

Travel Mode Choice as a Rational Choice – Different
Aspects

Dissertation zur Erlangung des
Doktorgrades (Dr. rer. soc.)
des Fachbereichs Gesellschaftswissenschaften
der Justus-Liebig-Universität Giessen

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2003

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Introduction

The PhD dissertation is a collection of chapters dealing with decision making in general, and with empirical testing of travel mode choice in particular. The papers take up theoretical, substantive and methodological issues, and combine theory and empirical work.

Rational choice theory has been increasingly used in the social sciences in the last two decades. However, its impact on empirical research has been small. The following chapters discuss, on the one hand, different versions of rational choice. On the other hand, they address the critique of several authors, who have argued that rational choice theorists neglect empirical work. Green and Shapiro (1994) have argued that researchers investigating individual behaviour concentrate on theory elaboration rather than on theory testing. Opp (1998) and Simon (1985) have called to pursue the hard work, which is often not done, of testing rational action theory empirically. Furthermore, Goldthorpe (1998, p. 52) has pointed out that in present-day sociology rational action theory and the quantitative analysis of large-scale data sets are pursued largely in isolation from each other (see also Blossfeld and Prein, 1998). Apart from encouraging to test action theories with data (Goldthorpe 1998: 33), researchers have argued that it may develop changes in theory in light of contradictory empirical results (Becker 1996:156). From such a viewpoint it is apparent that for exploring the sociological mechanisms of individual choices in general, and in the context of travel mode choice in particular, an affinity between rational action theory and data is to their mutual benefits. Five of the following chapters test rational choice models empirically with different sets of data, and all of them discuss the bridge between data and theory, thus linking theory and data. All in all, the chapters contribute to a better link between theory and data in the context of travel mode choice.

The substantive issue taken up is ecological behavior and decision making in the context of travel mode choice: what makes people choose transportation, which is

friendlier towards the environment? Social scientists have been expected to contribute to a better understanding of environmentally related behavior in order to find ways to ecologically improve it on the aggregate level. The topic of mobility in this context has been an increasingly important one, due to its continuous growth in the last decades. People travel more, and use more often their car in comparison to earlier years, partially due to changes in lifestyle. Determinants of travel mode choice may be sociological, social psychological and economic in nature. An interdisciplinary approach may achieve a better explanation and point to potentially successful policies. I try to apply this general approach in all of the following chapters.

The methodological issue taken up deals with structural equation modeling applied especially on new techniques to test panel data and interaction effects. Indeed, as Goldthorpe (1998:50) has pointed out, advances in modelling and estimation techniques steadily improve the chances of making effective evaluations.

The first chapter challenges the economic approach, and is an empirical test of Becker's study from 1965 on the role of time as an economic constraint in decision-making. It takes up several points which are central to the link between empirical data and theory of behavior and decision making in the context of travel mode choice: availability of variables to test a model; the need to construct auxiliary assumptions, for example alternative sociological mechanisms, for a better link between data and theory; and the limitedness of narrow versions of rational choice to explain behavior in a satisfactory manner. For the empirical test the German microcensus data of 1996 is used to test travel mode choice on the way to work. In this chapter I have restricted myself to maintaining three goals. First, I suggested testing a well-established theoretical model of behavior of Becker, questioning whether time in addition to monetary costs affects behavior in the context of travel mode choice. Second, I tried to test Becker's theory by using large-scale data from the German microcensus of 1996. Third, I checked whether socio-demographic characteristics have any effect on behavior after controlling for economic restrictions. As Green and Shapiro claimed (1994) and as previously pointed out, proponents of rational choice seem to be most

interested in theory elaboration, leaving for later or others the messy business of empirical testing. We tried to bridge this gap between rational choice theory and large-scale data analysis by testing an important rational choice model, which has not been seriously challenged so far in the context of travel mode choice.

Becker has been trying in his work to formulate a theory, which could explain any behavior, in the economic market, in choice of partners, in family relations and in social discrimination in the form of production functions. I have tried to test a special case in this theory, in respect with the decision whether to choose the car or the public transport on the way to work. As a theoretical framework, I drew out of his strongly and elegantly formulated theory testable hypotheses, in order to check how well his explanations work in a practical problem. Specifically I wanted to check if restrictions rather than preferences affect choices, and whether the effects of socio demographic characteristics, which may represent preferences in addition to time cost differences according to Becker, disappear, when objective restrictions as time costs are introduced in the empirical test. In formulating the hypotheses, I was confronted with the question how to model time costs. Such a question often comes out when one tries to test a rational choice model empirically, and operationalize a theoretical variable. Velocity incorporates two important factors to compute efficiency of time use, namely the duration of travel and also the distance. As it is the efficiency of the use of time rather than its absolute number, which reflects how costly or effectively it is used, I concluded that it would be best measured by the velocity of the means of transportation.

As theoretically expected, I found a significant effect of the time cost, reflected by the interaction term between higher income and velocity, on the travel mode choice in the sample of the German microcensus. As car is the faster mode of transportation, the more costly is the time, namely, the higher the income per hour, the higher the positive effect of higher velocity on the tendency to use the car on the way to work. This confirms the theoretical expectation of Becker, that time has a value, and thus an

effect on choices in time consuming daily activities, and particularly also on travel mode choice.

However, the empirical test could not confirm the second implication from Gary Becker's work that all socio demographic characteristics are reflected by different time costs. I suspected I would find a significant effect of some sociological characteristics on travel mode choice. In the findings, marital status and gender had a significant and overwhelming effect on travel mode choice. In addition, the interaction term of income per hour and velocity became insignificant. Women, indeed, use more public transportation as well as unmarried people. We found no direct significant effect of education on travel mode choice, which may be explained by the fact that maybe it is indeed strongly reflected by differences in time costs between the different education groups. Age had a very small but significant effect on travel mode choice, reflecting a higher car use for the middle age group. It may as well be explained by the fact that time cost differences may well represent the different age groups. Although females and unmarried earn less money per hour than married people and males, their socio demographic status overwhelmed the effect of their lower time cost on travel mode choice.

Indeed, in such a case, in order to have a better explanation of behavior, we must turn to other disciplines, and construct "bridge assumptions". To this point I am coming back in the sixth chapter in which I discuss the different interpretations of the term. According to one of the interpretations, bridge assumptions (or auxiliary assumptions as termed by Simon) link a theory with observational terms, thus formulating alternative explanations. It would make sense here to suggest bridge assumptions between gender and marital status on the one hand, and the sociological processes, which account for the chosen travel mode on the other hand, as gender and marital status had an overwhelming effect on the travel mode choice. Indeed, one such explanation concerning gender could relate to differences in technical affinity between men and women. A stronger technical affinity for men could account for an additional factor affecting a higher tendency of men to prefer the car as a travel mode

regardless of their time costs. Another explanation concerning marital status could relate to the finding that married couples tend to live in less urban areas, where public transportation use is less feasible or parking is less of a problem. In general, married people have also more children in the household than non-married. In such a case, a need for higher flexibility (which serves as an additional constraint) would affect a higher tendency to use the car. These explanations would serve as additional bridge assumptions to those of income and time cost differences between males and females or married and unmarried people suggested by Becker, and are discussed in this chapter. Additionally, they suggest according to Simon how other variables are related to preferences and utility. They could indeed bridge the gap regarding the influence of these socio economic characteristics on travel mode choice and serve as an additional plausible explanation for choosing a travel mode.

When one thinks of possible other explanations for the findings, we may suggest at least two. I received relatively low percentages of explained variance even in the third model. The highest explained variable we received was 14.4% (Nagelkerke). It may well be the case, that there are other economic and social-psychological factors, which may explain travel mode choice and nevertheless were not included in the models since they were not in hand in the German data of the microcensus. An example of such a variable is the availability of a car. Many studies show, that car availability is a central variable in transportation research, and may reflect both the socio demographic characteristics included in the analysis and other ones. Indeed, males, married people and people in the middle age group tend to have an available car more than females, unmarried and young or old people. Once one owns a car or has one in hand, the tendency to use it is usually higher. However, this problem cannot be easily solved outside a new design of the questionnaires. As users one can either employ the microcensus with all its obvious limits, or rather use another data set. However, I do not have any data set, which is equally suitable in Germany to fulfill and address the call of Goldthorpe (1998) for an alliance between official data and rational choice theory. The drawbacks (like a selective sample) of other smaller surveys, such as the environmental surveys in Germany are obvious, especially their

low response rate and their being far more biased than the microcensus data set. Future large scale data research might try to address these issues, like indeed some experimental studies already do by applying social psychological theories such as the theory of Planned Behavior to explain travel mode choice and testing them in smaller scales of data. I am going to apply this approach in some of the following chapters. In these studies, the explained variance is much higher. However, this is a problem, which might often happen when applying large scale data to test rational choice models, and one should be aware of the limits of representative data.

There might have been problems in the operationalization of the time costs. Maybe the arbitrary assignment of values for the extreme categories has led to inaccurate application of personal time costs. However, only 37 out of 1,742 had an income on the highest level, only 60 cases had a distance longer than 50 km and only 120 cases out of 1,742 needed more than one hour to go to work, and consequently the great majority of values used in the analysis are not arbitrary. Omitting cases with these extreme categories might cause another kind of bias to the data. As one of the main purposes was testing the theory, the data in hand was adequate to conduct an empirical test of the model. This represents indeed another problem in operationalisation of a model in an empirical test.

