Cum.	Freq.	Percent	Cum.
	Arable land			*Grassland*		
Forest-Steppe	774	39.03	39.03	69	31.51	31.51
Donbas	103	5.19	44.23	35	15.98	47.49
Steppe	649	32.73	76.95	102	46.58	94.06
The Carpathians	83	4.19	81.14	2	0.91	94.98
Western Polissia	271	13.67	94.81	2	0.91	95.89
Central Polissia	24	1.21	96.02			
Eastern Polissia	79	3.98	100.00	9	4.11	100.00

Source: Author's representation based on OpenMarketLand data (2018-2019)

Many auctions concluded with the price equal to or just above the reserve price: In about 46% of all auctions[5] bidding ended where the difference between the bid and the reserve price was less than the entry fee. It clearly contradicts the dominant strategy and the threshold that determines the optimality of participation (Eq. 4 above), if it is assumed that the winning bid represents the second-highest bidder's true valuation of the plot. The losing bidders in these auctions entered the auction with either a very low willingness to pay and/or some other factors that may be associated with auction design or land characteristics which prevented the bidders from revealing their valuations which led to bidding errors.

3.3.1.3 Hypotheses and empirical model

A typical measure of bidding errors is the propensity to overbid or underbid (Feng et al. 2016). To examine the occurrence of underbidding in the present case, a variable "underbid" was created and was given the value of 1 if the winning bid exceeded the reserve price by less than the entry fee and a value of 0 if otherwise. The propensity to underbid was further modelled as a function of auction characteristics and property attributes. The auction characteristics include entry fee, number of bidders, bid increment value, the average time a bidder spent in the auction, and if the auction was

[5] If the highest possible valuation of the second highest bidder reaches the amount of the winning bid plus one bid increment (Haile and Tamer, 2003), the participation threshold does not hold in about 44% of the auctions.

repeated, along with contract and property characteristics, such as contract term, month, plot area, land use designation, and location. Equation 5 is, therefore, our empirical model:

$$underbid = f(entry\_fee, nr\_bidders, increment\_ha, duration\_min, repeated, length, month, area\_ha, grassland, natural\_area) \quad (5)$$

There are many studies that investigate the effect of participation costs on bidding behaviour, but there is no consensus of what outcomes should be expected. Despite entry costs that are often seen as sunk and not relevant to rational decision making (McAfee *et al.* 2010), several papers (see, for ex., Augenblick 2016; Camerer and Weber 1999) contend that they have an effect on bidders' behaviour in a way that players become less willing to exit a situation as their commitments increase - even if these investments no longer seem worthwhile. In turn, Phillips *et al.* (1991) suggest that bidders may also ignore sunk costs or they may value an item less as the amount of sunk costs increase. Therefore, it seems reasonable to analyse the effect of higher participation costs on the propensity to underbid.

Greater competition in ascending price auctions with private values is often associated with overbidding (Paarsch, 1992; Bajari and Hortacsu, 2003b). When facing greater competition, bidders may offer a price that exceeds their valuation of property and overpay (Hou *et al.* 2009; Hüttel *et al.* 2013). Hence, we include the number of bidders as a reflection of the competition for the plot.

According to Haile and Tamer (2003), bidders in ascending price auctions may deviate from bidding their true valuations by one bid increment. This deviation may be more pronounced if bid increments are large. In line, Hickman *et al.* (2017) and Hickman (2010) claim that due to incremental bidding, participants in online auctions may engage in bid shading similar to those in first-price auctions. In the present case, bid increments vary from auction to auction and in some instances were quite large, therefore it may be expected that larger bid increments prevent bidders from revealing their true property valuations and this may lead to underbidding.

The time bidders spend in auction may have an effect on their behaviour, but this effect is ambiguous. On the one hand, the longer bidders stay in an auction, the more likely they are to submit a higher bid, possibly due to attachment or endowment that they develop in the course of bidding (Wolf *et al.* 2005). On the other hand, a long bidding process may be associated with bidders increasing monitoring costs, which may make them less willing to switch auctions in order to avoid new search and entry costs. Bidders may also subtract these costs from their willingness to pay for an item (Bapna *et al.* 2009; Goes *et al.* 2012). Therefore, the variable reflecting average time spent by each bidder in auction[6] is entered into model to investigate if the propensity to underbid decreases or increases when bidding lasts longer.

Both learning and gaining auction experience are often assumed to be remedies for bidding errors. Yet there is still room for ambiguity. On the one hand, Wilcox (2000) claims that bidders may still make systematic bidding errors even after many repetitions. On the other hand, Zhang *et al.* (2019) claim that participants may discover the dominant strategy through their prior observations. In line with this premise, it seems reasonable to suggest that participants in a repeated land auction[7] will be more likely to follow the dominant strategy, because they may at least obtain some information about the auction procedure and the competition for the specific plot during the initial auction, and they may more accurately bid for the same plot the second time. The repeated auctions dummy variable was added to control for this effect in the model.

Physical features, such as quality of an auctioned item can also explain bidding errors. Namely, higher item quality may motivate bidders to overbid rather than underbid (Malmendier and Lee, 2011). Thus, the "natural_area" variable indicating the physiographic region to which the plot belongs was entered into the model to control for the effect the location and characteristics of the plot. This includes factors such as soil quality, the availability of infrastructure, and the role agriculture plays in the regional economic structure which may have an impact on bidders' willingness to pay (Hüttel *et al.*, 2013; Nilsson and Johansson, 2013). The topsoil in the Forest-Steppe region is mainly represented by black soils (Fatieiev and Paschenko, 2003) that are the most productive and most expensive. This region was used as a reference category in the models, expecting that the willingness to pay for land located in this region is higher than in other regions and underbidding is less likely to occur. Compared to the Forest-Steppe region, other regions are expected to have lower land prices due to following reasons. Namely, the Steppe region is the warmest among all regions, has overall good conditions for agriculture, but mainly sod carbonate soils. The Donbas region has large agricultural areas and black soils (Fatieiev and Paschenko, 2003), but heavy industry (coal mining, chemical and metallurgical processing sites) dominates in the structure of regional economy (Yakovliev and Chumachenko, 2017), making agriculture a less attractive economic sector. Western Polissia is characterized by high humidity

[6] The average time was used, because the land auctions under consideration are not "button" auctions, so one cannot know how much time exactly bidders spent before they dropped.

[7] Bidders learn that the plot is auctioned for the second time in the auction announcement.

and poor soils due to insignificant nutrient reserves. The basis of the Central Polissian geostructure is formed by crystalline rocks, which participate in soil formation. Here sod-podzolic, sod mid-podzolic, light gray and gray forest soils predominate. Eastern Polissia is characterized by the combination of sod-podzolic soils and black soils. The Carpathians are a mountainous region with brown forest soils (Fatieiev and Paschenko, 2003). Therefore, Western, Eastern, Central Polissia and the Carpathians are less suitable for agriculture.

Many studies are dedicated to estimating the effect of plot size on pricing, yet this relationship is ambiguous (Hüttel *et al.* 2016). Land cultivation and farming activities may be better facilitated if one large plot is at the farmer's disposal, thus reducing transaction and machinery costs and resulting in a willingness to pay more for land (see, for ex., Hüttel *et al.* 2013; Hüttel *et al.* 2016). But larger plots may conversely be in lower demand due to budget constraints (Xu *et al.* 1993). Land prices may also be independent from plot sizes (Maddison 2000). It seems reasonable to control for the effect of plot size too, but its exact effect is to be determined.

Several papers (Grenadier 1995; Gunnelin and Söderberg 2003; Hüttel *et al.* 2016) have explored the role lease contract lengths play in the price formation process. Expectations about future rents may respond to changing market conditions (Gunnelin and Söderberg, 2003). To incorporate farmer expectations regarding future transformations, Gunnelin and Söderberg (2003) and Hüttel *et al.* (2016) analysed contracts negotiated at the same time of year over a period of several years and modelled price as a function of term structure (an interaction between the contract length and year, when the contract was concluded). However, our data only covers one year, so we can only control for contract length. In addition, the effect of time on the occurrence of very low winning bids is captured by the monthly dummy variables. Auctions that took place during the testing phase between October and December 2018 were chosen as a reference due to a small number of observations in the first months. Gunnelin and Söderberg (2003) and Hüttel *et al.* (2016) report case-specific results, therefore, it is difficult to predict expected positive or negative effects associated with the lease length and time of contract conclusion.

To check the robustness of the results, different model specifications and samples were used. Model 1.1 was estimated using the sample of winning bids. Model 1.2 accounted for arable land only. In Model 2.1 the variable "underbid_2" replaced the variable "underbid", where the definition of an underbid is increased by one auction increment. It was modelled as a function of the same dependent variables. Model 2.1 was estimated using the full sample. To additionally check the robustness of our estimated coefficients, the alternative specifications of the regression model (Models 3.1-4.1) were also estimated without the variable representing the number of participating bidders. All models use the cluster-robust (district-level) variance-covariance matrix. The data includes observations from 373 out of 490 Ukrainian districts (without cities).

A non-constant variance across observations (heteroskedasticity) may affect the consistency of the maximum likelihood estimators of probit model parameters (Holden, 2011). Therefore, both models were estimated by means of heteroscedastic probit regression. In comparison with a conventional probit model, this model allows the scale of the inverse link function to vary from observation to observation as a function of the independent variables. The presence of heteroscedasticity was tested by a likelihood-ratio test as suggested by Harvey (1976). Both models were estimated by maximum likelihood.

3.3.2 Estimation results and discussion of potential causes of underbidding

Table 3 presents the average marginal effects of Models 1.1-2.1. The respective coefficients are presented in Table C1 of on-line Appendix C. The estimation results of the model's alternative specifications that do not account for the number of bidders as an explanatory variable are presented in Tables D1 and D2 in on-line Appendix D. Jointly, the estimated coefficients of all models are significant according to the Wald test. The likelihood-ratio test of heteroscedasticity is also significant and therefore a heteroscedastic probit model is appropriate.

Table 3-4. Estimated marginal effects for the main model and its alternative specifications

	Model 1.1 (main)		Model 1.2		Model 2.1	
	Marg.Effect	Std.Err.	Marg.Effect	Std.Err.	Marg.Effect	Std. Err.
Dependent variable	*underbid*		*underbid*		*underbid_2*	
entry_fee	0.00	(0.00)	0.00^{*}	(0.00)	0.00	(0.00)
nr_bidders	-0.13^{***}	(0.01)	-0.13^{***}	(0.01)	-0.13^{***}	(0.01)
increment_ha	-0.00^{*}	(0.00)	-0.00^{*}	(0.00)	-0.01^{***}	(0.00)
duration_min	-0.06^{***}	(0.01)	-0.06^{***}	(0.01)	-0.06^{***}	(0.01)
repeated	-0.02	(0.05)			-0.01	(0.06)
length	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)
Monthly variables						
Oct.-Dec.18	Reference		Reference		Reference	
Jan.19	-0.14^{*}	(0.07)	-0.14^{*}	(0.06)	-0.14^{*}	(0.07)
Feb.19	-0.05	(0.05)	-0.06	(0.05)	-0.04	(0.05)
Mar.19	-0.11^{***}	(0.03)	-0.13^{***}	(0.03)	-0.11^{***}	(0.03)
Apr.19	-0.11^{***}	(0.03)	-0.12^{***}	(0.03)	-0.10^{**}	(0.03)
May.19	-0.17^{***}	(0.03)	-0.17^{***}	(0.03)	-0.17^{***}	(0.03)
Jun.19	-0.07^{*}	(0.03)	-0.07^{*}	(0.03)	-0.07^{*}	(0.04)
Jul.19	-0.09^{*}	(0.04)	-0.09^{*}	(0.04)	-0.08	(0.04)
Aug.19	-0.05	(0.04)	-0.06	(0.04)	-0.05	(0.04)
Sept.19	-0.08^{*}	(0.04)	-0.08^{*}	(0.04)	-0.08	(0.04)
area_ha	-0.01^{***}	(0.00)	-0.01^{***}	(0.00)	-0.01^{***}	(0.00)
grassland	-0.00	(0.03)			0.00	(0.03)
Natural area						
0 Forest-Steppe	Reference		Reference		Reference	
1 Donbas	0.03	(0.04)	0.04	(0.04)	0.02	(0.04)
2 Steppe	0.01	(0.02)	-0.00	(0.02)	0.01	(0.02)
3 Carpathians	-0.01	(0.06)	-0.02	(0.06)	0.00	(0.06)
4 Western Polissia	0.08^{*}	(0.04)	0.08^{*}	(0.04)	0.09^{*}	(0.04)
5 Central Polissia	0.05	(0.07)	0.04	(0.07)	0.05	(0.06)
6 Eastern Polissia	0.09^{***}	(0.03)	0.07^{**}	(0.03)	0.09^{**}	(0.03)
N	2247		2022		2247	