Some practical implications can be drawn from this analysis, also as to what social groups are to be addressed in order to bring more car drivers to use public transportation. Apparently, it is quite a sociological question what makes people use public transportation, and what makes them rather use the car. These social mechanisms (such as place of residence or technical affinity) are to be explored more deeply, in order to find the dynamic processes, which lead some groups to a more ecological behavior in respect to travel mode choice.

When we try to model a rational behavior, the question which model to choose and which factors to incorporate in the model relates quite often to whether rational choice should be modeled and tested in a narrow version in which only objective

factors such as time and money are taken into account, or in a wide version, in which subjective social-psychological as well as sociological variables should be taken into account (Opp, 1999). Our critique on Becker's approach is indeed empirically oriented. We test the different versions in the fourth chapter and come to similar conclusions, that is, that the narrow version does not provide satisfactory explanations in the context of travel mode choice.

However, Becker is considered as a proponent of the hard (narrow) rational choice version according to Opp in many cases. As there are other versions of rational choice, such as the wide one as Opp defines it, it could be that the model of Becker is not sufficient. Indeed, Simon (1985) criticized Becker of making a lot of untested assumptions, but those criticisms were ignored. Our work demonstrates quite clearly, that behavior might be influenced by many different factors and explanations via auxiliary assumptions, whose interpretations are discussed in the sixth chapter. It is an empirical question to be tested which factors are relevant, and whether narrow or wide rational choice is the right behavioral model. As we want to get as close as possible to a good explanation of behavior, I can conclude that for a synthesis, instead of constraining a model only to objective economy oriented explanatory factors, one should let it include in advance different theoretically based explanations from different disciplines to be tested empirically.

In order to explore these mechanisms more carefully, Goldthorpe (1998:50) has pointed out that advances in modelling and estimation techniques steadily improve the chances of making effective evaluations. Indeed, the first chapter is an exit point for the proceeding chapters, because it relates to several factors, which are central in exploring the link between theory and data: the importance of considering auxiliary assumptions for a real link between theory and data, testing different versions of rational choice and applying advanced techniques of testing travel mode choice models.

The theory of planned behavior is often applied to test empirical data of travel mode choice. The second chapter tries to answer if there is an interaction effect between perceived restrictions and intention to perform behaviour in the theory of planned behavior. Finding out whether such an interaction exists can contribute to a better understanding of the determinants of travel mode choice as well as of other kinds of behavior. However, so far there has not been a clear-cut answer whether such an interaction can be empirically verified. The chapter gives an overview in the form of a meta-analysis of different studies testing the interaction effect between perceived behavioural control and intention. In the second part, an empirical test of this interaction is conducted with three new techniques on data of travel mode choice from a first wave of a field study in Frankfurt conducted in the years 2001-2003. The three new estimation techniques are latent variable scores, maximum likelihood and robust maximum likelihood.

Reviewing research on this topic in a meta-analysis, we found out that about half of the studies (8 out of 14) that tested the interaction, indicated *no significant effect*. However, those papers used OLS techniques to test it. We do not trust regression results, because they assume that there are no random and non-random measurement errors. Jaccard and Wan pointed out why structural equation modeling, which controls for measurement errors, is preferred. Three studies in the meta-analysis applied more advanced techniques based on structural equation modeling (SEM), such as a multi-group analysis or ML. All of them found a positive interaction effect (according to what the theory postulates) and two of them found evidence also for a negative interaction. As stated in the chapter, one possible reason for receiving a negative interaction effect could be due to multicollinearity. Another reason could be the content and measurement mode of the constructs' items. Our own study found in two of the three estimation methods applied a positive interaction effect.

The question is whether one should consider in a meta-analysis all studies, or only those applying appropriate estimation techniques, which control for measurement errors using structural equation modeling. As Lipsey and Wilson discuss it, there are

different estimation methods and techniques possible: multivariate analysis, multiple regression, factor analysis, structural equation modeling and the like. Meta analysts have not yet developed effect size statistics that adequately represent results of different techniques and their complexity and diversity across studies with regard to the selection of variables involved. Even if one takes into the meta-analysis only studies using estimation methods which control for measurement errors, different studies may report a variety of correlations: between indicators, indices or factors. Moreover, different estimation methods may be used, such as a multi-group analysis, ML, RML, TSLS, WLS, LVS and so on. Results may not be robust over studies, and different methods may produce different results with the same data as we evidenced here.

One may conclude, that conducting a meta-analysis is an impossible mission. We believe, that all studies should be taken into account in such a report. However, one should also report the estimation methods used. One way to overcome the problem of mixed estimation methods in the future might be to recalculate the results of the studies in the meta-analysis using the same method over all the data sets. Indeed, advanced techniques for estimation may confuse the mission of testing rational choice models, especially when different results like in this case are produced.

In this study we chose LVS, ML and RML to test the interaction. We reported in the introduction our main reasons for choosing these methods for the test. The fit measures of the RML and the ML estimation methods were poor. However, as we only wanted to test the interaction model, we did not try to improve them.

The LVS estimation evidenced a significant interaction between intention and PBC on behavior and significant additive terms. This is a simple method. It can be used to get a preliminary sign of an interaction effect. Since it is a two-step method, there is no overall model fit available. Although this method does not require multi-normality for the observed variables, it does require more indicators for the latent variables. Put differently, the more indicators a latent variable has, the better the estimated score

will be. Evaluation of this method is still needed. The ML estimation indicated an interaction effect between intention and PBC in predicting travel mode choice. However, the standard errors and Chi-squares were in principle incorrect because of the use of product variables. RML was used to correct the standard errors and the Chi-square. It showed neither an evidence of a significant interaction nor significant additive effects. This method does give corrected standard errors and Chi-squares, but it requires considerably large samples. However, such samples are not always available.

From the results of the meta-analysis and from our own study we noticed that the different methods might lead to different results. Researchers may wonder which method to apply. From the simplicity point of view, we may conclude it is advisable to use multi-group analysis. If the interaction variable is latent, the latent variable scores (LVS) approach or the two-stage least squares (TSLS) approach are probably the most reasonable. All these three approaches have no special requirement for the distribution of variables, they are easy to implement, and they can clearly indicate whether there is an interaction or not. The disadvantage is that none of these approaches provides a model fit. In the case of a multi-group analysis, we also do not get any coefficient for the interaction effect.

The full information methods do provide a parameter estimate for the interaction and an overall model fit. However, in practice they are difficult to apply due to the complicated non-linear constraints that must be specified and the necessity to have large samples and to use an asymptotic covariance matrix. The multi-normality of observed variables is required in order to apply a ML estimation method, but most non-linear models do not fulfill it. As a result of the violation of normality, the standard errors and χ^2 are wrongly estimated. However, according to Yang-Jonsson, ML often performs well in medium and large sample sizes. For small samples, TSLS, LVS and Klein and Moosbrugger's method are better. As LVS is very new, simulation studies that compare these methods are still missing. For large samples,

RML and WLS are preferred, but further simulation studies are needed to compare them.

The third chapter also addresses the call of Goldthorpe to apply advanced techniques to test rational choice models. This chapter introduces three techniques to test longitudinal data: autoregressive (AR) models, latent growth curve (LC) models and hybrid models, which combine both. It tests whether there is an effect of a soft policy intervention in the form of information on travel mode choice. The study examines travel behavior after moving to live in Stuttgart, and was conducted in 2001. There were three primary goals for this chapter. The first was to compare AR and LC models, to identify the pros and cons of each of them, and to introduce the hybrid model suggested by Curran and Bollen. The second goal was to apply them with real data on travel mode choice. The third goal was to pursue two extensions of the LC model suggested by Curran and Bollen: the first is regressing the variable, which is changing over time on an exogenous variable, namely the intervention variable; the second was to conduct a multi-group analysis and test for interactions.

The three models according to the three techniques fit the data very well. The corresponding value of chi square divided by the number of degrees of freedom is lower than 2 for all the models. Although the LC model with the multi-group analysis has a higher ratio of chi-square to degrees of freedom than the hybrid model, they are not significantly different. The AIC value for all the models is lower than in the saturated model. P-value is higher than 0.5 only for the LC model (.533). The p-value of the hybrid model is higher than in the LC model with an interaction test (.314 compared to .105). RMSEA is lower than .05 for three of the models, and only slightly higher than .05 for the third. The P-value of close fit is higher than .5 for three of the models, and lower than .5 for the LC model with the multi-group analysis. In this set of analyses, models 3 and 4 are nested. Model 4, the hybrid model, performs better according to all the fit measures presented.

The set of autoregressive and latent curve models provides a better understanding of the relation between the intervention (the soft policy) and public transport use, and in such a way strengthens the link between data and rational choice theory. First, in both modeling approaches we found developmental changes in public transport use to be positive between the first and the second wave and to be negative between the second and the third wave according to the expected means (except for the AR model). Second, a similar development of the behavioral trajectory was found for the two groups of subjects: those with a high initial level of intention to use public transport and those with a low one. Third, we learned from the latent curve model, that individual differences in the initial degree of public transport use are negatively associated with changes (increases or decreases) in public transport use. That is, on average, participants with a lower initial use of public transport tended to report steeper changes in behavior. In addition, we observed this correlation in both groups.

It was the multi-group analysis that allowed for an interaction test between the intervention variable and the degree of initial intention to use public transport. Whereas at first we observed no effect of the intervention on behavior in the LC model, in the multi-group analysis the result was different. In the group with a low initial intention to use public transport a positive effect of the intervention on travel behavior was observed. However, in the group with a high initial intention to use public transport a negative effect was observed. The hybrid model provided us with the strengths of the autoregressive model and the latent growth model. We received stability coefficients in the multi-group analysis for both groups, the high intention group and the low intention one. The pattern of results has not changed, but this time combined into one framework. It performed better than the LC model according to several fit measures.

To sum up, the proposed AR and LC modeling strategies are important tools for analyzing change over time in general, and of travel mode choice in particular. However, each approach has its own merits and disadvantages. Autoregressive models are simple, include a test for the stability of behavior, enable to estimate the

mean of the observed variables over time and provide data on the whole group process. They also enable to test cross-lagged relations between two measurement time points. However, they do not provide any information on the individual level and on the whole process of change. Therefore, one cannot test whether, for instance, the process of development is linear, quadratic etc. LC models do not provide any information on the stability from one time-point to the other, and cannot check for feedback relations. However, they support us with invaluable information on the developmental process, explain individual changes over time and enable us to conduct multi-group analyses to test for interactions. As we have seen, those models are not competitive, but rather complementary, and allow for a combined test in the form of a hybrid model. Such a test is more flexible, and provides us with the strengths of both approaches to evaluate relations over time.

The next two chapters use the same data set. The fourth chapter discusses the two versions of rational choice as defined by Opp (1999): the narrow one and the wide one. It provides empirical tests of the two versions, thus links data with theory, and concludes that the wide one is more adequate. We tested the fruitfulness of the different versions of rational choice in the explanation of behavior after an introduction of an intervention. The central difference between the narrow and the wide versions of rational choice lies on the importance they allot to social psychological processes in the explanation of behavior. In the narrow version such subjective variables are often neglected, and it is believed that only objective determinants affect behavior. In the wide version of rational choice it is believed that subjective social psychological processes have a significant effect on behavior.

In order to test both versions we used data collected in an intervention field study. The intervention was intended to change subjective perceptions of objective variables such as duration of travel or its price. In this “soft policy” lack of information and motivation to use public transport were replaced by persuasion, in which it was shown that public transportation is not as bad as one may perceive it to be. Since such a policy does not change any objective determinants of behavior, it should not have

any effect according to the narrow version of rational choice. However, according to the wide version it is expected that the intervention will have an effect on behavior. In this study we have used a real randomized experimental design. In such a design it is possible to evaluate differences in behavior between a control and an experimental group as a result of the intervention.

We observed a significant increase in public transport use in the experimental group, which was exposed to the intervention. In the control group there was no significant change in behavior. Indeed, according to the wide version of rational choice, soft policy can actually affect behavior although it does not change any objective variables. In many studies on travel mode choice, which apply the narrow version of rational choice, the determinants affecting behavior applied are the availability of a car and the relative time and monetary costs. These variables were not affected by the intervention.

Applications of the theory of planned behavior as a social psychological variant of the wide version of rational choice is a promising means to explain travel mode choice. The theory shows, that not only the subjective relative time and monetary costs affect behavior, but also attributes such as reliability and degree of stress. Moreover, it indicates that travel behavior is also influenced by social and normative factors as much as by attitudes, partial and often incorrect information and intentions. People are often not informed about the available public transportation, but continue to maintain their habitual behavior without endeavoring to gather some more information. Only if they have a doubt that their behavior might not be optimal, are they motivated to inform themselves about other possible alternatives. Moving to a new town is indeed a situation in which they are motivated to do so and test new alternatives. These factors are not considered by the narrow version of rational choice.

Consequently, it seems that the use of the narrow version of rational choice in the context of travel mode choice is very problematic. Its prognosis that the intervention

named “information packet” will have no effect on behavior is not verified by the data of this study. It is probably the case that the assumptions it contains regarding what may constitute an effect on behavior are too restrictive.

The fifth chapter tries to contribute to a stronger link between rational choice models and data in the context of travel mode choice. Are habits stronger than rationality? This chapter conducts a theory comparison of the term ‘habits’ as discussed in the sociological, social-psychological and economic literature. It provides an empirical theory comparison of the theories which give hints how to test them empirically: the social-psychological approaches and the rational choice model suggested by Stigler and Becker (1977). The data used is, as in the two previous chapters, from a longitudinal intervention study to change travel mode choice in Stuttgart.

In this paper we have restricted ourselves to maintaining three goals.

-First, we wanted to shortly present and compare various aspects of explanations of habits in the sociological, social psychological and economic literature.

-Second, we did not try to develop a better model to explain the formation of habits, but rather conduct an empirical theory comparison of these approaches.

-Third, to test a rational choice model empirically. Becker has called to test his models with real data. Green and Shapiro (1994) indicated, that proponents of rational choice theory seem to be more interested in the theory elaboration, and therefore tend to leave the messy business of testing their models empirically to others. We wanted to address their call, and try to bridge between experimental data and an important rational choice model, which has not been tested so far especially in the context of travel mode choice. Additionally we wanted to test whether socio-demographic variables reflecting alternative social mechanisms have any effect on behavior beyond the predictions of the model.

Some authors we reviewed approached habits as a rather automatic process, whether others considered them rational. Weber viewed them as automatic but not at random, Durkheim viewed them as automatic, Bourdieu as internalized, and one of the social

psychological approaches as automatic. Esser and Camic understood habits as automatic but also involving a rational process, similarly to Weber. The second social psychological approach discussed (Ajzen) viewed habits as rational, and so did the economic approach of Stigler and Becker. The main difference between the economic approach and the other ones is that whereas in the rational choice model individuals are assumed to maximize consumption, the other models do not assume any maximization but just a repetition of past behavior due to different reasons.

In order to conduct the empirical theory comparison we used data from a field study. To learn about the formation and persistence of habits we used a new context. Such a new environment may assist in testing whether habits are rational or rather automatic. Since only social psychological theories and Stigler and Becker's model provided hints how to operationalize them in an empirical context, they were the only two approaches we could directly test. This test examined the degree of automaticity of habits, and since this aspect was also discussed by other theories, it was an indirect test for alternative approaches.

Becker has been trying in his work to formulate a theory, which could explain any behavior, in the economic market, in choice of partners, in family relations, in committing crimes and in social discrimination in the form of production functions. In this model, Stigler and Becker try to explain habits rather than study their role in the explanation of daily behavior. They explain habits in an economic fashion, as a utility-maximizing behavior and suggest that habits are reasoned and could make sense, when one is in a new environment where information is needed and is costly.

When formulating the hypotheses we were confronted with the question how to model and measure habits and information levels, and furthermore how to translate the model to testable hypotheses. Such a problem also rose in the first chapter, in the theory operationalisation stage. For habits we applied the new measure of Verplanken. Although it correlated highly with past behavior in our data, it was independent of actual behavior. For different information levels we had two groups in

the field study: an experimental group, which received information, and a control one which did not. In addition, we controlled for previous search costs individuals were engaged with, and tested their effect. The new setting of moving to a new town served as a new context for the test of the model.

At first, our results showed that in contrary to Stigler and Becker's expectation and to social psychological approaches viewing habits as rational, habits did have a positive and significant effect on present travel mode choice after a change in the environment. The stronger the old pattern to use public transport, the higher its present use, or automatic application. A possible explanation is that the test was conducted a few weeks after the move, and respondents may have not learned the new surrounding yet.

Belonging to an intervention group and receiving information had a positive and significant effect on behavior as well. This confirmed the expectation of Stigler and Becker that information in a new context increases the tendency and frequency of the behavioral alternative to which information is given.

However, we could not confirm the second implication from Stigler and Becker's theory, that habits are expected to have a weaker effect on behavior for the younger respondents in our sample. On the contrary, for younger respondents habits had a stronger effect on travel mode choice. This could be a result of at least two factors. First, the age range was between 19 and 58 in the sample, and the average was 28. As a result, our sample was composed of mainly young and middle-aged respondents. It could well be the case, that young people had a lower income, and therefore could not afford a car. In such a case, their tendency to use public transport would be higher. On the other hand, middle-aged respondents earn more, and can afford it. In a random sample of the whole adult population like the GSS or the ALLBUS, this result might change. As we have data only on income on the household level, we could not test this correlation (the correlation between the *household's* income and 'age' was insignificant). Additionally, this result might have reflected a negative correlation

between 'age' and behavior, rather than a negative effect of the interaction term. Indeed, age and behavior correlate negatively in the sample.

The third implication from Stigler and Becker's theory, that socio-demographic characteristics are mediated by habits, and minimization of costs mechanism for acquiring information, could not be fully confirmed. In our findings, 'higher education' had a significant and overwhelming effect (on the 10% level of significance) on behavior. The interaction term 'habitage' and the variable 'habit' became insignificant. We performed an interaction test between 'habit', 'habitage' and the two socio-demographic characteristics 'availability of a car' and 'higher education', but it was never higher than 0.4. The correlation of 'habitage' with 'availability of a car' and 'higher education' was significant (-0.37 and -0.23 respectively). 'Habit' correlated with 'availability of a car' (-0.397) and with 'higher education' (-0.192) significantly. Therefore, we assume the results might indeed imply a true overwhelming effect of 'higher education'. Respondents with higher education indeed had a weaker tendency to use public transportation in the new town. Previous search for information correlated highly with 'habit', and once added to the regression, it had a positive and significant effect according to the theory on the 10% level of significance, and 'habit' lost its significant influence.