Note: Standard errors in parentheses

Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

The marginal effects of entry costs, competition, bid increment, and the average time bidders spent in auction on the propensity to underbid are also shown in Fig. C1a-d in on-line Appendix C for both the beginning and the end of the observed period. Auctions at the beginning of the pilot project are characterized by a slightly higher occurrence of underbidding when compared with the last month. Greater competition (the number of bidders) significantly decreases the propensity to underbid. It approaches zero if the number of bidders increases to eight (Figure C1b in on-line Appendix C). This finding met the expectations and is in line with related studies (see, for ex., Cooper and Fang 2008; Feng *et al.* 2016; Hou *et al.* 2009; Kagel and Levin 1993; McGee 2013) that demonstrate that auctions with higher competition are more prone to overbidding – diminishing the chance of underbidding. Larger minimum bid increments tend to decrease the propensity to underbid, though the marginal effect is barely identifiable. Underbidding is not observed, when the per-hectare bid increment is greater than 200 UAH (Figure C1c in on-line Appendix C). This finding is in line with the studies by Hickman (2010) and Hickman *et al.* (2017) which suggest that incremental bidding may affect bidding behaviour in online auctions. Furthermore, it was found that underbidding is less likely when bidders spend more time in an auction. In particular, if the average time each bidder participates in an auction increases to 15-20 minutes, the likelihood of underbidding approaches zero (Figure C1d in on-line Appendix C). Thus, the possible negative effect of higher monitoring costs as described in Bapna *et al.* (2009) and Goes *et al.* (2012) that bidders would subtract from their valuations and bids - was not found. Instead, bidders who spent more time in an auction were more inclined to win the property in question, possibly to avoid renewed auction-related costs of search, entry, and monitoring. Besides, greater entry fees slightly increase the propensity to underbid (Model 1.2). This finding contradicts the expectation that higher entry costs may compel bidders to submit higher bids (McAfee *et al.* 2010). Instead, larger entry fees in land lease auctions make bidders more attentive to costs (Figure C1a in on-line Appendix C).

Contract terms were found to have an insignificant effect on the propensity to underbid. Therefore, there is no sufficient evidence to conclude if farmers were either more interested and/or willing to pay more for longer-term contracts.

The estimation also shows that the intrinsic features of the land auctioned may partly explain the propensity to underbid. First, when compared with the Forest-Steppe region, where the soils are the most productive and agriculture is an attractive economic activity, auctions that took place in Western and Eastern Polissia were more prone to underbidding. This confirms that better lot quality may motivate bidders to overbid rather than underbid (Malmendier and Lee, 2011). Second, bidders tend to underbid less if a larger plot is being auctioned. Larger plots are more convenient and efficient to cultivate, as many land market studies claim (see, for ex., Hüttel *et al.* 2013; Hüttel *et al.* 2016) that may explain this result. Overall, this finding is also in line with the ideas described in Malmendier and Lee (2011) which suggests that item characteristics can explain the occurrence of bidding errors.

3.4 Conclusion

This study contributes to a scarce body of literature related to the occurrence of bidding errors in agricultural land auctions. Among the first to analyse the issue are Seifert and Hüttel (2020), who examined the occurrence of overbidding in agricultural land sales auctions in eastern Germany under the assumption that bidders derive their valuation from some commonly known pricing information. The present study adds further evidence from the land lease auctions in Ukraine that employ the ascending price rule. It assumes that land valuations are private and independent - due to scarcity of reliable statistical rental rate information available to farmers for deriving their land valuations.

A close look at the publicly disclosed data from the 2018-2019 online agricultural land auctions in Ukraine indicate that winning bids of almost one-half of auctions exceeded the reserve price by less than the entry fee. Assuming that the winning bid represents the second-highest bidder's true valuation of the plot, the losing bidders in these auctions entered the auction with either a very low willingness to pay and/or some factors prevented them from revealing their valuations, if these valuations were higher. This led to underbidding and consequently revenue losses for the landowners. This motivated the need to examine which factors - auction and property characteristics - could lead to this situation. The selection of factors was based on the theoretical and empirical evidence related to the occurrence of bidding errors in SPAs that are thought to be equivalent to an ascending price auction under the IPVP. It examined the effects of the causes that lead to bidding errors in agricultural land lease auctions for the first time.

The analysis confirms that parameters of auction design affect bidding behaviour, and if not optimally set, they may lead to bidding errors that affect the plot rental rate as well as subsequent rental payments. The estimation results show that highly competitive auctions are not prone to underbidding, but over the studied period there were few highly competitive auctions observed. As a revenue-maximizing landowner may want to attract more actual bidders and facilitate more competitive bidding, this may be achieved by improving the information provided about the auctions to potential interest groups. If a landowner wants to ensure the cultivation of a plot, and revenues are of secondary importance, then they may decrease the reserve price. Lowering reserve prices will likely allow bidders with lower valuations to enter the bidding, which should enhance competition, but may not necessarily have a positive price effect, especially if the second highest bid that determines the winning bid was placed by a bidder with a low valuation. Another suggestion may be to standardize the reserve price amounts. So far, there is no legally determined method for setting reserve prices and the majority of landowners calculate it by themselves, generally being around 8-10% of the normative land appraisal. This may serve as a good indication of land quality for bidders, on the one hand. This may also be difficult for bidders to rely on if landowners do not follow this unwritten rule. Standardizing reserve prices in the documentation regulating the auction procedure may improve the transparency of the auctions process. Entry fees may also dissuade participants from entering if the price is deemed high and bidders are not sure about their chances of winning (Reiss and Wolak, 2007).

Hence, a higher number of bidders can enter an auction if an entry fee is smaller. In addition, larger entry fees decrease a bidders' willingness to pay more for land. Therefore, an auctioneer seeking to maximize revenue may charge entry fees that decline in correlation with the magnitude of the bid placed - helping to motivate higher bids and deemphasizing the effect entry fees have on bidding behaviour (Matthews 1983; Matthews 1984; Wilson 1992; Maskin and Riley 1984).

To further facilitate competitive bidding, the timing of bids and bid increment amounts may be amended. Underbidding does not occur if the time each bidder participates in an auction averages to 15-20 minutes. However, this time exceeds the average time spent by actual bidders in the sample by 2-3 times. The auctioneer should consider that bidders may have no prior experience and may need some time to learn the auction rules and the bidding strategy (Duffy and Ünver, 2008). So, in order to prevent early auction closure, the timing between placing their bids may be extended. Long bidding may also be a result of very small bid increment amounts that bidders use to raise their bids. The estimation results reveal that underbidding does not occur if the size of the bid increment is above 200 UAH/ha - substantially exceeding the average amount observed. Bidders and landowners may find it useful if the auctioneer increases the bid increment amount.

The limitations of this study reside mainly in the estimation technique utilized and the amount of auction data available. The reduced-form estimation by means of a heteroscedastic probit model allowed for the factors that influence the occurrence of bidding errors to be analysed. The calculation of optimal entry fee amounts and bid increment sizes used to achieve higher land auction efficiency goes beyond this paper. Second, the auction data used in the present study does not provide sufficient means to conduct a detailed demand side analysis, because the identities of bidders and winners are confidential. Thus, it is not possible to analyse if the same bidders took part in repeated auctions and if any learning effects took place. Third, the publicly disclosed auction data allowed accounting for many important factors that impact the occurrence of bidding errors. However, this list of factors is not complete. Last but not least, absent the personal information about bidders, they were all treated as symmetrical and homogeneous. However, in farmland auctions asymmetric bidder structures and different bidder types depending on their values and risk preferences may also be assumed (Croonenbroeck *et al.* 2020; Menezes and Monteiro 2000; Ivanova-Stenzel and Salmon 2011; Palfrey and Pevnitskaya 2004). Therefore, some follow-up research may be done in the future if additional data becomes available.

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Appendix A. Common vs. independent private values

In the present study bidders' estimates are considered under the IPVP. The section provides reasoning, why these assumptions are considered to be valid.

Private values assumption

The primary arguments that one may use to justify the use of the private values assumption is that bidders form their estimates based upon their use of a property acquired via auction (Krishna 2010: 3), and that there is no secondary market where this property can later be resold (McAfee and McMillan 1987). Agricultural land valuations are often considered as private (for ex., Croonenbroeck *et al.* 2020; Ooi *et al.* 2006), because each bidder forms their own personal value for each plot (Colwell and Yavaş, 1994) and this value can be thought of as a potential bidder's estimate of the present value along with the returns from the optimal use of the land. It will differ for each bidder, because they each utilize the land according to their specialization, which depends upon many factors: their experience and expertise (Ooi *et al.* 2006), future volumes of yields from land cultivation, overall net income flow, wealth status, and technologies employed as well as time and risk preferences (Croonenbroeck *et al.* 2020). However, if a plot was acquired with the purpose of resale on the secondary market, valuations may also contain a commonly known information component that is based on potential returns from resale or payments from the future leasing of a purchased parcel (Seifert and Hüttel 2020). In turn, in land lease auctions the subleasing of a rented plot may not be foreseen and bidders may derive their valuations solely from land use.

To decide between private and common values, Paarsch (1992) suggested testing the behaviour of bidders, assuming that they compete differently in private values auctions and common values auctions. According to the paper, at procurement auctions where the lowest bid wins, within the CVP bid functions may first decrease but will then increase with the number of bidders, while at auctions within the private value paradigm they will decrease monotonically. This may be observed among the winning bid functions too. Bajari and Hortacsu (2003b) extended this proposition and applied it to online ascending price auctions where the highest bidder wins. The authors suggest that if resale is possible, there should be some referential price known to all bidders. They normalized the bids on the reference price and estimated the effect the number of bidders had on this ratio. If the valuations were common, bidders were expected to bid more carefully as the number of bidders increases, fearing to overbid.

Seifert and Hüttel (2020) suggest that when forming their valuations, bidders in agricultural land auctions may refer to the statistical information about comparable sales or lease pricing that is usually available on a regional level. Following this premise, the effect of competition in the present case was investigated by utilizing the statistical information about land rental prices reported by the State GeoCadastre (The State GeoCadastre 2018, 2019). The average prices are published on their webpage once a year. So, one may assume that bidders could use the average rental prices for land in their region from the previous year to form their valuations. If the CVP holds true, they are expected to decrease their bids if they face greater competition. Following the same procedure as proposed by Paarsch (1992) and Bajari and Hortacsu (2003b), the winning bids in the land lease auctions were normalized on the average respective regional price observed the previous year. The normalized winning bids were regressed by the number of bidders. The specifications of the model repeat the specifications of the model described in papers of Paarsch (1992) and Bajari and Hortacsu (2003b).

Table A 3-1. Estimation results

	Linear model	Quadratic model	Logarithmic model
Dependent variable	Normalized winning bid	Normalized winning bid	Log. normalized winning bid
nr_bidders	0.29^{***}	0.69^{***}	
	(0.01)	(0.05)	
nr_bidders_squared		-0.05^{***}	
		(0.01)	
log_nr_bidders			1.20^{***}
			(0.05)
N	2247	2247	2247
R^2	0.174	0.201	0.194

Note: Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The result shows that competition has positive effect on prices (Table A1) and provides confirmative evidence that the private values assumption is adequate in the present case.

Independency assumption

There are two reasons to assume that bidder signals in land lease auctions under consideration are independent. The first argument to justify that bidder signals are not correlated is that bidding in these auctions is free-form. Bidders are not required to indicate if they are still participating and do not know the same about their rivals. Consequently, they are not aware if the highest bid has already exceeded the valuations of others and possess considerably less information about the competition when compared with bidders participating in a "button" auction (Haile and Tamer, 2003). Lacking this information, bidders are less likely to form a strong linkage to the estimates of other bidders (Quint, 2016). In turn, bidders in "button" auctions have the possibility to gain the greatest amount of information about the competition, because they know how many competitors have dropped out, having exceeded their valuations (Menezes and Monteiro, 2005; Quint, 2016).

The second argument for the use of the independency assumption is that bidder estimates are individual-specific and independent due to differences in the cost structures of bidders. Therefore, bidders reveal no useful information about the true value of the property during auction (Paarsch and Hong, 2006). Since bidders in farmland auctions form their valuations largely based on returns from cultivation (Croonenbroeck *et al.* 2020; Ooi *et al.* 2006; Colwell and Yavaş 1994), their valuations will be equal only if they possessed the same technology, information about soil fertility, input and output pricing, and would be able to make the same net income from land area farmed (Colwell and Yavaş 1994). Besides, the bidder with the highest signal may not necessarily be the best-informed bidder but rather may be the most technologically advanced farmer - or simply be the most optimistic one. These bidders can potentially send the wrong signals to other bidders (Seifert and Hüttel, 2020). Similarly, in the present case, the concealed identities of bidders prevent their competitors from guessing, how the bidder with a high signal is going to generate income from land cultivation, what they will cultivate, what technologies are employed, etc. that will allow the farmer to yield greater returns from cultivation and enable them to cover their higher costs of land tenancy.