To answer the question we started with, we can conclude that there is reason in habitual behavior in the context of travel mode choice with our data. When controlling for other variables that may reflect alternative explanations, habits have an insignificant effect in the new context. In order to have a better explanation for our results, we must turn to other disciplines and construct "auxiliary assumptions". Auxiliary assumptions link a rational choice theory with observational terms, thus formulating alternative explanations. It would make sense here to suggest such assumptions between age and education level on the one hand, and the sociological processes, which account for the chosen travel mode on the other hand. Indeed, we have just offered such an explanation concerning age for the third model, which relates to differences in income between young and middle-aged respondents. As

young people are still in an investment phase in life, their income is lower than somewhat older people. Thus, regardless of the intervention, the new context and the information provided, younger people might have a higher tendency to carry out their habit to use public transport anywhere they go more than the middle age group. They may also have a stronger preference to save money on transportation. Indeed, we found a negative correlation between age and public transport use of -0.27 in the sample. Moreover, according to Becker (1965), people with a lower income per hour have a lower time value. As public transport is usually slower and therefore more time-consuming, middle-aged people who have higher earnings will value time more highly, and therefore would use the quicker means of transportation, namely the car (Davidov, Schmidt and Bamberg 2003). As for higher education, a car as a status symbol might be a trigger for more educated respondents to purchase it and use it more often as a result of status-striving. Additionally, the effect of previous search on available public transport in the new town may be also explained by a feeling of 'sunk cost', which increases the preference for public transport. These auxiliary assumptions suggest how other variables are related to preferences and utility. They could indeed bridge the gap regarding the influence of socio economic characteristics on travel mode choice and serve as an additional plausible explanation for choosing a travel mode.

We received relatively low percentages of explained variance even in the third model. The highest explained variable we received was 24.0% (Nagelkerke). It may well be the case that there are other economic, sociological and psychological factors, which may explain travel mode choice, and nevertheless we did not include in our models. However, one of our main purposes was testing theories, rather than developing an alternative one. Additionally, using experimental data, we could overcome some of the difficulties of using large-scale data sets. One difficulty is that one cannot choose the variables in the survey, but only apply existing ones. The experimental setting enabled us to test the difference between people who received information in a new context and others who did not. Such a test is not available in survey data such as the German microcensus. However, we are aware of the fact that our data may also lead

to biased results, because the sample is small, participation is not compulsory, and the sample is not representative. However, this problem cannot be easily solved outside a new design of a field study with a representative sample, which might be very costly. Future field studies might address these drawbacks.

Some practical implications can be drawn from our analysis, also as to what social groups are to be addressed in order to bring more car drivers to use public transportation. Apparently, also in this application it is quite a sociological question what makes people use public transportation, and what makes them rather use the car. These social mechanisms (reflected in variables such as age or education) are to be explored more deeply, in order to find the dynamic processes, which lead some groups to a more ecological behavior in respect to travel mode choice.

When we try to model a rational behavior, the question which model to choose and which factors to incorporate in the model relates quite often to whether rational choice should be modeled and tested in a narrow version in which only objective factors such as monetary restrictions are taken into account, or in a wide version, in which subjective social-psychological as well as sociological variables should be taken into account. Becker calls to release some of the assumptions on individuals' preferences, and include in this broader approach altruism, past experiences, culture, social interactions and habits (see for example Becker, 1996:5-7). Becker did not release all the assumptions of traditional economic theory in this model, and in this way constituted a hybrid model of the narrow and wide versions of rational choice.

Our empirical findings suggest that the Stigler and Becker's model on habits may be once again insufficient. Indeed, Simon (1985) criticized Becker of making a lot of untested assumptions, but those criticisms were often ignored. At the same time, other sociological theories on habits have not provided any hints how they could be put into test. It may be the case that the way to a good theory to explain habits and rational behavior may be through a dialogue between improvement of existing theoretical explanations and empirical findings, which test the theoretical implications and the

assumptions of the theory. In Becker's own words, "a close relation between theory and empirical testing helps prevent both the theoretical analysis and the empirical research from becoming sterile. Empirically oriented theories encourage the development of new sources and types of data...At the same time, puzzling empirical results force changes in theory" (Becker 1996:156). Once these conditions are fulfilled, the way is opened for such a dialogue between data and theory in order to reach a better explanation of behavior in general, and of habitual behavior in particular.

Finally, the last chapter tries to close the circle. It summarizes a central issue in this dialogue and link between data in the context of travel mode choice and theory, namely the concept of "bridge assumptions". This chapter clarifies with examples taken from the field of transportation the confusion between different interpretations of the term 'bridge assumptions', which is central to the rational choice literature, and tries to bridge between them. Rational choice theory has no empirical content, because its terms consist of theoretical concepts, which have to be linked to observational terms. Correspondence rules connect latent variables with observational terms, whereas bridge assumptions and also auxiliary assumptions have been regarded in the literature as connecting more abstract theoretical concepts with latent variables. These two relations are similar, but should be differentiated. Theoretical concepts in rational choice theory, such as alternatives, goals or utilities, preferences and restrictions are meaningless before they are related to measurable latent terms, such as "achieving a high status" for goals or "confronting monetary limits" for restrictions. The latent terms "achieving high status" and "monetary restrictions" can in turn be measured empirically. In order to link observations and theory different scholars have introduced bridge assumptions in the rational choice literature. In that sense, bridge assumptions are propositions developed to bridge the gap between reality and the theoretical concepts of a model, which tries to explain reality, and therefore are central to rational choice theory and empirical studies of travel mode choice.

The different meanings of the term ‘bridge assumptions’ as observed in the literature and discussed in the sixth chapter create confusion. Therefore, I believe that a distinction of the two practices of the concept by different terms might solve the confusion prevailing nowadays with it. I propose the following distinction:

- a) ‘Bridge assumptions’ (hypotheses) to represent only assumptions constructed to connect the macro level with the micro level of explanation (which is in line with Coleman, Lindenberg and Esser);
and
- b) ‘Auxiliary assumptions’ (hypotheses) as Simon originally termed them, that is assumptions about behavioral alternatives, behavioral outcomes or goals, subjective evaluation of the different outcomes or goals, subjective probabilities of each outcome, and restrictions on behavior (in line with the second interpretation).

In this sense, “Auxiliary assumptions” link abstract theoretical concepts with latent variables. “Correspondence rules” link latent variables with observational terms. In order to construct “auxiliary assumptions” and “bridge assumptions” one must enter the empirical field, and apply for example large-scale data or interviews. In this way one can find the real links between theory, models and individual behavior in general and in the context of travel mode choice. These links may occur on the macro level and on the micro level of analysis. “Bridge assumptions” connect the two levels into one framework of explanation.

Results of the theoretical arguments and empirical tests conducted in this dissertation leave several questions open. Nevertheless, they try to provide some useful answers to existing questions regarding the link between data and theory. What are the socially structured mechanisms and social background, which operate “behind-the-back” to restrict rationality in traffic decisions? Different models of rational choice such as those developed by Becker and Ajzen for example, belonging to the narrow, wide or bounded versions, give hints how they can be operationalised and empirically validated. In some cases the models especially of the narrow version of rational

choice have been too restrictive. Indeed, people are not always fully rational as it is perceived often in neoclassical economics, and there are factors beyond relative time and monetary costs in travel mode choice, which may restrict “rationality” but also reflect “real life” decision-making in this context. The interdisciplinary approach taken applying advanced techniques to test different models with travel mode choice data have indicated, that such tests are not always easy to implement, and many compromises have to be made in terms of variables applied, methods used and hypotheses being tested. Not every hypothesis can be tested, as variables or data may be not satisfactory or existing in the data set, and not every argument which is tested is directly implied from a theory. Nevertheless, theories can and should be tested empirically in order to encourage theory development by the side of sophistication of empirical tests for a better dialogue between the two. Although it is still not obvious whether the wide version is empirically more valid than the bounded version defined by Simon, every such test draws us near our goals of reducing alienation between rational choice and traffic data, improving theories of travel mode choice and data analysis techniques and learning more about behavior in the context of travel mode choice.

Acknowledgements

I would like to thank Peter Schmidt for his caring and almost unlimited support, for insightful, thoughtful, far-reaching advice, for the countless enjoyable hours we spent together and for all the many things I learned from him as a person, a researcher and a teacher. Thanks to him, work was also fun. Without his mentoring, I would not have been able to reach this point.

I would like to thank Sebastian Bamberg for his care and advice, many comments and time to help me finalize important parts of this work.

I wish to thank my late grandparents, Baba and Dedi, who raised me, and have taught me the importance of love, inspiration and creativity by the side of learning and accuracy. Their inspiration has been and still is a crucial part of my work.

Working on these chapters was done with Peter Schmidt, Sebastian Bamberg and Fan Yang-Wallentin. I would like to thank everyone for an enjoyable time in which I learned a lot. I have profited from discussions and comments from Icek Ajzen, Karl-Dieter Opp, Moshe Semyonov, presentation forums in the Essex Summer School in Social Science Data Analysis and students at the University of Giessen, Department of Cultural and Social Sciences. I am also grateful to the members of the PhD committee – Dagmar Krebs, Karl-Dieter Opp, Peter Schmidt and Andrea Herrmann – for their time and effort. I would like to thank the University of Giessen and the Institute for Political Science for enabling me to meet many people, and Ute Schneider for her kindness and help. Special thanks to Karsten Schulz for carefully proof-reading the dissertation, and for providing helpful comments, and to Kyrill Farbmann for his support and for helpful and valueable advice.

Thanks to all my friends including family, my father, Bernadette and Heinrich and so many more, in Israel, in Germany and elsewhere for their inspiration, support, help and a lot of time spent together! Thanks to them I felt much more at home here, and work was much more fun.

Finally, I would like to thank the Deutscher Akademischer Austausch Dienst (the DAAD, German Academic Exchange Service) for their financial support during the work on this dissertation.

Published in European Sociological Review, 2003, 19(3), 267-280.

**Time and Money: An Empirical Explanation of Behavior in the Context of
Travel Mode Choice with the German Microcensus¹**

Abstract

Whereas variance in preferences is a central explanation for human behavior in the social sciences, economists traditionally avoid using preferences to explain behavior. Rather, change in behavior or different kinds of behavior are explained solely by differences in the economic restrictions imposed on an individual. Whereas restrictions have been analyzed as monetary constraints in traditional economics, Gary Becker has broadened this term. In his work, he tried to integrate “time” – the non-monetary restriction- into the economic constraints. In our paper we test empirically the effects of monetary and time restrictions on the travel mode choice of a representative sample of the German population. We do this by means of testing some hypotheses from Becker’s work on microcensus data from Germany. These data include the following variables: travel mode choice, distance of travel, time of travel as well as some additional socioeconomic characteristics. Results of introducing these additional socioeconomic variables will also raise the question if it is really true, that only monetary and time costs matter.

1) Introduction.

In the empirical social sciences, preferences have a key role in explaining behavior. Psychologists use the term “attitude” rather than “preference” as a construct, which explains behavior. They evaluate the positive or rather negative attitude of individuals towards an object. For example see Ajzen/Fishbein (1980) and Ajzen (1991), or its implementations, as for example in Bamberg and Schmidt (1998).

¹ A joint work with Peter Schmidt and Sebastian Bamberg.

Sociologists use socio demographic characteristics as well as different opportunity structures and differing historical conditions to explain behavior. They believe, that not only historical, social and political conditions impose restrictions on behavior. Rather, personal and socio demographic characteristics play also an important role (see for example, Semyonov, Lewin-Epstein and Davidov (2002) for the explanation of differences in housing values among immigrants to Israel).

What is obviously common to social scientists is the way individuals are analyzed. Individuals are basically perceived as different human beings with different needs and ambitions, thus with different preferences. These individuals face different alternatives, acquire different resources and choose the best alternative of behavior according to their both preferences and abilities.

Economists as well assume, that preferences play an important role in the explanation of behavior. The individual evaluates his alternatives of behavior, his restrictions and the costs, and finally chooses rationally the best alternative according to his preferences. However, economists assume (in modeling as well as in practical empirical research) that all individuals have the same preferences. Thus, empirical research in economics is mainly concentrating in the differences of measurable monetary restrictions imposed, since according to this assumption only different restrictions will lead to different behavior (Stigler and Becker, 1977; Simon, 1985).

Simon (1985) and Opp (1999) argue, that human rationality is limited, and therefore one finds empirical evidence for violations of rationality. Simon suggests, that many of these deviations could be explained by taking into account the limitations of the human brain. Differences in choice could account for different tastes, different restrictions but also to different cognitive abilities, since we rather investigate a *Homo psychologicus* than a *Homo economicus*.

Opp (1998) and Simon (1985) call to pursue the hard work, which is often not done of testing rational action theory empirically. Furthermore, as Goldthorpe (1998, p. 52)

has pointed out, in present-day sociology rational action theory and the quantitative analysis of large-scale data sets are pursued largely in isolation from each other (see also Blossfeld and Prein, 1998). This paper will try to bridge this gap by testing a rational action theory using a large-scale data set from the German microcensus of 1996.

In our empirical analysis, this criticism of economists on the manner social scientists try to explain behavior is taken seriously. We will test changes and differences in behavior in the context of the rational choice of travel mode, car or public transportation on the way to work. After a short description of the theoretical importance of monetary and time restrictions, we formulate empirically testable hypotheses about the influence of monetary and non-monetary restrictions on travel mode choice. In the next section, we test empirically these hypotheses using logit analysis. Finally we summarize the main findings and discuss the relevance for Becker's theory and for empirical tests of rational choice in general.

2) Theoretical Background

Micro- and macroeconomic theories deal intensively with the influence of the attribute "price" on the economic behavior. Price is the value that a vendor receives in return to his product from the buyer or the customer, since the price of this product presumably represents its quality. During the purchase, the buyer must use financial means from his income in the size of the price of the product. People can buy products whose prices cannot exceed their total income. Hence, the influence of the attribute "price" on the economic behavior rests on the income restriction.

In the context of traditional consumer theory (Deaton&Muellbauer 1980; Maier&Weiss 1990; Varian 1984), the monetary prices of the different means of transportation constitute determinants of the choice of transportation by individuals. Consequently, private car users could be persuaded from the economic perspective to use more ecological public means of transportation by using the "price" instrument. Measures such as gasoline taxation or road taxation are expected to reduce the use of

the private cars. Alternatively, reductions of the prices of public transportation by means of a monthly ticket or a reduced student ticket for instance are expected to increase the use of public transportation.

So far several studies have shown that neither the pure factor of price nor that of income have a significant effect on the decision of the used means of transportation (Domencich & McFadden 1975; Hensher & Dalvi 1978; Held 1982; Ben-Akiva & Lerman 1985; Erke 1990; Molt 1990; Bruederl & Preisendoerfer 1994; Diekmann 1994). Alternatively, these studies have shown, that factors such as duration of travel, socioeconomic and socio-demographic characteristics such as age, family size, gender, education and professional status have a strong influence on the means of transportation choice. Apparently, the explanation of the choice of means of transportation lies not only on one context such as the monetary costs and the income. These critics of the economic approach to explain behavior point out, that it is easier to explain the choice of travel mode on the basis of empirical findings by individual differences in motives, norms and sociological characteristics which can all represent preferences, than by differences in financial restrictions.

According to Becker (1965), the weakness of traditional consumer theory to explain behavior rests not on the lack of consideration of differences in preferences, but on the lack of consideration of other non monetary restrictions in addition to the monetary restrictions. Becker suggests, that “time” becomes a clear factor and resource, when households are considered not only as consumers, but also as producers. Households produce basic commodities (Becker, 1965), such as “a nice apartment”, “leisure-time experiences” or “healthy nourishment”, in which they comply with cost-minimization rules of producer’s theory, and use “time” as an input. The price of the basic commodity, which is produced in the household, is regarded as the sum of the price of this product in the market and the price of the invested time.

How can time be quantified? Time is limited, and has a value for every consumer, which evolves from its scarcity. Differently from money, time is a resource, which

cannot be saved, but rather reallocated. Time can be spent by doing specific activities rather than doing other ones. Becker divides the time one has to “working time” and “non working time”. Since in recent years the non-working time has grown in many countries, the allocation and efficiency of it have become more important for economic welfare than that of working time. Only a limited part of the non-working time is spent for necessary activities such as eating and sleeping. When the income increases, the opportunity costs of the time increase as well, because every hour spent on leisure rather than work becomes more expensive. A reaction to such an increase might be for example saving time of preparing food by buying ready made (and sometimes more expensive) food products.

In Becker’s words, “households will be assumed to combine time and market goods to produce more basic commodities that directly enter their utility functions. One such commodity...depends on the input... and time. These commodities will be called Z_i and written as

$$Z_i = f_i(x_i, T_i) \dots \dots \dots (1)$$

Where x_i is a vector of market goods and T_i a vector of time inputs in producing the i th commodity... when capital goods such as... automobiles are used, x refers to the services yielded by the goods” (Becker 1965, p. 495). f_i is the individual production function². As Becker points out (p. 510), “The transport field offers considerable opportunity to estimate the marginal productivity or value of time from actual behavior”. In our case, f_i could be referred as the production function of traveling to work (Z_i), where time (T_i) and market goods such as traveling in public transportation means or in the private car are the inputs (x_i) of the function. People “combine time and market goods via the “production functions” f_i to produce the basic commodities Z_i , and they choose the best combination of these commodities in the conventional way by maximizing a utility function” (Becker 1965, p. 495).

² For a discussion of production functions see for example Lindenberg 1996.

In this way, Becker constitutes a substitution between money and time. Time is money and money is time. By using time, money can be saved, for example by repairing problems in the water canalization by oneself, and by using money time can be saved, for example by inviting a plumber to do that job. In this manner, time has value that can be expressed by money, and alternatively money has value that can be expressed by time.

Implications for the use of transportation

According to Becker's paper, we suggest to regard transport as a production process, in which a household combines "market commodities" that are restricted by his income, and time that is restricted as well, in order to maximize his utility. The total cost of transport is thereof the sum of the direct cost (the monetary cost) and the indirect cost (the time expressed by monetary units).