In the light of the arguments mentioned above, it seems reasonable to favour the IPVP over the CVP and affiliated values paradigms as long as the IPVP may hold in the real auctions.

Appendix B

Table B 3-1. Oblasts and physiographic regions of Ukraine.

List of *oblasts* of Ukraine	Natural area
Khmelnytskyy, Vinnytsia, Cherkasy, Ternopil, Poltava regions, northern part of Kharkiv region, part of Lviv region, north-eastern part of Chernivtsi region, southern parts of Kyiv, Chernihiv, Zhytomyr and Sumy regions	Forest-Steppe
Donetsk and Luhansk regions	Donbas
Dnipro, Zaporizhzhia, Kherson, Odesa, Mykolaiv regions, southern part of Kirovohrad and Kharkiv regions	Steppe
Ivano-Frankivsk, Transcarpathia, parts of Lviv and Chernivtsi regions	Carpathians
Volyn, Rivne, Lviv regions (partially)	Western Polissia
northern parts of Zhytomyr region and north-western part of Kyiv region	Central Polissia
northern parts of Chernihiv and Sumy regions, north-eastern part of Kyiv region	Eastern Polissia
The Crimean Peninsula	Crimea

Table B 3-2. Number of plots rented via online auction per oblast for two groups of lands (N=2,247).

Oblast	Freq.	Percent	Cum.	Freq.	Percent	Cum.
	Arable land			Grassland		
Cherkasy	74	3.66	3.66	2	0.89	0.89
Chernihiv	62	3.07	6.73	6	2.67	3.56
Chernivtsi	27	1.34	8.06	1	0.44	4.00
Dnipro	60	2.97	11.03	20	8.89	12.89
Donetsk	62	3.07	14.09	32	14.22	27.11
Ivano-Frankivsk	76	3.76	17.85			
Kharkiv	42	2.08	19.93	1	0.44	27.56
Kherson	44	2.18	22.11	29	12.89	40.44
Khmelnytskyy	41	2.03	24.13	1	0.44	40.89
Kyiv	53	2.62	26.76			
Kirovohrad	116	5.74	32.49	46	20.44	61.33
Lviv	120	5.93	38.43	4	1.78	63.11
Luhansk	48	2.37	40.80	7	3.11	66.22
Mykolaiv	141	6.97	47.77	9	4.00	70.22
Odesa	307	15.18	62.96			
Poltava	94	4.65	67.61	5	2.22	72.44
Rivne	85	4.20	71.81			
Sumy	111	5.49	77.30	6	2.67	75.11
Ternopil	144	7.12	84.42	52	23.11	98.22
Transcarpathia	18	0.89	85.31			
Vinnytsya	86	4.25	89.56	4	1.78	100.00
Volyn	164	8.11	97.68			
Zaporizhzhya	9	0.45	98.12			
Zhytomyr	38	1.88	100.00			

Source: Author's representation based on OpenMarketLand data (2018-2019)

Appendix C

Table C 3-1. Estimated coefficients for the main model and its alternative specifications

	Model 1.1 (main)		Model 1.2		Model 2.1	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
Dependent variable	*underbid*		*underbid*		*underbid_2*	
entry_fee	0.01	(0.00)	0.01*	(0.00)	0.01	(0.00)
nr_bidders	-1.01***	(0.17)	-1.00***	(0.16)	-0.94***	(0.16)
increment_ha	-0.03*	(0.02)	-0.04*	(0.02)	-0.05***	(0.01)
duration_min	-0.46***	(0.11)	-0.45***	(0.11)	-0.44***	(0.11)
repeated	-0.12	(0.40)			-0.05	(0.41)
length	-0.16	(0.14)	-0.17	(0.15)	-0.16	(0.15)
Monthly variables						
Oct.-Dec.18	Reference		Reference		Reference	
Jan.19	-1.11*	(0.52)	-1.19*	(0.50)	-1.06*	(0.52)
Feb.19	-0.45	(0.47)	-0.52	(0.50)	-0.37	(0.47)
Mar.19	-0.95**	(0.34)	-1.07**	(0.36)	-0.89*	(0.35)
Apr.19	-0.96**	(0.34)	-1.04**	(0.36)	-0.83*	(0.35)
May.19	-1.36***	(0.37)	-1.37***	(0.37)	-1.25***	(0.37)
Jun.19	-0.60	(0.35)	-0.68	(0.36)	-0.58	(0.36)
Jul.19	-0.78	(0.41)	-0.81	(0.42)	-0.67	(0.42)
Aug.19	-0.48	(0.37)	-0.56	(0.38)	-0.45	(0.37)
Sept.19	-0.69	(0.42)	-0.74	(0.42)	-0.64	(0.42)
area_ha	-0.04**	(0.01)	-0.05***	(0.01)	-0.06***	(0.02)
grassland	-0.03	(0.22)			0.00	(0.22)
Natural_area						
Forest-Steppe	Reference		Reference		Reference	
Donbas	0.27	(0.32)	0.29	(0.33)	0.18	(0.29)
Steppe	0.06	(0.15)	-0.02	(0.16)	0.08	(0.15)
Carpathians	-0.04	(0.45)	-0.14	(0.46)	0.02	(0.45)
Western Polissia	0.65*	(0.32)	0.63	(0.33)	0.73*	(0.33)
Central Polissia	0.36	(0.55)	0.35	(0.56)	0.39	(0.45)
Eastern Polissia	0.70**	(0.24)	0.59*	(0.23)	0.67**	(0.26)
Const.	1.21	(3.02)	-0.59	(3.18)	1.44	(3.06)
N	2247		2022		2247	

Note: Standard errors in parentheses

Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

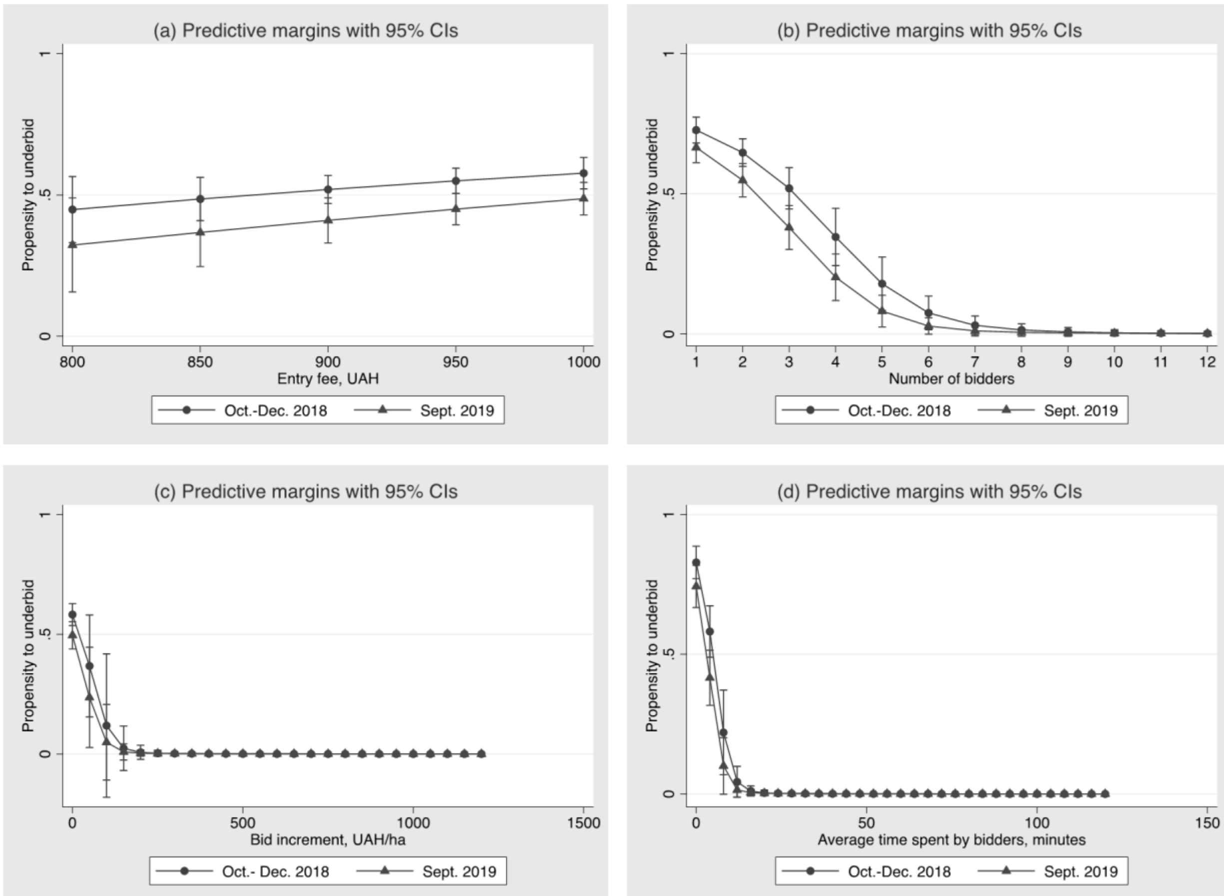

Figure C 3-1. Plots of the predictive margins with 95% confidence intervals of (a) entry fees, (b) the number of actual bidders, (c) the minimum bid increment amount, (d) and the average time spent by bidders in an auction upon the propensity to underbid (the testing phase vs. the last month of the pilot project) (N=2,247).

Source: Author's representation based on estimation results.

Appendix D

Table D 3-1. Estimated coefficients for the model's alternative specifications (without the variable representing the number of bidders)

	Model 3.1		Model 3.2		Model 4.1	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
Dependent variable	*underbid*		*underbid*		*underbid_2*	
entry_fee	0.01^{*}	(0.00)	0.01^{**}	(0.00)	0.01^{*}	(0.00)
increment_ha	-0.04^{**}	(0.01)	-0.04^{**}	(0.01)	-0.05^{***}	(0.01)
duration_min	-0.52^{***}	(0.11)	-0.52^{***}	(0.11)	-0.50^{***}	(0.10)
repeated	-0.12	(0.40)	0.04	(0.47)	-0.07	(0.42)
length	-0.19	(0.14)	-0.19	(0.16)	-0.19	(0.15)
Monthly variables						
Oct.-Dec.18	Reference		Reference		Reference	
Jan.19	-0.73	(0.46)	-0.82	(0.45)	-0.70	(0.46)
Feb.19	-0.18	(0.43)	-0.23	(0.46)	-0.13	(0.43)
Mar.19	-0.63	(0.34)	-0.75^{*}	(0.36)	-0.60	(0.34)
Apr.19	-0.59	(0.35)	-0.71	(0.37)	-0.51	(0.35)
May.19	-0.91^{*}	(0.36)	-0.95^{*}	(0.37)	-0.84^{*}	(0.36)
Jun.19	-0.27	(0.34)	-0.38	(0.35)	-0.27	(0.35)
Jul.19	-0.18	(0.38)	-0.19	(0.40)	-0.13	(0.38)
Aug.19	-0.01	(0.36)	-0.06	(0.39)	-0.02	(0.35)
Sept.19	-0.30	(0.41)	-0.40	(0.42)	-0.28	(0.40)
area_ha	-0.06^{**}	(0.02)	-0.07^{***}	(0.02)	-0.07^{***}	(0.02)
grassland	0.15	(0.22)			0.16	(0.23)
Natural_area						
Forest-Steppe	Reference		Reference		Reference	
Donbas	0.28	(0.31)	0.27	(0.35)	0.21	(0.29)
Steppe	-0.07	(0.14)	-0.15	(0.15)	-0.04	(0.14)
Carpathians	-0.24	(0.49)	-0.34	(0.51)	-0.17	(0.49)
Western Polissia	0.88^{**}	(0.31)	0.88^{**}	(0.32)	0.93^{**}	(0.32)
Central Polissia	0.67	(0.47)	0.68	(0.48)	0.67	(0.41)
Eastern Polissia	0.33	(0.33)	0.18	(0.32)	0.33	(0.32)
Const.	-2.11	(3.12)	-4.12	(3.31)	-1.68	(3.12)
N	2247		2022		2247	

Note: Standard errors in parentheses

Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table D 3-2. Estimated marginal effects for the model's alternative specifications (without the variable representing the number of bidders)