Since the direct monetary costs of daily transport are usually relatively small whereas they are time consuming, the total cost of transport (which includes the time-cost component) will significantly change and be influenced by the duration of travel. We will demonstrate it with an example, given by Bamberg (1996). Let us assume that traveling a 15 km way to work lasts 50 minutes with the bus and 20 minutes with a private car. The costs for using the bus are 18 cents per kilometer, and for the private car are 36 cents per kilometer. If a person earns 10 Euros per hour, his costs using the bus would be 11 Euros and for using the car 8.7 Euros although the direct monetary costs of using the car are higher. In such a case the monetary costs themselves would not be a good explanation for the travel mode choice, but the duration of travel or the velocity could very well be one.

As mentioned before, several studies have shown that socio-demographic and socioeconomic variables have an influence on the choice of travel mode. Whereas these studies suggest, that these effects represent differences in preferences of different individuals, Becker suggests that they reflect differences in the money and

time restrictions. Now we will refer to some possible effects according to Becker between socio-demographic characteristics and travel mode choice mediated by the time use.

- The effect of income on travel mode choice.

According to Becker, basic commodities produced by a household cost more when they are more time consuming. Following this, change in the time cost of such a product would produce a stronger increase in the total cost of a product. People would tend to substitute in that case the time consuming product with the product with higher direct monetary cost, which is less time consuming, especially if their income increases.

Public transport, which is usually more time consuming, becomes more expensive in relation to the car when the income per hour increases, even though the monetary costs of the bus and the car remain the same. With a higher salary, one will continue to use the bus if either the duration of bus travel decreases or its direct cost decreases to compensate for the increase of the time price. Otherwise, one would substitute the time consuming public transportation with the time saving car.

This can explain the increase in the last years of both income and gas use. The increase in income has caused a substitution from the time consuming public transportation to the time saving private car. Education, age and professional status can all be reflected in the income, and therefore serve as indirect effects on the travel mode choice. In that sense, higher education, and an age range somewhere after schooling and somewhere before retirement can all reflect higher income and a higher tendency to use the car³.

- The effect of gender on travel mode choice.

The finding that women use the bus more frequently than men could be explained by time costs of the members of the household. The one who earns the highest amount of

³ Unfortunately we do not have enough details about professional status in our data, since the indicators of the type of profession one is occupied with are too general.

money per hour is the one from the point of view of efficiency, who should lose the least time for transportation, because transportation time is most expensive for him. Therefore the members of the household would let him use the car, assuming there is only one car in that household. If only one of the people in the household takes part in the labor market, it would be most efficient that he/she would use the car, because his/her transport costs would be the highest. Since in Germany there are still many women who earn less than men (see for example Diekmann, Engelhardt and Hartmann, 1993), it is clear that his time cost would be the highest, and therefore he would be the one to use the car.

- The effect of marital status on travel mode choice.

Another implication of Becker's paper is the influence of marital status on travel mode choice. The finding that married people tend to use the car more than the public transportation can be explained by different time costs. Being married usually involves activities that singles are not obliged to do, such as spending time at home together with the partner or taking care of other members of the household. These obligations consume time, and thus time outside of work spent by married people becomes scarcer, and more valuable. Traveling with the car becomes cheaper relatively to the time consuming bus, and therefore car becomes their preferred choice⁴.

We believe this is not a full explanation, and in order to better account for the processes involved in the choice of travel mode one has to build bridge assumptions (Kelle & Luedemann, 1998). Bridge assumptions (or auxiliary hypotheses in Simon, 1985) reflect mechanisms, which relate socio-demographic characteristics, such as

⁴ The effect of profession on travel mode choice.

It is interesting to note, that another implication of Becker's paper is the influence of professional status on travel mode choice. In this sense, time costs are reflected not only by income. People such as pensioners who get their money not by the hour but as a lump sum have a lower time cost than people who are employed and paid by the hour. Therefore we find, that older people tend to use more public transportation, even when they have an available car. For these people time does not play an important role. The relative costs of using public transportation decrease significantly, and make it their preferred choice. However, as we analyze only working people, we exclude this group from our analysis.

gender, marital status and age to behavior, and in our case to travel mode choice. They may serve as additional explanations to the one offered by Becker relating to time costs and income differences. As considering only time and monetary costs as valid restrictions is typical for the narrow version of rational choice (Opp, 1999), offering other explanations serves the wide version of rational choice as a theoretical basis to explain behavior. However, our critique on Becker's approach is empirically oriented, and we will suggest such alternative bridge hypotheses, which reflect a wider version of rational choice in the discussion section.

In the literature we find studies based on regression analyses to explain travel mode choice. For example, Franzen (1997) showed based on environmental surveys in Germany (see below), that the difference in time and money costs of public transportation and car rather than the absolute costs are better determinants of travel mode choice. He also found how important the factor "comfort" has been for the decision whether to choose public transport or car. However, these findings have not been based on a systematic development of a formal rational choice model in the form of a production function for example (see also Diekmann and Preisendoerfer, 1998), but are results of regression analyses. These findings have also not been applied to transform and improve a systematically developed rational choice model so that it will include these findings, and in this way serve as a better model. Therefore they may not necessarily link rational choice and large-scale data analysis.

Other sources of data to be considered for the purpose of testing a rational choice model are environmental surveys in Germany (e.g. Diekmann, Gautschi, Franzen and Preisendoerfer, 1996). There are some deficiencies in these surveys. First, they are not representative, and include a few thousand respondents. What is a little more bothering is the selection bias, as the response rate is less than 50% in some cases. In 1996, 1,095 out of 1,680 sampled households in former western Germany (65.2%) and 1,212 out of 1680 sampled households in former eastern Germany (72.1%) were actually analyzed. Indeed, in a comparison we have conducted between the 1996 environmental survey and our data from the same year, we have found significant

differences in the travel mode choice (modal split), especially in the choice of car and car joining and in walking, which might severely affect computations. Some significant biases are also reported by the environmental survey in socio demographic characteristics. Variables, such as marital status, size of household (with significant over-representation of one-person households), gender and education are heavily biased (for details see Diekmann, Gautschi, Franzen and Preisendoerfer, 1996 p.8-9). The advantage of the microcensus data is its representative sample of the entire population, and the fact that people are forced by law to participate and respond to the questions (a zero percentage of non-response), thus reducing selection bias. In this way we address the call for alliance between official data and rational choice and enrich the data analysis giving better data estimators. As our main goal was modest, trying to test Becker's rational choice model of time and money and do it with large-scale data analysis, we found the microcensus data most adequate for that goal.

Narrow models of rational choice, such as the elegant models suggested by Becker, are indeed clear and sharp in their theoretical explanation. However, they have not been extensively tested empirically, and therefore may not always suggest a thorough explanation as we find in our analysis because they may not be validated. Some other variables than those mentioned in some "narrow" rational choice models, like sociological variables such as gender and age (and possibly others we could not use here) may have strong additional explanatory power via additional bridge assumptions.

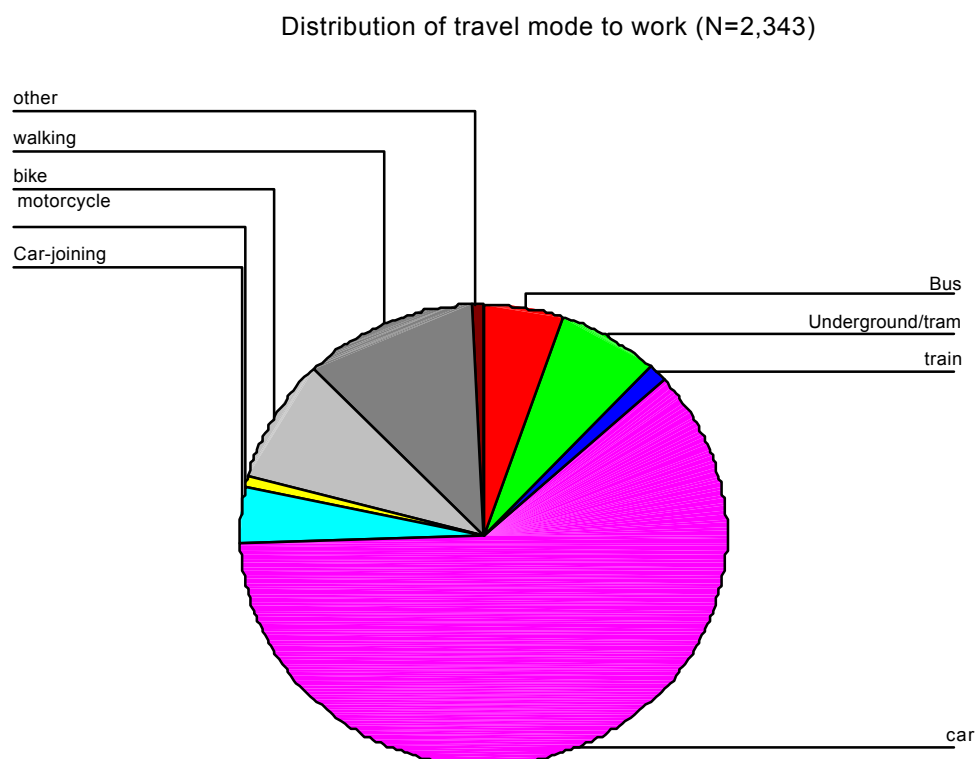
3) Data.

We will now report the analysis of the travel mode choice for the way to work of individuals with data obtained from the German microcensus. We will especially focus on the possible effect of external restrictions, especially time restriction, rather than the influence of preferences, on the travel mode choice.

The German microcensus collects data on individuals residing in Germany once a year, and contains a randomized 1% data of the total population (approximately

800,000 cases). Once in four years data about travel mode choice are collected, and the last available are from 1996 (for further documentation see Luettinger and Riede 1997; Schimpl-Neimanns 1998). We analyzed a randomized 1% of the data available from the German microcensus because this was sufficient for our purpose. As we are interested to analyze travel mode choice of working people, we concentrate in our analysis only on people who go to work. As we can see in Figure 1, 61% of the people who travel to work use their private car and another 4% accompany them. About only 13% use public transportation (bus, underground, tram and train), 1% of the people use a motorcycle to go to work, 9% use their bicycle and approximately 11% walk to work.

Figure 1: Distribution of travel mode on the way to work of the sample-modal split⁵ (N=2,343)



⁵ Modal split is defined as the distribution of travel mode choice in transportation research.

As data in the German microcensus on travel time and distance of travel to work is categorical⁶, we had to convert these values into continuous values, and therefore presumed that each category had the middle value of its original category. In other words, for the variable “distance to working place” category 1 received the value “5 km”(3.1 miles), category 2 received the value “17.5 km” (10.9 miles), category 3 received the value “37.5 km” (23.3 miles) and category 4 received (arbitrarily) the value “60 km” (37.3 miles) (as there is no data available on the distribution of distances for those people reporting a bigger value than 50 km (31.1 miles)). For the variable “duration of travel to working place” category 1 received the value “0.08” (which equals to five minutes), category 2 received the value “1/3” (which equals to 20 minutes), category 3 received the value “0.75” (which equals 45 minutes) and category 4 received the value “1.25” (which equals 75 minutes) arbitrarily (as there is no data available on the distribution of time to work for those reporting a value “more than one hour”).

Our dependent variable is travel mode choice for going to work. In the data, people reported different means of transportation for their way to work, including for example underground, train, bus, private car (alone or as an accompany), bicycle and walking. We decided to define our dependent variable as a car user or as a public transportation user for the following reasons: (1) it is our main interest to check what could divert the mass of people using their private car into using public transportation, which is in most cases the available alternative, as jobs are in many cases not in a bicycle or walking distance; (2) we received unacceptable values for the “velocity” variable for bicycle users and people who walk. These velocities were much higher than reasonable for walking or for riding the bike. It could happen possibly because of inaccurate values either reported by the individuals (who are likely to be less aware of the time because they have no train to catch) or due to our arbitrary transformation which affected mostly the extreme values for time (walking

⁶ The categories for the variable “distance to working place” in the microcensus are 1. “below 10 km”, 2. “between 10 and 25 km”, 3. “between 25 and 50 km” and 4. “50 km and more”. The categories for the variable “duration of travel to working place” in the microcensus are 1. “below 10 minutes”, 2. “between 10 and 30 minutes”, 3. “30 minutes up to one hour” and 4. “one hour and more”.

or riding the bike may have lasted longer than driving or using the train) and thus bringing inaccurate value for the velocity variable. Therefore, we decided to neglect bikers and people who walk; (3) car and public transportation users constitute the biggest group of travelers (approximately three quarters). As a result, our defined dependent variable is “car user” which is 1 if individual uses the car on his way to work, and zero if he uses public transportation, namely, underground, tram, train or bus (all other cases are filtered).

We calculated the “velocity” variable by dividing the “distance to work” variable with the “duration of travel to work” variable, thus creating an index, which incorporates both time and distance components. As it is the efficiency of the use of time rather than its absolute number, which reflects how costly or effectively time is used, we concluded that time costs would be best measured and represented as an empirical variable by the velocity of the means of transportation. Monetary costs are represented in this case as the opportunity costs of time.

The income variable was given in categories. Therefore, we followed the same procedure as for the variables “distance to work” and “duration of travel to working place” by taking the middle value of each category. For the last category (income is 3,750 Euros or more) we followed again what we had done before, and gave it a value of 4,000 Euros arbitrarily (as there is no data available for the distribution of income for the people earning more than 3,750 Euros). We calculated the number of hours worked per month by using the following procedure: we applied the available variable “normal number of hours worked per week” and multiplied it by four (assuming 4 weeks of work per month). By division we received the “income per hour” variable. As the highest 20% earn 9,50 Euros per hour or more, and we are interested to know whether level of income has any effect on travel mode choice we created a dummy variable: “income 9,50 or more?” receiving the value of 1 for people earning 9,50 Euro per hour or more and 0 otherwise (it enables us to create an interaction variable multiplying it with the velocity variable).

We defined “age square” as the “age” variable given in the microcensus data with the power of two. According to the data, young and old people tend to use public transportation more often than others, which justifies using a nonlinear variable for age. The “Higher education” variable receives the value 1 for people completing studies beyond high school, and 0 otherwise⁷. “Gender” receives the value of 1 for men and 0 for women. “Velocity X income 9,50 or more” is the interaction term between the variables “velocity” and “income 9,50 or more?”. Thus, this variable will receive a velocity value only for people earning a high salary, and zero otherwise. In this manner, we can test whether higher velocity has a stronger effect on the tendency to use private car on people earning more per hour. The “Marital status” variable receives the value of 1 for married people, and zero otherwise.

4) Descriptive Overview

In the following section we give a short description of our data. As we intend to analyze only working people who travel to their working place either with a car or by public transportation, all other cases are excluded. In that way, the number of cases reduces to N=1,742. Table 1 presents the average and standard deviation of the variables in the analysis.

As can be seen in Table 1, approximately 35% of the sample of working people earns 9,50 Euros or more, and about 82% use a car on their way to work. The average of the overall income per hour of working people in the sample is 9.17 Euros/hr. 61% of the working people are males and the same percentage of people are married, and approximately 20% of them have obtained higher education. The average age is 38.5. As expected, the average velocity of cars (43.1 km/hr) is significantly higher than the average velocity of public transportation on the way to work (30.1 km/hr). The average velocity in general is 40.7 km/hr.

⁷ We considered creating more categories for the education variable. However, since we had no data about number of studied years we could not create an interval variable. Additionally, the categories given for education in our data are not ordinal. Therefore, we are satisfied with having only a dummy variable for the categories higher education or not.

Becker's theory implies, that any differences in income per hour between different socio demographic groups should be responsible for different choices of travel mode due to different time costs. Thus, before checking whether there is any effect of different socio demographic groups like gender or age on travel mode choice, we check whether these groups differ in income per hour in our sample. After all, it could be the different income they represent, which is responsible for the differences in travel mode choices and not the sociological groups. For this purpose, we test whether there is a significant difference in the variable "income 9,50 or more?" between males and females, between married and unmarried, between people who obtained higher education and people who did not and between the different age groups. Later on we test if these groups differ in travel mode choice.

Table 1: Descriptive Overview of Variables in the Analysis (N=1,742)

Variable	Description	Mean	Stand. Dev.	Mean For groups higher education=1 and 0	Mean For groups marital status=1 and 0	Mean For groups gender=1 and 0	Mean For groups higher education=1 and 0	Mean For groups marital status=1 and 0	Mean For groups gender=1 and 0
Income per hour		9.17	6.17						
income 9.5 Euros or more?	1=yes, 0=no	0.35	0.48	0.66*, 0.30*	0.41*, 0.24*	0.44*, 0.20*			
Car user	1=yes, 0=no	0.82	0.38				0.88, 0.84	0.85*, 0.78*	0.89*, 0.71*
Gender	1=male, 0=female	0.61	0.49						
Marital status	1=yes, 0=no	0.61	0.49						
Higher education	1=yes, 0=no	0.20	0.40						
Age	Continuous variable	38.5	11.4						
Velocity (for all means of transp.)	In km/hr	40.7	23.2						
Velocity (for car)	In km/hr	43.1	22.6						
Velocity (for public transport)	In km/hr	30.1	22.8						

* Significantly different from one another.

As table 1 describes, approximately 66% of the people who obtained higher education earn 9,50 Euros per hour or more, whereas only 30% of the people who did not obtain higher education earn that much. Significant differences in earnings are observed among the other groups as well. Whereas 41% of the married people and 44% of the males earn 9,50 Euros per hour or more, only 24% of the unmarried and only 20% of the females do so. As for the relation between age and income per hour, in a correlation analysis we find a significant 0.247 (N=1,672) correlation between the variable “income 9,50 Euro or more” and age, and a significant 0.225 correlation between “income 9,50 Euro or more” and the age with the power of two variable. Therefore, whereas different sociological groups are indeed correlated with income significantly and therefore representing different income groups, this correlation is not so high, and there is still some independent explanation for sociological factors and for income. We will return to this point in the multivariate analysis.

The next question we ask is if there is any significant difference in travel mode choice between different socio demographic groups. As can be seen in table 1, males and married people use a car on their way to work significantly more than females and unmarried (89% and 85%; 71% and 78% respectively). Different categories of the variable “higher education” and the variables “age” and “agesquared” show no special pattern with their relation to the variable “car user”. Is the difference in car use within some of our socio demographic groups related to their difference in income, or rather to other traits imbedded in the socio-demographic group? According to Becker we ought to expect it to be related only to the difference in income and time costs. A multivariate analysis might give us an answer.

5) Multivariate Analysis.