	Model 3.1		Model 3.2		Model 4.1	
	Marg.Effect	Std.Err.	Marg.Effect	Std.Err.	Marg.Effect	Std. Err.
Dependent variable	*underbid*		*underbid*		*underbid_2*	
entry_fee	0.00^{*}	(0.00)	0.00^{**}	(0.00)	0.00^{*}	(0.00)
increment_ha	-0.01^{**}	(0.00)	-0.01^{**}	(0.00)	-0.01^{***}	(0.00)
duration_min	-0.08^{***}	(0.01)	-0.08^{***}	(0.01)	-0.08^{***}	(0.01)
repeated	-0.02	(0.06)	0.01	(0.07)	-0.01	(0.07)
length	-0.03	(0.02)	-0.03	(0.02)	-0.03	(0.02)
Monthly variables						
Oct.-Dec.18	Reference		Reference		Reference	
Jan.19	-0.12	(0.07)	-0.12	(0.07)	-0.11	(0.07)
Feb.19	-0.03	(0.06)	-0.03	(0.06)	-0.02	(0.06)
Mar.19	-0.10^{*}	(0.05)	-0.11^{*}	(0.05)	-0.10^{*}	(0.05)
Apr.19	-0.09	(0.05)	-0.10^{*}	(0.05)	-0.08	(0.05)
May.19	-0.15^{**}	(0.05)	-0.14^{**}	(0.05)	-0.14^{**}	(0.05)
Jun.19	-0.04	(0.05)	-0.05	(0.05)	-0.04	(0.05)
Jul.19	-0.03	(0.05)	-0.03	(0.05)	-0.02	(0.06)
Aug.19	-0.00	(0.05)	-0.01	(0.05)	-0.00	(0.05)
Sept.19	-0.04	(0.06)	-0.06	(0.06)	-0.04	(0.06)
area_ha	-0.01^{***}	(0.00)	-0.01^{***}	(0.00)	-0.01^{***}	(0.00)
grassland	0.02	(0.04)			0.03	(0.04)
Natural area						
0 Forest-Steppe	Reference		Reference		Reference	
1 Donbas	0.04	(0.05)	0.04	(0.05)	0.03	(0.04)
2 Steppe	-0.01	(0.02)	-0.02	(0.02)	-0.01	(0.02)
3 Carpathians	-0.04	(0.08)	-0.05	(0.08)	-0.03	(0.08)
4 Western Polissia	0.13^{***}	(0.04)	0.12^{**}	(0.04)	0.14^{***}	(0.04)
5 Central Polissia	0.10	(0.06)	0.10	(0.06)	0.10	(0.06)
6 Eastern Polissia	0.05	(0.05)	0.03	(0.05)	0.05	(0.05)
N	2247		2022		2247	

Note: Standard errors in parentheses

Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4 The Role of Lessor Reputation in Land Auctions: Empirical Analysis of Field Data

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Abstract

A good seller reputation is expected to positively impact the rate of transaction success and its price. Presumably so does a good lessor reputation: Potential tenants may be more willing to conclude a long-term agreement with a trustworthy lessor and pay higher rental rates. This paper uses data from the pilot stage of an agricultural land lease online auction project in Ukraine that started in October 2018 and was aimed at increasing the transparency of publicly-owned land management. This paper investigates if, over the first year of the project's implementation, regional agencies responsible for agricultural land management in their regions were able to build a positive reputation among participants of online auctions, who could observe the publicly disclosed information about all previous online auction outcomes. The results estimated by several regression models confirm that a regional agency's good reputation record may be associated with the greater probability of future transaction success and a substantial price premium. The costs of further lot preparation tend to decrease if auctions were more successful in the past.

Keywords: lessor reputation, land auctions, reputation premium, rental rates, transaction success

4.1 Introduction

Seller reputation and trustworthiness are considered to be important intangible assets that influence the behavior of buyers and sellers, transaction success rates, and final prices (Holmström, 1999; Gilkeson and Reynolds, 2003; Melnik and Alm, 2005; Bar-Isaac, 2007; Bar-Isaac and Tadelis, 2008; Wang and Wang, 2012; Bergemann and Hörner, 2018; Janas and Oljemark, 2021). Several existing studies have analyzed reputation-related issues in real estate markets. For ex., Maher (1989) investigated the role of auction agents within the broader context of auction institutions in Melbourne. Clapp and Tirtiroglu (1994) found a significant positive relationship between the rate of change of housing transaction prices for property located in neighboring towns in the same metropolitan area. Ong et al. (2005) found differences in the probability of an auction's success and the winning bid amounts between different auction houses. Yang et al. (2015) investigated land lease auction mechanisms employed in China along with the effects local government behavior and policies have upon land lease arrangements for real estate development and indicated that bidders with a better-known reputation are more likely to win. Hüttel et al. (2016) investigated the role of institutional sellers and evaluated if they shape price formation and agricultural land allocation in Germany. They concluded that when compared to private landowners, privatization agencies sold at significantly higher prices. Moreover, two institutional sellers on the German farmland market sold land at different price levels. Reputations may also play a pronounced role in land rental markets, but to our best knowledge, the empirical evidence related to the role of a lessor's reputation in agricultural land markets was scarce.

A pilot project to auction rental contracts via ascending-price online auction was launched in October 2018 in order to assist regional agencies in leasing the publicly owned land plots they manage (Kvartiuk et al., 2022; Kvartiuk et al., 2020). The field data from these online auctions has been publicly disclosed. All interested lessees and other parties were able to observe and analyze the online auction outcomes. The available data shows that over the first year of the project's implementation, roughly 55 percent of the land plots auctioned were rented. Approximately 30 percent of the auctions failed because of a lack of demand and 15 percent were nullified either before or after the auction took place due to parties refusing to sign a rental agreement, court decisions, problems with documentation, or other legislatively prescribed reasons (The Cabinet of Ministers of Ukraine, 2017).

The development of a feedback system on numerous online auction platforms has made reputation measurable through the number of unique positive or negative responses[8] (Bajari and Hortacsu (2003), Cabral and Hortacsu (2010), Lumeau et al. (2015), Clapp et al. (1995), Dalmia and Filiz-Ozbay (2021),

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[8] Yet the feedback given may also be dishonest and biased. Li (2010) found that only half of buyers leave feedback after a transaction, and nearly all feedback left was positive. Gesche (2022) discovered the greater probability of receiving negative feedback when a buyer finds the same item at a lower price.

Ubbink (2019), Georgoulias et al. (2022), Copeland et al. (2019), Li (2010)). Using feedback reports as a measure of a seller's reliability and reputation, Livingston (2005) found a strong positive effect based upon the first few eBay buyer feedback reports and decreasing marginal returns from additional reports. For that reason, Livingston (2010) suggested that the relationship between price and seller reputation is nonlinear. Houser and Wooders (2006) developed the theoretical and empirical models for online auctions and investigated whether reputation effects winning bid amounts. They concluded that a 10 percent increase in the number of positive comments a seller has can be associated with a 0.17 percent increase in the final price, whereas a 10 percent increase in neutral or negative feedback decreases the price by 0.24 percent.

Unlike eBay auctions, the online land auction platform under consideration provides detailed information about all past auction outcomes. We assume that such information environment may be considered as an approximation for a fundamental assumption of seller reputation models that implies that bidders observe previous auction outcomes and use this information to form their impression about the seller (Bar-Isaac and Tadelis, 2008) or the regional agency responsible for land management and auction organization in our case[9]. The article investigates if region specific information about past auction outcomes influences the probable success of future auctions, land pricing, and the efforts exerted by the regional agencies of the analyzed regions. It provides complementary evidence to the existing studies that regard online auction feedback as a measure of seller reputation. Reputation is measured as the ratio of previously conducted successful to non-successful transactions. It additionally provides evidence about the strategies implemented by the institutional lessors in response to their reputations.

We believe that the information regarding a lessor's reputation and its effects is important for both parties negotiating a rental contract – the potential tenant and the lessor. For potential tenants, it is important to know that the regional agency in question has successful experience, as it likely reduces the risk of transaction failure. On the other hand, if potential bidders see that a lessor has a poor reputation and doesn't exert much effort to improve it, they may consider renting a privately-owned plot-substitute when available. If bidders know about the bad reputation of a lessor and yet no substitute plot can be found, they may still decide to rent the plot, but will need to consider that they

[9] Though bidders in agricultural land lease auctions were likely local farmers, and via word-of-mouth recommendations they might also get advice from other farmers regarding local land, along with the information about potential problems and opportunities associated with the managing agencies and the related contracts.

might incur some extra costs and update their land valuations, taking these risks into account. As for the regional agencies, having a positive reputation may also be beneficial, because then they may expect greater revenues and a better transaction success rate. Moreover, they may amend the amount of efforts they expend depending on their market reputation – to either preserve a good reputation or to improve a bad one - and in this way auction farmland more efficiently.

The remainder of the paper is structured as follows: The subsequent section briefly introduces the theoretical framework that incorporates several approaches related to seller reputation. This is followed by a description of the data collected from agricultural land lease auction and outlines the estimation method. By means of regression analysis, the effects of reputation-related and property characteristics on the probability of transaction success, its price, and the efforts exerted were estimated. Then there is a discussion of the estimation results and a conclusion.

4.2 Theoretical background

4.2.1 The seller reputation framework

The theoretical background for this article is based on the unifying seller reputation framework published in Bar-Isaac and Tadelis (2008) that incorporates several different approaches under one umbrella. In its basic settings, the seller (or the lessor in our case) engages in one transaction that can result in a success, which is denoted as 1, or a failure which is denoted as 0 to any buyer (or tenant). The outcome may depend upon the seller's abilities and effort - denoted as e - as well as the buyers' opinion about the seller. To reflect their reputations, sellers are assigned as "good" or "bad" and are indexed as $\theta \in (b, g)$. A good seller has a higher probability of success than a bad one so that the following threshold holds $0 \leq b \leq g \leq 1$.

Potential buyers are expected to learn the sellers' categorization by observing past transactions. Their opinion of the seller is observable in the end of the period $t \in T$ and denoted by μ_t. Following a successful outcome S in the first period, the buyers' beliefs about the seller will be calculated according to Bayes' rule by Eq. 1:

$$\mu_1(\mu_0, S) = \frac{\mu_0 g}{\mu_0 g + (1-\mu_0) b} \tag{1}$$

Following a failure F in the first period, the reputation will be expressed by Eq. 2:

$$\mu_1(\mu_0, F) = \frac{\mu_0(1-g)}{\mu_0(1-g) + (1-\mu_0)(1-b)} \tag{2}$$

As the number of periods increase, buyers will be better informed about a seller's reputation record and μ_t will converge either to 0 for a bad seller or to 1 for a good one. The buyers' opinion about a seller may have an effect on the transaction price that is denoted as p. If at a period t, the seller has a reputation denoted as μ_t the buyers' willingness to pay is expressed by Eq. 3:

$$p = \mu_t g + (1 - \mu_t)b \tag{3}$$

The probability of transaction success is expressed as $e\theta$. It depends on the seller's efforts. The efficient level of a seller's effort that maximizes social surplus is obtained by maximizing $\theta e - c(e)$, where $c(e)$ stands for the seller's effort expenses (Bar-Isaac and Tadelis, 2008; Bar-Isaac, 2003).

Sellers may also exert more or less efforts in subsequent periods, depending on their knowledge about their reputation. However, it is generally expected that seller efforts in the first period will exceed those in the second period $e_1 > e_2$ for two main reasons: First, the lack of knowledge about a seller's reputation in the first period will motivate them to exert more effort so that buyers in a subsequent period will be able to observe previous positive outcomes. Second, the amount of efforts a seller invests will diminish over time following the intuition that by working harder in the first period the reputational effects will last through several consequent periods. In this case, the transaction price that accounts for seller reputation as described in Eq. 3 in the first period becomes

$$p_1 = \mu_0 e_1 g + (1 - \mu_0)e_1 b, \tag{4}$$

where the price in the first period depends on prior seller reputation μ_0 and the efforts of the seller during the first period e_1. In the second period, price will also depend on the seller's existing reputation. Following the reputational successes from the first period, reputation in the second period μ_1^S will be calculated using the Bayes' rule as follows:

$$\mu_1^S = \frac{\mu_0 e_1 g}{\mu_0 e_1 g + (1-\mu_0)e_1 b} = \frac{\mu_0 g}{\mu_0 g + (1-\mu_0)b} \tag{5}$$

Depending if the first-period transaction was successful or not, a different level of effort is expected in the second period, therefore the price determined by Eq. 4 in the second period will become

$$p_2^S = \mu_1^S e_2 g + (1 - \mu_1^S)e_2 b \tag{6}$$

Following a transaction failure, the seller's reputation will be calculated by the formula

$$\mu_1^F = \frac{\mu_0(1-e_1 g)}{\mu_0(1-e_1 g)+(1-\mu_0)(1-e_1 b)} \tag{7}$$

and the corresponding price equation will be described by Eq. 8 as follows

$$p_2^F = \mu_1^F e_2 g + (1 - \mu_1^F) e_2 b \quad (8)$$

(Holmström, 1999; Bar-Isaac and Tadelis, 2008).

If the seller reputation is already known, one may further model the different levels of effort they exert. Sellers can increase or decrease their efforts in response to a success or failure both of which will have an impact upon their future successes and revenues (Bar-Isaac and Tadelis, 2008). The baseline scenario is that good sellers with an infinite time horizon will not sustain a high level of effort, because after buyers learn about a seller positive reputation, the sellers' incentive to exert the same level of effort in consequent periods diminishes (Holmström, 1999; Bar-Isaac and Tadelis, 2008). However, in some cases a good seller may invest more efforts in future periods in order to separate themselves from the competition, especially if there is substantial uncertainty about their reputation (Mailath and Samuelson, 2001; Bar-Isaac and Tadelis, 2008). Sellers may also choose to exert more effort to help improve their record and to avoid potential losses from a bad reputation record (Kreps and Wilson, 1982; Kreps et al., 1982; Bar-Isaac and Tadelis, 2008; Dalmia and Filiz-Ozbay, 2021).

4.2.2 Reputation reduced-form regression model

Several papers derived an empirical reduced-form model for online auctions, one that enables the effect of a seller's reputation on transaction prices and/or winning bids in online auctions to be estimated by applying regression analysis. The reduced-form equation is described as a function of reputation measures and other supply- and demand-related factors (Cabral and Hortacsu, 2010; Feichtinger and Salhofer, 2016; Houser and Wooders, 2006; Livingston, 2010) as follows:

$$p^* = f(reputation, other\ demand\ and\ supply\ factors) \quad (9)$$

where p^* is the winning bid of auction i.

4.3 Data, descriptive statistics, and methodology

4.3.1 Data and descriptive statistics

The present study uses publicly disclosed data from agricultural land lease auctions that took place in the period between October 2018 - September 2019 in Ukraine. The observations were collected from the OpenMarketLand platform that is run by the state enterprise "The system of electronic trade of seized property" in partnership with the Ukrainian State Service for Geodesy, Cartography, and Cadaster (also referred to as the State GeoCadaster). The project was launched to help the regional agencies of the State GeoCadaster, who were responsible for auctioning the publicly-owned land in their regions online (also referred as lessors[10]). The information about the property dimensions, land use designation, location, contract term, cadaster number, and a rental agreement draft, along with the auction specifics of the minimum bid (also referred to as a reserve price), bid increment, entry fee, etc. was published on the project's webpage. Personal information about bidders and winners and details of the final agreement between winners and the regional agencies were kept confidential.

Over the considered period, 4,890 online land auctions took place, representing 97,004.93 hectares (ha[11]) of agricultural land. Over the observed period about 55 percent of the online auctions resulted in the successful conclusion of land lease agreements. Approximately 50,000 ha of the land was rented. The majority of land lease contracts auctioned had a seven- or ten-year duration that may be extended for a term of up to 50 years according to the Land Code (The Verkhovna Rada of Ukraine, 2002).

Auctions were considered a failure, if no bidders registered or the registered bidders did not submit a bid equal to or higher than the minimum bid. The auction outcome could also be cancelled due to the parties refusing to sign a rental agreement, court decisions, or other legislative reasons. Around 30 percent of the auctions failed and the remaining auctions were nullified. The information about failed and cancelled auctions was also published. This includes the same information components without a winning bid (The Cabinet of Ministers of Ukraine, 2017).

From the collected dataset, only the arable land plots were selected to increase homogeneity of the sample (732 observations representing the other land use designations were deleted). Outliers below 1st percentile and above the 99th percentile from the variable representing plot area were also removed in order to eliminate the unusually small and large plots. This led to the deletion of 34 more transactions. A further six winning bids below the reserve price were also removed. These adjustments were made to drop the observations that were likely documented by mistake. Auctions with preparation costs exceeding 15,000 UAH/ha were also removed, as such that were also mistakenly documented or could represent plots with buildings or other infrastructural objects. This adjustment

[10] The considered regional agencies acted as lessors – if rented plots were administered directly by the regional agency of the State GeoCadaster or as intermediaries between landowners and the executor of auctions – if in the course of decentralisation publicly owned plots were already transferred to lowest level administrations, such as territorial communities.

[11] 1 ha = 2,47 acres

led to the removal of 50 more observations. Additional 195 plots with normative appraisals above 50,000 UAH/ha were also deleted, because these plots were likely to not solely be used for cultivation. As it can be seen in Table 1, the final sample consists of 3,874 arable land plots, of which 2,178 or 56 percent were successful auctions.

Table 4-1. Descriptive statistics (N=3,874).

Variable	Notation	Mean	Std.Dev.	Min	Max
Successful auctions in the sample	S_i	0.56	0.50	0	1
Rental price, UAH/ha[12]	P_i	3696.18	4437.14	40.49	70816.60
Reputation (ratio of successful to non-successful auctions)	R_i	1.75	1.31	0	10.33
Number of bidders	C_{i}	2.47	2.05	0	18
Reserve price, UAH/ha	RP_i	1427.31	1071.82	1	20361.99
Preparation costs, UAH/ha	PC_i	1790.02	1895.76	0	14546.78
Time on the market (days)	TOM_{i}	179.79	86.79	0	347
Number of previous auctions before each auction within each region	N_i	110.16	95.26	0	467
Number of future auctions after each auction within each region	M_{i}	156.53	91.1	11	483
Plot area, ha	$\mathrm{A_i}$	20.49	120.03	0.60	5221.02
Soil quality	Q_{i}	63.7	17.9	19.47	91.33
Farmland area in the region, thousand ha	F_{i}	1667.60	678.76	4.4	2591.6
Regions	$Region_{\mathrm{i}}$			1	24
Month[13]	$Month_{\mathrm{i}}$			1	10

Source: own representation based on OpenMarketLand (2018-2019), The Ukrainian Academy of Sciences, 1978), The State Statistics Service of Ukraine (2019) data.

We consider this dataset and the one-year period that it covers are appropriate for the analysis for several reasons. First, the regional agencies had no prior experience of renting plots via online auction before the pilot project began. Therefore, all responsible agencies faced equal conditions at the beginning of the studied period and no reputation-based effects could be observed. As the project developed and the auctions grew in popularity among farmers, some regional land managing agencies

[12] Calculated for successful auctions only (N=2,178).

[13] The sample includes 12 months. The first three months of auctioning land rights online were used as a reference to make it comparable with the rest of the months due to a small number of observations.

gained positive reputation and some did not. This allowed assuming the presence of a potential reputation effect that could influence auction outcomes and land pricing. Second, the observed period includes sufficient information for analysis, but at the same time over this period, there were likely no events that led to significant changes in administrative team compositions that could lead to the splitting up of reputation effects between the efforts made by senior and junior team members. Moreover, there were no significant changes in state, regional or local land policies and reputation effects could not be attributed to such policy changes as described in previous relevant studies (Bar-Isaac and Tadelis, 2008; Morrison and Wilhelm, 2004; Bar-Isaac, 2007; Levin and Tadelis, 2005). Third, Bar-Isaac and Tadelis (2008) and Hörner (2002) suggest that in order to benefit from the reputation premium adequate competition should be present in the market. Reputation benefits can only be seen in sufficiently competitive markets, as a monopolized marketplace does not require seller competition and exerting efforts to keep a good record is superfluous. On the other hand, too much competition can diminish the reputation effect. The supply side in the Ukrainian land market is represented by the regional agencies that manage publicly owned lands (state-owned lands make up approximately 10.5 million ha or one-quarter of all available agricultural areas) and numerous small-scale private landowners, who received their plots during the process of land privatization after the dissolution of the Soviet Union (Lerman, 2001; Kvartiuk and Herzfeld, 2019). Although the agencies manage a substantial amount of agricultural land and may possess some degree of market power, a sufficient amount of market competition between the regional land management agencies and private landowners may be assumed, because potential land tenants have the choice of renting either privately-owned land or a state-owned parcel. It may still be a valid claim that all market players exist in a competitive environment and will be interested in having a reputation premium. Otherwise, a lack of willingness to rent publicly owned lands and/or a low willingness to pay for it will result in lower revenues of regional and community budgets. Last but not least, potential tenants on the considered auction platform could view all previous auction outcomes, so the fundamental assumption behind the seller reputation models - potential buyers or tenants are aware of past transactions of a particular seller or lessor as described in Section 2 with a reference to Bar-Isaac and Tadelis (2008) - is valid.

All bids are presented in Ukrainian currency, Hryvnia (UAH). At the time of data collection, 1 Euro corresponded to approximately 30 UAH (The National Bank of Ukraine, 2019). Winning bids (only observable in successful auctions) ranged between 40.49 and 70,896.60 UAH per hectare. The average winning bid was 3,696.18 UAH/ha or about 123 Euro/ha. It was 2.6 times higher than the average reserve price. This price increase was achieved by means of competitive bidding: On average, 2-3 bidders took part in each auction. Eighteen bidders participated in the most competitive auction.

Lessors achieved different results in auctioning land online. The average number of previous successful transactions was around 66 auctions. The number of failed previous auctions before each transaction within each region was 29 and the number of cancelled auctions was around 15. The average share of previous successful transactions was about 58.5 percent. The share of previous failed auctions held before each transaction within each region was 27.7 percent and the share of cancelled auctions was much smaller – about 12.4 percent. Consequently, the ratio of successful to non-successful auctions varied between 1.31 to 10.33 with a mean value of 1.75 that means that on average the number of successful auctions exceed the number of unsuccessful transactions by 75 percent. The ratio was used as a measure of reputation. Figure *4-1* presents the relationship between winning bids, competition, and reputation.

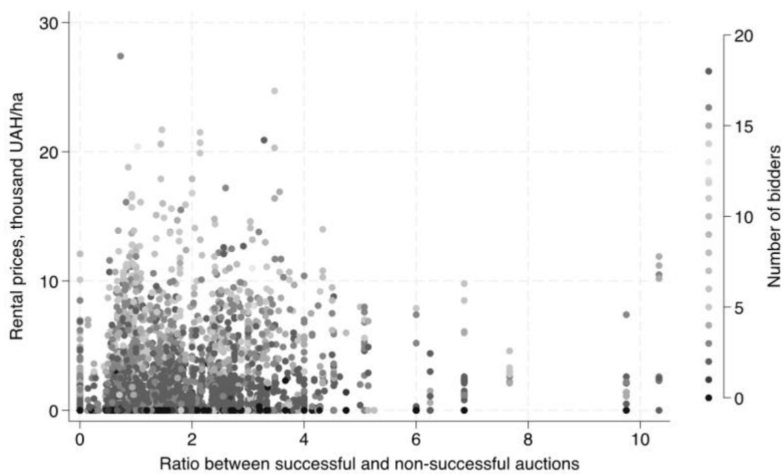

Figure 4-1. The relationship between winning bids, competition, and reputation.

Source: own representation based on OpenMarketLand (2018-2019) data.

The average time between the first and the last auction conducted in one region was 180 days. Plots were auctioned in each of Ukraine's 24 *oblasts* (regions). As aforementioned, none of the regional agencies had prior online auction experience. Over the course of the project, some agencies started auctioning land in the first days of the testing phase in October 2018. Their time operating on the market amounted to 348 days (347 days plus one day). In the regions where land was actively auctioned up to 485 auctions were held. More auctions were held in regions with more available agricultural land, such as Odesa with 2,591.6 thousand ha[14], where about 12.5 percent of all auctions took place and almost 70% of them were successful as Figure *4-2* shows.

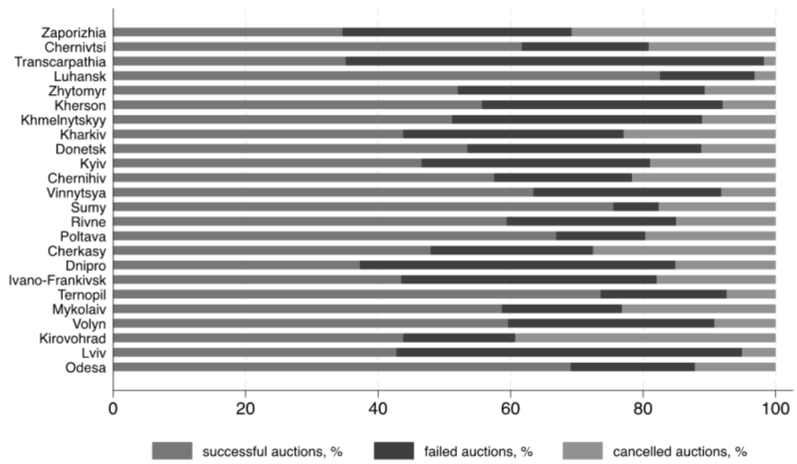

Figure 4-2. Auction outcomes across regions.

Source: own representation based on OpenMarketLand (2018-2019) data.

The costs required to prepare a plot for auction varied considerably. For some plots there were no declared costs for plot preparation while others disclosed rather high per-hectare expenses – about 14,547.31 UAH/ha. On average, preparation costs for one hectare of land was 1,790.02 UAH. These costs may include the expenses of obtaining the plot's cadastral number from the State GeoCadaster, the costs for preparing the technical documentation on the normative monetary valuation of the plot, the cadastral preparation plan reflecting the land use designation, the description of adjacent land holdings (land uses) for the designated land plots and their unique cadastral numbers, as well as the agrochemical passport (The Cabinet of Ministers of Ukraine, 2017; The Verkhovna Rada of Ukraine, 2002).

Reserve prices are often assumed to be the seller's or lessor's estimate of the auctioned property value (McAfee and McMillan, 1987). In this case, reserve prices varied between 1071.82 and 20,361.99 UAH/ha. The highest reserve price likely indicates a high land value. The average per-hectare reserve price was about 1,427.31 UAH/ha.

Auctioned plots varied in terms of size and soil quality. The managing agencies auctioned both very small plots (0.6 ha) and very large ones (more than 5,221 ha). The average plot size was about 20.5

[14] The data comes from the report of The State Statistics Service of Ukraine (2019).

ha. Soil quality index[15] varied between 19.47 and 91.33 with a mean value of 63.7 that indicates good quality agricultural land auctioned.

4.3.2 Models' and hypotheses' formulation

Based on the theoretical framework and the reduced-form model described in Section 2, winning bids are represented as a function of reputation-related and other demand and supply factors. The price model (Model 1.1.) was first estimated as a one-stage multiple regression with fixed regional and time effects, as described by Eq. 10:

$$P_i = f(R_i, C_i, R_i * C_i, RP_i, PC_i, TOM_\mathrm{i}, N_i, M_\mathrm{i}, \mathrm{A_i}, Q_\mathrm{i}, F_\mathrm{i}, Region_\mathrm{i}, Month_\mathrm{i}) \qquad (10)$$

Auction data may be subject to a non-random sample selection that may lead to a sample selection bias (Paarsch and Hong, 2006). If observations in the sample used to conduct a regression analysis are non-randomly selected, the concern arises that selection could affect the coefficients (Cook et al., 2022). One well-known reason for sample selection is when there is a lack of registered (actual) bidders with a willingness to pay above the minimum bid, leading to an auction failure (Livingston, 2005; Paarsch and Hong, 2006). In our particular case, prices were observable in a bit more than one half of the auctions and a non-random sample selection may occur. Therefore, a two-stage estimator (Model 2) was used to jointly estimate the selection and outcome processes as suggested by Heckman (1979) and further described and elaborated in other papers, like Cook et al. (2022), Mulligan and Rubinstein (2008). The first stage equation is estimated as a probit regression with binary dependent variable indicating auction success, which determines sample selection and is reflected by the variable that represent successful auction outcomes. The variable was assigned a value of 1 if the auction in the sample was successful and 0 if otherwise. It was modelled as a function of the same factors related to lessor reputation and property characteristics (Eq. 11) as the price model (Eq. 10). The price equation is estimated as a second-stage regression, taking into account the correlation coefficient (or covariance) between the error terms of the two equations that makes the sample selection model different from

[15] The assessment was made by agricultural groups and subgroups of soils. The evaluation criterion is the average long-term yield of a group of cereals without considering the costs of land cultivation. Soils with the highest cereal yield were evaluated with 100 points (The Ukrainian Academy of Sciences, 1978; Grachev, 2019).

just a regression model and a probit model estimated as two different one-stage regressions (Verbeek, 2004). For comparison, a one-stage probit model was also estimated (Model 1.2.).

$$S_i = f(R_i, C_i, R_i * C_i, RP_i, PC_i, TOM_\mathrm{i}, N_i, M_\mathrm{i}, \mathrm{A}_\mathrm{i}, Q_\mathrm{i}, F_\mathrm{i}, Region_\mathrm{i}, Month_\mathrm{i}) \qquad (11)$$

The models were formulated to test the following hypotheses. The first hypothesis is based on Houser and Wooders (2006) and Livingston (2010, 2005), who suggest that a seller's reputation - the number of positive and negative feedbacks given – can influence auction outcomes. In this paper, we measure reputation as the ratio of successful to non-successful auctions and expect that a growing number of positive past outcomes compared to negative ones will make future transactions more likely to succeed and will lead to a higher willingness to pay by the tenant.

Land leasing is typically associated with transaction costs (Ritter et al., 2020; Kvartiuk and Herzfeld, 2019). In the states that emerged after the dissolution of the Soviet Union, these costs often occur, because of the anachronistic and opaque bureaucracies responsible for land transactions. Due to these bureaucratic hurdles, the land registration process may be cumbersome and costly (Vranken and Swinnen, 2006; Kvartiuk and Herzfeld, 2019). These lot preparation costs are assumed here to be a measure of lessor efforts. The larger amounts of preparation costs are expected that have a positive effect on both the success of the subsequent auctions and its final price, as it signals to bidders that the plot will not require future substantial expenditures for issues such as registration.

The amount of time a seller/lessor has been on a market may also play a role, because with each auction period the following sequence of events will unfold: In the first period, buyers/tenants have no knowledge about a seller/lessor's reputation. As the number of auction periods increases, reputations will become more refined with time providing evidence of their true nature (Bar-Isaac and Tadelis, 2008).

A buyers' knowledge about the reputation of a seller may also depend on the amount of available information about the seller's previous outcomes. If a seller has more observable past transactions, there is more information, which can spread more rapidly. The likelihood that buyers know about negative outcomes becomes greater and their concerns about a sellers' reputation may also become greater (Rob and Fishman, 2005; Bar-Isaac and Tadelis, 2008). In the present case, a greater number of previous auctions is assumed to provide a larger volume of publicly known information about the previous auction outcomes of a lessor.

Then, farmland plot and auction characteristics can affect transaction prices and the likelihood of auction success. A greater willingness to lease a plot and a greater willingness to pay should theoretically be observed if the plot is larger, as large plots are considered to be more convenient and cost-effective to cultivate when compared with several small and/or remote plots (Hüttel et al., 2013; Hüttel et al., 2016). Land with higher reserve prices are generally supposed to be more productive, as is more productive land (Ritter et al., 2015), so this should have a positive impact on rental prices. Nevertheless, greater opening bid amounts may lead to a lack of registered actual bidders with a willingness to pay above the minimum bid, something that leads to auction failure (Livingston, 2005). So, it is expected that greater opening bids may negatively influence the probability of an auction's success. The effect of bidder competition that was measured as the actual number of bidders is supposed to have a positive price effect and to increase the probability of auction success (Milgrom, 1985, 1989; Salant, 2014).

Some supply-side factors were also considered. A greater number of following auctions may impact bidding decisions (Anwar et al., 2006; Salant and Cabral, 2019; Zeithammer, 2006), because bidders may also implement some forward-looking strategies, participate in upcoming auctions. They may also search for privately owned plots-substitutes. More substitutes will likely be available in regions with a larger amount of farmland.

The abovementioned theoretical framework (Bar-Isaac and Tadelis, 2008) also suggests that a seller's reputation record may not only affect their future transaction successes and future winning bids but also efforts exerted by sellers, in our case the amounts of preparation costs of subsequent lots. Therefore, they were modelled as a function of the reputation-related factors, plot area, and soil quality that may determine these costs as described by Eq. 12. The estimation was conducted using mediation two-stage regression analysis (Model 3). On the first stage the price model was estimated. Per-hectare costs for lot preparation in this model was used as an independent variable. In the second stage, preparation costs were used as a dependent variable. The estimation also allowed for checking the coefficients' robustness and efficiency.

$$PC_i = f(R_i, \mathrm{A_i}, Q_\mathrm{i}) \tag{12}$$

The cost model was formulated to test the following hypotheses. Lessors' costs for the preparation of subsequent lots may vary, depending on their reputation. The expectation is that the growing share of successful auction outcomes may lead to a decrease in a lessor's amount of effort, because they may expect that the effect of a positive reputation will last over subsequent periods (Holmström, 1999; Bar-Isaac and Tadelis, 2008) and buyers will be able to determine the type of seller or lessor more easily. Transaction costs may also depend on the size and quality of a plot provide the details related to fixed and variable land transaction costs that are also relevant for this hypothesis). It may be expected that the per-hectare preparation costs of larger and more productive plots may be lower, because of the economy of scale.

4.4 Parameter transformation and estimation methods

To estimate the parameters of the first-stage of Heckman model (Eq. 11), the auction outcome model is presented as follows:

$$\begin{aligned} S_i &= \alpha_1 + \alpha_2 R_i + \alpha_3 C_i + \alpha_4 R_i * C_i + \alpha_5 \, \mathrm{RP}_i + \alpha_6 \, PC_i + \alpha_7 \, \mathrm{TOM}_i \\ &\quad + \alpha_8 \, N_i + \alpha_8 \, M_i + \alpha_9 \, A_i + \alpha_{10} \, Q_i + \alpha_{11} \, F_i + \sum_{j=1}^{24} \eta_j Region_{ji} \\ &\quad + \sum_{k=1}^{10} \mu_k Month_{ki} + u_{1i} \end{aligned} \tag{13}$$

where i indicates a transaction, $\alpha_1 - \alpha_{11}$ are the coefficients to be estimated, and u_{1i} is an error term.

Livingston (2010) suggest that identifying the correct functional form is an important issue for research on any topic involving online auctions that helps avoiding the risk of generating biased and inconsistent estimates. The relationship between prices or winning bids and reputation-related variables may be non-linear. Following a Box-Cox testing procedure, the variable representing rental rates in the price model was log-transformed. The final price model was presented as Eq. 14:

$$\begin{aligned} \log(P_i) &= \beta_1 + \beta_2 R_i + \beta_3 C_i + \beta_4 R_i * C_i + \beta_5 \, \mathrm{RP}_i + \beta_6 \, PC_i + \beta_7 \, \mathrm{TOM}_i \\ &\quad + \beta_8 \, N_i + \beta_8 \, M_i + \beta_9 \, A_i + \beta_{10} \, Q_i + \beta_{11} \, F_i + \sum_{n=1}^{24} \delta_j Region_{ni} \\ &\quad + \sum_{m=1}^{10} \theta_m Month_{mi} + u_{2i} \end{aligned} \tag{14}$$

Eq. 15 presents the final cost model:

$$PC_i = \gamma_1 + \gamma_2 R_i + \gamma_3 A_i + \gamma_4 Q_{\mathrm{i}} + u_{3i} \tag{15}$$

In Eq. 14-15, i indicates a transaction, $\beta_1 - \beta_{11}$, and $\gamma_1 - \gamma_4$, are the coefficients to be estimated, and u_{2i}, and u_{3i} are error terms.

The models were estimated with regional and time fixed effects and robust standard errors or with fixed time effects and clustered standard errors (regions) to prevent any possible omitted variable bias and to account for possible heteroskedastic variances (Hüttel et al., 2013; White, 1980). All specifications of the one-stage price and auctions success models and the Heckman model were estimated using the maximum likelihood method. The mediation analysis was conducted using the quasi-maximum likelihood method that employs the maximum likelihood method to fit the parameters and allows the residuals of two equations to be correlated (Acock, 2013). The relaxation of the assumption of the error terms' uncorrelatedness results in smaller standard errors and measurement errors are less likely to occur (VanderWeele, 2016).

Table 4-2. Estimation results of all regression models

	Coef.	(St. Errors)	Av.marg. effects	(St. Errors)	Coef.	(St. Errors)	Coef.	(St. Errors)
	Model 1.2				**Model 2**		**Model 3**	
Dependent variable – successful auctions								
Reputation	0.22*	(0.09)	0.06*	(0.02)	0.16*	(0.05)	-	-
Number of bidders	0.27*	(0.11)	0.08*	(0.02)	0.24*	(0.07)	-	-
Reputation *Nr. of bidders	-0.02	(0.04)	-0.01	(0.01)	-		-	-
Reserve price	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-	-
Preparation costs	-0.00+	(0.00)	-0.00+	(0.00)	-0.00*	(0.00)	-	-
Time on market	-0.00+	(0.00)	-0.00+	(0.00)	-0.00	(0.00)	-	-
Previous auctions	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	-	-
Future auctions	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-	-
Plot area	-0.01*	(0.00)	-0.00*	(0.00)	-0.01*	(0.00)	-	-
Soil quality	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-	-
Farmland area	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-	-
Cons.	-0.11	(0.45)	-	-	0.01	(0.38)		
Nr. of obs.	3874		-	-	-	-	-	-
Fixed effects	Monthly dummies		-	-	-	-	-	-
Standard errors	Clustered std. errors (regions)		-	-	-	-	-	-
	Model 1.1				**Model 2 (cont.)**		**Model 3**	
Dependent variable - rental price (log)								
Reputation	0.08*	(0.03)	-	-	-0.01	(0.02)	0.08*	(0.03)
Number of bidders	0.33*	(0.03)	-	-	0.27*	(0.03)	0.33*	(0.03)
Reputation *Nr. of bidders	-0.02+	(0.01)	-	-	-	-	-0.02+	(0.02)
Reserve price	0.00*	(0.00)	-	-	0.00*	(0.00)	0.00*	(0.00)
Preparation costs	-0.00*	(0.00)	-	-	-0.00	(0.00)	-0.00*	(0.00)
Time on market	0.00+	(0.00)	-	-	0.00+	(0.00)	0.00+	(0.00)
Previous auctions	0.00	(0.00)	-	-	-0.00*	(0.00)	0.00	(0.00)
Future auctions	-0.00*	(0.00)	-	-	-0.00	(0.00)	-0.00*	(0.00)
Plot area	0.01*	(0.00)	-	-	0.01*	(0.00)	0.01*	(0.00)
Soil quality	0.00	(0.00)	-	-	0.00	(0.00)	0.00	(0.00)
Farmland area	0.02*	(0.00)	-	-	0.00*	(0.00)	0.02*	(0.00)
Cons.	-16.35*	(6.87)	-	-	5.80*	(0.34)	-16.35*	(6.81)
							Model 3 (cont.)	
Dependent variable - lot preparation costs								
Reputation	-	-	-	-	-	-	-110.26*	(18.60)
Plot area	-	-	-	-	-	-	-43.95*	(2.77)
Soil quality	-	-	-	-	-	-	-13.85*	(1.77)
Cons.	-	-	-	-	-	-	3522.47*	(143.39)
Error terms' correlation	-	-	-	-	-0.60*	(0.15)	-	-
Nr of obs. / Nr. of selected obs.	2178		-	-	3874 /	2178	-	-
Fixed effects	Regional and monthly dummies				Monthly dummy variables		Regional and monthly dummies	
Standard errors	Robust				Clustered std. errors		Robust	

Note: significance levels are indicated as $^{+}$ $p < 0.10$, * $p < 0.05$.

Table 4-2 presents the estimation results of each specification of the estimated regression models. It has been found that a growing number of successfully held auctions is associated with higher winning bids and a greater probability of successful subsequent transactions. These results met our expectations that were based on the framework presented in Bar-Isaac and Tadelis (2008), according to which a seller or lessor is expected to be rewarded for having a good reputation.

The probability of auction success and the winning bid achieved during an auction increases substantially, if more bidders participate. This meets the expectations and is in line with other auction-related studies (Milgrom and Weber, 1982; Paarsch, 1992; Salant, 2014; Ong et al., 2005). The observed positive price effect of reputation holds mainly for auctions with 2-4 bidders (or 87% of observations in the sample of successful auctions) and slightly diminishes if auctions are more competitive as Figure 4-3 shows.

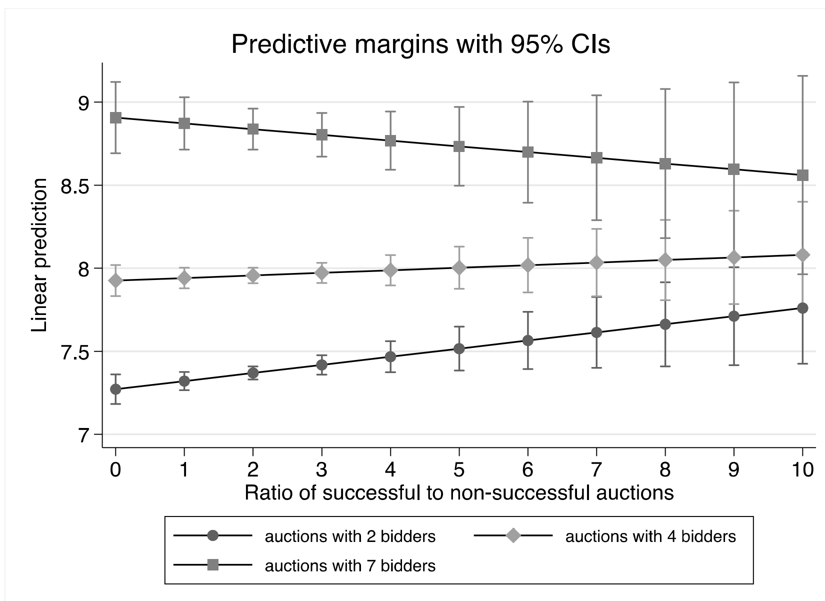

Figure 4-3. The marginal effects of reputation and competition on prices.

The greater numbers of previous and future auctions lead to lower prices. It confirms the hypothesis that the likelihood that buyers know about negative outcomes becomes greater and their concerns about a sellers' reputation may also become greater, having an adverse price effect. The finding is in line with results published in Rob and Fishman (2005) and Bar-Isaac and Tadelis (2008). Bidders' willingness to pay may also be lower if they are forward-looking and expect more future auctions. This finding meets our expectations, based on Zeithammer (2006).

Finally, the estimation results also show that auction and property characteristics may have an effect upon a transaction's success and rental pricing. A positive relationship between reserve prices and the winning bid amounts indicates that if higher opening bid amounts are disclosed in the auction announcement, bidders with a higher willingness to pay participate. This meets the expectations and is in line with the results presented in Bajari and Hortacsu (2003). Third, larger plots were more expensive, but were less in demand. This effect may be explained by capital constraints that bidders face (Xu et al., 1993). Additionally, plots in the regions with a larger farmland area were a bit more expensive.

The effect of preparation costs on the probability of auction success and winning bids was found to be very small, negative and significant. Additionally, the estimation results of Model 3 suggest that lessors tend to respond to the better reputation records with the lower costs of subsequent lots' preparation. It meets the expectations and suggests that lessors tended to decrease their efforts in subsequent auction periods as they considered themselves to be established as lessors with a positive reputation, and therefore their incentive to exert further efforts diminished. Although the lessors analyzed are regional agencies that manage publicly owned land, and they are not at risk of being driven out from the market, regardless of their reputation, they were still participating in a competitive environment where potential tenants could select a privately-owned plot-substitute if they considered the conditions offered by the regional agencies to be unfavorable. The implementation of this strategy by the regional agencies seems to be justifiable (Bar-Isaac and Tadelis, 2008; Kreps et al., 1982; Kreps and Wilson, 1982).

In addition, the results from Model 3 show that the relationship between plot size and per-hectare lot preparation costs is negative: The auction preparation of a larger plot is less expensive when compared to smaller plots. The same holds true for more productive plots. So, the agencies may consider some form of land consolidation in order to reduce transaction costs. This possibility has also been discussed in Kvartiuk and Herzfeld (2019), in which the authors briefly discuss the problem of land fragmentation and suggest that land consolidation is a solution that could significantly reduce transaction costs affiliated with land leasing. However, lessors should also consider that potential tenants may face budget constraints and the demand for larger plots may subsequently be lower than for smaller plots. Moreover, land repackaging may also be associated with additional costs that lessors must also take into account (Ritter et al., 2020).

4.5 Conclusion

This article investigates if information about past land lease transactions may be associated with the success of future transactions, farmland rental rates, and the efforts exerted by the lessors. It complements the theoretical seller reputation models by providing empirical evidence from agricultural land lease auctions that took place in Ukraine between October 2018 and September 2019. The paper provides complementary evidence to earlier existing studies that primarily considered eBay auctions and regarded online auction feedback comments as a measure of a seller's reputation (see, for ex., Bajari and Hortacsu (2003), Cabral and Hortacsu (2010), Lumeau et al. (2015), Clapp et al. (1995), Dalmia and Filiz-Ozbay (2021), Ubbink (2019), Georgoulias et al. (2022), Copeland et al. (2019), Li (2010)) by reconstructing potential tenant's information set from the previous transactions that were publicly disclosed on the auction webpage.

Lessors and auctioneers in the present study are represented by regional land management agencies from the Ukrainian State GeoCadaster, and they had no prior online auction experience before the pilot stage of the online auction project began. They could gain some reputation among farmers during the period studied, because all the previous auction outcome information was publicly disclosed and bidders could thus formulate their impressions about the lessors based on this data. Before this, potential tenants had very little amount of reliable statistical information at their disposal, if any. After the online land auction project began, the auction outcome information became available to all parties interested.

The theoretical seller reputation framework implies that a good seller can expect to be rewarded and this prediction was confirmed: A good lessor reputation record has a positive effect on the probability that subsequent auctions will succeed and also has a positive price effect. Maintaining a good reputation or improving a bad reputation is crucial for achieving a better efficiency of land allocation and securing higher amounts of revenue for the regional agencies' budgets. It seems reasonable for all parties to keep track of previous auction outcomes and to act in response to either positive or negative reputation feedback. Lessors may optimize/decrease the amount of efforts they exert long term in response to an already recognized good reputation and vice versa: They may consider taking some actions to improve their record by, for example, exerting more effort in preparing plots for rent or decreasing reserve prices to attract more potential tenants, because a lower starting bid will allow more individuals with a lower willingness to pay to participate. A lower achievable rental rate may later be compensated by a reputation premium, if bidders see that said agency has substantially improved their record.

There are several limitations to be mentioned. First, the study utilizes publicly owned land transaction data, assuming that if a transaction with the regional agency for some reasons failed, potential tenants could search for a privately-owned plot-substitute. The data related to private land transactions could be helpful in creating a more comprehensive picture about the market competition lessors face. Second, the study is based on supply side information, as the information about potential and actual tenants is unfortunately not available. The availability of this information could also be useful in analyzing both parties in a rental contract, suggesting that lessors may also provide some beneficial conditions for good tenants, for example to those who are known to be solvent and financially reliable and who invest in the land rented and cultivate it sustainably. Third, the study utilizes one-year of data and ignores changes in team composition and policies, as such that it was not expected to take place in such a short term. To investigate these effects, an analysis covering a longer period of time may be necessary. Last but not least, it was assumed that past transaction outcomes are observable and potential tenants were aware of them. The study may be extended to capture the effects of the imperfect signals potential tenants receive about lessors as considered in Cai and Obara (2009).

Data availability statement

The dataset analyzed during the current study and the code may be provided upon request.

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5 Discussion and Conclusion

Agricultural land has long been considered a safe and attractive investment with high returns and low risk (Baker *et al.*, 2014). The growing demand for food and biofuels has led to increased investment in agricultural land (Antonelli *et al.*, 2015). In turn, inefficient regulation, highly bureaucratic and corrupt procedures for acquiring farmland, socio-economic shocks, and the lack of subsidies and incentives for farmers have led to uncertain returns on potential investments and decreased their volumes.

Ukraine has large agricultural areas: Agricultural land makes up approximately 70% of the territory, or more than 40 million ha (Food and Agriculture Organization, 2023). During the first three decades of public land privatization that began in 1990, three-quarters of all available farmland or around 30 million ha have been privatized, while the rest remains state-owned (Kvartiuk & Herzfeld, 2019). Farmland could attract significant volumes of investments into Ukraine's economy; however, the lack of a well-functioning transparent free market is a considerable barrier. In addition, Russia's invasion in February 2022 significantly affected Ukraine's economy and land market, as Russian forces occupied 20% of its territory, including large agricultural areas (European Commission, 2023). Nevertheless, Ukraine is likely to remain among the world's largest agricultural producers and exporters (Caprile, 2022; European Commission, 2023; Tarassevych, 2023). The need to use and manage agricultural land efficiently is also likely to remain.

Issues related to the land market in Ukraine have received substantial attention from researchers. Research has focused on three main areas. First, researchers have studied the emergence and development of the agricultural land market in Ukraine, land reforms, privatization and land distribution after the dissolution of the Soviet Union (Johnson *et al.*, 1994; Lerman *et al.*, 1995; Lerman, 1999, 2001; Wegren, 2002). Second, studies have focused on land market efficiency and productivity during and after the reform implementation period (Koester and Striewe, 1999; Lerman &and Sedik, 2007; Lissitsa and Odening, 2005). Third, researchers have analyzed the role of large agricultural producers that emerged during the transition from a centrally planned economy to a free market economy, and were thought to exercise some market power (Gagalyuk and Valentinov, 2019; Graubner *et al.*, 2021). For these purposes, they have used aggregated statistical data from Ukraine's State Statistical Service, survey data, and data from agro-holdings' corporate reports, financial statements, and official websites.

Mandatory state-owned land auctions were introduced in 2012. The reforms stipulated that rental rights for state-owned agricultural land could only be transferred via English ascending-price auctions (Kvartiuk *et al.*, 2022). However, their effectiveness and transparency have been criticized, with some studies highlighting corrupt practices (Deininger *et al.*, 2022). Since 2018, a large number of land auctions have been held online, with plans for this to continue in the future (The Cabinet of Ministers of Ukraine, 2017).

The results of these auctions have been publicly disclosed and can be used by researchers. Several studies have analyzed the data (Kvartiuk *et al.*, 2020; Deininger *et al.*, 2021; Deininger and Ali, 2023), but no comprehensive study that investigates the impacts of competition, active bidding, lessor reputation and other auction and property characteristics on online auction outcomes has been conducted. Moreover, no study has investigated factors that lead to bidding errors, such as underbidding. This is defined as the submission of low bids that are theoretically not optimal and rational, and lead to revenue loss. This thesis bridges these research gaps, conducting a comprehensive analysis of the factors that impact land auction outcomes and bidding decisions, and providing recommendations for improving the efficiency of land auctions. This thesis is based on three peer-reviewed journal articles, namely Myrna (2022, 2023); Myrna and Teuber (2024).

5.1 Empirical findings

5.1.1 The impacts of competition among bidders

Competition among bidders was found to have the biggest impact on auction outcomes. Chapter 2 shows that if an additional bidder participates, the probability of auction success increases and the price increases by 41.4%. Similar results were found for arable land (40.4%) and grassland (54.8%). As the number of bidders increases, the observed price effect of competition diminishes slightly. An increase in the number of bids is also associated with a higher chance of an auction being successful, and each additional bid leads to a 0.8% price increase. The positive and significant effect of competitive bidding on auction outcomes is also confirmed in Chapter 4. This generally meets expectations and is in line with other land auction-related studies (Croonenbroeck *et al.*, 2020; Hüttel *et al.*, 2013; Ong *et al.*, 2005).

Chapter 3 provides additional evidence that greater competition among bidders significantly decreases the propensity to underbid. If the number of bidders increases to eight, the propensity to underbid approaches zero. This finding also meets expectations and is in line with related studies (see, for example, Cooper and Fang 2008; Feng *et al.* 2016; Hou *et al.* 2009; Kagel and Levin 1993; McGee

2013), which demonstrate that auctions with higher competition among bidders are more prone to overbidding than underbidding.

5.1.2 The impacts of auction characteristics

Auction characteristics also significantly impact outcomes. Chapters 2 and 4 show that the relationship between per-hectare reserve prices and winning bid amounts is positive. According to the estimation results in Chapter 2, a 1% higher reserve price is associated with a 0.7% higher winning bid. This indicates that if higher opening bid amounts are disclosed in the auction announcement, bidders with a higher willingness to pay participate. The positive price effect complies with the theory (Bajari & Hortacsu, 2003; Krishna, 2010) and meets expectations.

Larger bid increments have a negative effect on the probability of auction success, as the estimation results in Chapter 2 show. Large increments could intimidate potential bidders and deter them from entering or bidding, as Avery (1998) suggests. In an auction with large bid increments, bids could exceed private individual valuations and result in overbidding that does not constitute an optimal outcome (Hou *et al.,* 2009; Hüttel *et al.*, 2013; Hüttel *et al.*, 2013). In addition, Chapter 3 demonstrates that larger minimum bid increments tend to decrease the propensity to underbid. Underbidding was not observed when the per-hectare bid increment was greater than 200 Ukrainian hryvnia. This finding is in line with the studies by Hickman (2010) and Hickman *et al.* (2017), which suggest that incremental bidding may affect bidding behavior in online auctions.

Greater entry fees slightly increase the propensity to underbid, according to the estimation results in Chapter 3. This finding contradicts the expectation that higher entry costs may compel bidders to submit higher bids (McAfee *et al.* 2010). Instead, larger non-refundable entry fees in land lease auctions make bidders more attentive to costs, and they appear to subtract this amount from their bids.

Chapter 3 also reveals that underbidding is less likely when bidders spend more time in an auction. In particular, if the average time each bidder participates in an auction increases to 15-20 minutes, the likelihood of underbidding approaches zero. Thus, a negative effect of higher monitoring costs (Bapna *et al.*, 2009; Goes *et al.*, 2012) was not found. Instead, bidders who spent more time in an auction were more likely to be successful.

5.1.3 The impact of lessor reputation

Relaxing the private values assumption and assuming that some common information component exists, Chapter 4 demonstrates that the performance of land management agencies matters, and it is likely that bidders use information about past transactions to form an impression of lessors. A better reputation is associated with higher winning bids and a greater probability of subsequent transaction success. The observed positive price effect of reputation holds mainly for auctions with two to four bidders (or 87% of observations in the sample of successful auctions), and slightly diminishes if auctions are more competitive. These results meet our expectations and are consistent with the framework presented in Bar-Isaac and Tadelis (2008), according to which a seller or lessor is expected to be rewarded for having a good reputation.

Greater numbers of previous auctions lead to lower prices. The likelihood that buyers know about negative outcomes becomes greater if more information about past transactions is available, and their concerns about a seller's reputation may also become greater, having an adverse price effect. This finding is in line with results published in Rob and Fishman (2005) and Bar-Isaac and Tadelis (2008). Bidders' willingness to pay may also be lower if they are forward-looking and expect more future auctions. This finding meets our expectations, based on Zeithammer (2006).

The effect of preparation costs on the probability of auction success and winning bids was found to be very small, negative and significant. Additionally, the estimation results suggest that lessors tend to respond to improved reputation by lowering the cost of preparing subsequent lots. This meets expectations: Lessors tend to decrease their effort in subsequent auction periods as they consider themselves to be established as lessors with positive reputations, and therefore the incentive to exert more effort diminishes (Bar-Isaac and Tadelis, 2008; Kreps *et al.*, 1982; Kreps and Wilson, 1982).

5.1.4 The impacts of property characteristics on auction outcomes

Property characteristics also matter. Chapters 2 and 4 reveal a negative relationship between the probability of auction success and plot size. This result may be because larger plots are in lower demand due to the budget constraints of bidders, as Xu *et al.* (1993) indicate. A positive price-size relationship is also found in Chapter 4. Chapter 3 indicates that bidders are less likely to underbid if a larger plot is being auctioned. This finding meets expectations: Larger plots are more convenient and efficient to cultivate, as many land market studies claim (see, for example, Hüttel *et al.,* 2013; Hüttel *et al.*, 2016), and bidders are willing to pay more for such plots.

Furthermore, Chapter 2 provides evidence that for each unit increase in the soil quality index, a 0.3-0.4% higher per-hectare rental rate is expected. This meets our expectations: More fertile soil is associated with higher crop yields, higher annual net returns, and higher demand for land (see, for example, Croonenbroeck *et al.*, 2020; Myrna *et al.*, 2019; Ritter *et al.*, 2019, 2015).

Chapter 4 shows that the relationship between plot size and per-hectare lot preparation costs is negative: It is cheaper to prepare larger plots for auction than smaller plots. Preparation costs are also lower for more productive land.

Land market studies often attribute differences in land prices to structural variations in the regional economy and the role of agriculture (Nilsson & Johansson, 2013), existing infrastructure, and other factors (Hüttel *et al.*, 2013). It has been found that the location of auctioned land matters too. For example, compared with the central region of Cherkasy which has above-average rental prices, average rental rates in the industrial south-eastern regions of Donetsk and Odesa were lower. Plots located in different regions have different probabilities of being rented out, as confirmed by significant coefficients in eight of the 24 regions considered in this research. In Cherkasy, approximately 51.5% of auctions were successful, whereas higher probabilities of auction success were found in the four south-eastern regions of Kherson, Luhansk, Mykolaiv and Odesa, the western region of Volyn, and the northern region of Sumy. The probability of auction success was lower in the regions of Zaporizhzhia and Kirovohrad.

Chapter 3 shows that regional features may explain the propensity to underbid. Compared with the Forest-Steppe region, where the land is most productive and agriculture is an attractive economic activity, auctions that took place in regions where the land is less productive, like Western and Eastern Polissia, were more prone to underbidding. This confirms that property characteristics impact the occurrence of bidding errors (Malmendier & Lee, 2011). Underbidding may occur if the land is less productive.

Chapter 2 shows that price fluctuations over time also exist, which is in line with expectations. However, no distinct time trend was observed. The months when we observed higher prices were not necessarily the months when more successful auctions took place.

5.2 Main conclusions and policy recommendations

The results of this thesis reveal that competition among bidders has the most pronounced positive impact upon auction outcomes. Therefore, a revenue-maximizing landowner may want to attract more actual bidders and facilitate more competitive bidding among them. This may be achieved by improving the information provided about the auctions to potential interest groups, or by lowering reserve prices to allow bidders with lower valuations to enter the bidding, enhancing competition. However, the latter may not necessarily have a positive price effect, especially if the second highest bid that determines the winning bid is placed by a bidder with a low valuation. If landowners want to ensure that the land is cultivated instead of maximizing revenue from the lease agreement, they may decide to reduce reserve prices, decreasing the probability of auction failure due to a lack of participants.

Another suggestion is to standardize the reserve price amounts. There is no legally determined method for setting reserve prices, and the majority of landowners do their own price calculations, which generally equate to around 8-10% of the normative land appraisal. This may serve as a good indication of land quality for bidders, but may also be misleading if landowners do not follow this unwritten rule. Standardizing reserve prices in the documentation regulating auction procedures may improve the transparency of the auction process.

Entry fees may also dissuade participants from entering the auction, if the price is deemed high and bidders are not sure about their chances of winning (Reiss & Wolak, 2007). In addition, larger entry fees decrease bidders' willingness to pay. A revenue-maximizing auctioneer may charge entry fees that decline in correlation with the magnitude of the bid placed—helping to motivate higher bids and de-emphasizing the effect entry fees have on bidding behavior (Matthews 1983; Matthews 1984; Wilson 1992; Maskin and Riley 1984).

Maintaining a good reputation or improving a bad reputation is crucial for achieving better efficiency of land allocation and securing higher revenue for regional agencies' budgets. It seems reasonable for all parties to keep track of previous auction outcomes and to act in response to either positive or negative reputation feedback. Lessors with good reputations may decrease the amount of effort they exert in the long term, while those with poorer reputations may take actions to improve their record by, for example, exerting more effort in preparing plots for rent.

Land management agencies may also consider some form of land consolidation in order to reduce transaction costs. However, lessors should consider that potential tenants may face budget constraints, and the demand for larger plots may subsequently be lower than for smaller plots. Land repackaging may also be associated with additional costs (Ritter *et al.*, 2020).

Bidders and landowners may expect higher prices if land is more fertile, and in regions where agriculture plays an important role in the structure of the regional economy (mainly located in central

Ukraine). However, such regions are not necessarily those where farmers are willing to rent public agricultural land through online auctions. Moreover, some intra-annual market changes may affect pricing.

5.3 Limitations and future research directions

There are several important limitations related to the choice of estimation techniques and the data available for this study.

The reduced-form approach used in this thesis allowed us to examine the main hypotheses, and to suggest how land may be auctioned more efficiently and profitably. No suggestions could be made about how to optimize auction design characteristics, such as reserve price, entry fee and bid increment size amounts, in order to achieve higher land auction revenues and efficiency. Structural estimation may remedy this problem in the future.

The publicly disclosed auction data do not include information about the identities of bidders. Absent this information, symmetry among bidders was assumed. However, land market studies suggest that buyer asymmetries may arise from the size of a firm, its production constraints, or the possession of better information (Croonenbroeck *et al.*, 2020), and may affect farmland prices (Curtiss *et al.*, 2013). If the identities of bidders and winners are known, this could allow us to consider asymmetric bidder structures (Croonenbroeck *et al.* 2020; Menezes and Monteiro 2000; Ivanova-Stenzel and Salmon 2011; Palfrey and Pevnitskaya 2004). Hidden identities of bidders and winners prevented us from checking if the same bidders took part in repeated auctions, and whether any learning effect took place. The availability of bidder information could also be useful for analyzing all parties in a rental contract. Lessors may provide some beneficial conditions for good tenants, who are known to be solvent and financially reliable, and who invest in the land and cultivate it sustainably. This hypothesis may be considered if additional data become available.

The sample only includes state-owned lands, assuming that if a transaction with the regional agency fails, potential tenants could search for a privately-owned plot. Data related to private land transactions could help create a more comprehensive picture of the land market.

To investigate the role of lessor reputation, the thesis utilizes one year of data and ignores changes in team composition and policies, assuming that they do not take place in the short term. To investigate these effects, an analysis covering a longer period may be necessary. Additionally, it is assumed that past transaction outcomes are observable and potential tenants are aware of them. The study may be extended to capture the effects of the imperfect signals potential tenants receive about lessors, as considered in Cai and Obara (2009).

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