In the following section we would test the hypotheses evolving from Becker’s theory⁸. We would expect to receive the following results:

- (1) Due to the fact that resources are limited, we expect people to maximize their utility in their decision process, in such a way that they would choose a travel mode,

⁸ The hypotheses are deduced from Becker’s theory, but he does not form them explicitly.

which would waste the least out of their limited time and limited money. In our research we concentrate on the time restriction. As the “velocity” variable incorporates both the distance component and time of journey component, this would be our indicator of the time use, so that the higher the velocity, the more efficiently time is used. As cars are faster than public transportation, we expect people with higher income per hour to tend to use the more time efficient travel mode, namely the car. We also expect that the effect of velocity on choosing the car is stronger for the high-income group.

To put it precisely:

H1) we expect a positive and significant coefficient of velocity on car use;

H2) we expect the interaction term velocity X income 9.5 or more to have a positive and significant effect on car use.

(2) According to Becker’s theory, there should be no direct effect of socio-demographic characteristics on travel mode choice, but only indirect via the time restriction. As different characteristics such as gender, age, marital status or education are expected to be reflected by different income per hour, different time costs are expected to take over, and be the main forecast for travel mode choice. However, as we saw the correlations between income and sociological factors are significant but not high, we suspect sociological factors by themselves have an additional explanatory power for travel mode choice.

To put it more precisely:

H3) we expect the variable gender to have a significant effect on car use after controlling for velocity and for velocity X income 9.5 or more.

H4) we expect the variable age squared to have a significant effect on car use after controlling for velocity and for velocity X income 9.5 or more.

H5) we expect the variable family status to have a significant effect on car use after controlling for velocity and for velocity X income 9.5 or more.

We test our hypotheses in a series of logit models using SPSS. In each model, the dependent variable is the travel mode choice: car or public transportation. The results are presented in table 2.

Table 2: Logit Models to Explain Travel Mode Choice (Dependent Variable is “Car User?”) (Standard Error in Brackets).

Variable	Model 1	Model 2	Model 3
Velocity	.0305** (.0034)	.0263** (.0035)	.0242** (.0042)
Velocity X income 9.5 or more?		.0127** (.0040)	.0057 (.0048)
Gender			1.0351** (.1610)
Agesq			-.0002* (.00008635)
Family status			.356* (.1657)
Higher education			.1932 (.2152)
Constant	.4194 (.1258)	.3993 (.1276)	.3041 (.2311)
-2 Log Likelihood	1,528.768	1,479.793	1,071.045
Goodness of Fit	2,738.251	2,125.904	1,510.138
Cox & Snell R ²	.053	.058	.083
Nagelkerke R ²	.086	.095	.144
N	1,726	1,656	1,392

* P<0.05, ** P<0.01

In the first model we test whether velocity has any effect on travel mode choice. We find out a positive and significant relation between velocity and car use (.0305). Indeed, the higher the velocity, the higher the probability that the used travel mode is the car. This confirms once again our expectation, that car is the faster mean of transportation in our data. In the next step we are going to test, whether this has any different effect on travel mode choice over different income groups.

In model 2, we test hypothesis 2, whether the interaction effect between velocity and the variable “income per hour 9,50 Euro or more” has a significant effect on travel mode choice. As table 2 presents quite clearly, both velocity and the interaction effect between income per hour and velocity have a positive and significant effect on travel mode choice (.0263, .0127 respectively). This means that the high-income group has

a higher tendency to use the car than the lower income group. In other words, the effect of velocity is stronger for the high income group.

Finally, we test whether socio-demographic characteristics have any effect on travel mode choice. In model 3, we add to the independent variables velocity and interaction between velocity and “income per hour 9,50 Euro or more” the variables gender, marital status, age with the power of two and higher education. As table 2 indicates, the results of model 3 contain several interesting points. First, velocity has a remaining positive and significant relation to car as the preferred travel mode. Second, all socio demographic variables except higher education have a significant direct effect on the dependent variable. In other words, males and married people are significantly more likely to choose the car to travel to work than females and unmarried people. Age with the power of two indicates a small, negative and significant effect on the dependent variable. Namely, in younger and older ages it is less likely that people in our sample would use a car, but it is more likely they would do so when they are in a middle age. Obtaining higher education has no significant effect on travel mode choice.

Finally, after including socio demographic variables to explain travel mode choice to test hypotheses 3, 4 and 5, the interaction term between income per hour and velocity becomes insignificant. In other words, as higher and lower incomes are already reflected in several socio demographic variables, the effect of the interaction between high income and velocity becomes insignificant. Whereas the Cox & Snell R^2 was only between 5% and 6% in models 1 and 2, it improved to 8.3% in the third model. The Nagelkerke R^2 was 8.6% in the first model, 9.5% in the second model and improved to 14.4% in the third model.

6) Discussion.

In this paper we have restricted ourselves to maintaining three goals. First, we suggested testing a well-established theoretical model of behavior of Becker, questioning whether time in addition to monetary costs affects behavior in the context

of travel mode choice. Second, we tried to test Becker's theory by using large-scale data from the German microcensus of 1996. Third, we checked whether socio-demographic characteristics have any effect on behavior after controlling for economic restrictions. As Green and Shapiro claimed (1994), proponents of rational choice seem to be most interested in theory elaboration, leaving for later or others the messy business of empirical testing. We tried to bridge this gap between rational choice theory and large-scale data analysis by testing an important rational choice model, which has not been seriously challenged so far.

Becker has been trying in his work to formulate a theory, which could explain any behavior, in the economic market, in choice of partners, in family relations and in social discrimination in the form of production functions. We have tried to test a special case in this theory, in respect with the decision whether to choose the car or the public transport on the way to work. As a theoretical framework, we drew out of his strongly and elegantly formulated theory testable hypotheses, in order to check how well his explanations work in a practical problem. Specifically we wanted to check if restrictions rather than preferences affect choices, and whether the effects of socio demographic characteristics, which may represent preferences in addition to time cost differences according to Becker, disappear, when objective restrictions as time costs are introduced in the empirical test. In formulating the hypotheses, we were confronted with the question how to model time costs. Velocity incorporates two important factors to compute efficiency of time use, namely the duration of travel and also the distance. As it is the efficiency of the use of time rather than its absolute number, which reflects how costly or effectively it is used, we concluded that it would be best measured by the velocity of the means of transportation.

As theoretically expected, there is a significant effect of the time cost, reflected by the interaction term between higher income and velocity, on the travel mode choice in our sample of the German microcensus. As car is the faster mode of transportation, the more costly is the time, namely, the higher the income per hour, the higher the positive effect of higher velocity on the tendency to use the car on the way to work.

This confirms the theoretical expectation of Becker, that time has a value, and thus an effect on choices in time consuming daily activities, and particularly also on travel mode choice.

However, we could not confirm the second implication from Gary Becker's work, that all socio demographic characteristics are reflected by different time costs. We suspected we would find a significant effect of some sociological characteristics on travel mode choice. In our findings, marital status and gender had a significant and overwhelming effect on travel mode choice. In addition, the interaction term of income per hour and velocity became insignificant⁹. Women, indeed, use more public transportation as well as unmarried people. We found no direct significant effect of education on travel mode choice, which may be explained by the fact that maybe it is indeed strongly reflected by differences in time costs between the different education groups. Age had a very small but significant effect on travel mode choice, reflecting a higher car use for the middle age group. It may as well be explained by the fact that time cost differences may well represent the different age groups. To check it, we ran an OLS regression of income per hour on the variables age squared and education, and indeed, both coefficients were highly significant. Although females and unmarried earn less money per hour than married people and males, their socio demographic status overwhelmed the effect of their lower time cost on travel mode choice.

Indeed, in such a case, in order to have a better explanation of behavior, we must turn to other disciplines, and construct "bridge assumptions" (see for example Kelle and Lüdemann, 1998). According to one of the interpretations, bridge assumptions (or auxiliary assumptions as termed in Simon, 1985) link a theory with observational terms, thus formulating alternative explanations. It would make sense here to suggest bridge assumptions between gender and marital status on the one hand, and the

⁹ We performed a correlation test between the interaction term and each of the other explanatory variables. The correlation was significant but never more than 0.25 with each of the socio demographic characteristics. Therefore we assume, the result implies a true overwhelming effect of sociological characteristics.

sociological processes, which account for the chosen travel mode on the other hand, as gender and marital status had an overwhelming effect on the travel mode choice. Indeed, one such explanation concerning gender could relate to differences in technical affinity between men and women (see for example Pasero et al., 2002 or Wajcman et al. 1994). A stronger technical affinity for men could account for an additional factor affecting a higher tendency of men to prefer the car as a travel mode regardless of their time costs. Another explanation concerning marital status could relate to the finding, that married couples tend to live in less urban areas, where public transportation use is less feasible or parking is less of a problem (see for example Lichtenberger, 1998, p.318 for the case of Vienna). In general, married people have also more children in the household than non-married. In such a case, a need for higher flexibility (which serves as an additional constraint) would affect a higher tendency to use the car. These explanations would serve as additional bridge assumptions to those of income and time cost differences between males and females or married and unmarried people suggested by Becker. Additionally, they suggest according to Simon (1985) how other variables are related to preferences and utility. They could indeed bridge the gap regarding the influence of these socio economic characteristics on travel mode choice and serve as an additional plausible explanation for choosing a travel mode.

When we think of possible other explanations for the findings, we may suggest at least two. We received relatively low percentages of explained variance even in the third model. The highest explained variable we received was 14.4% (Nagelkerke). It may well be the case, that there are other economic and social-psychological factors, which may explain travel mode choice and nevertheless we did not include in our models since they were not in hand in the German data of the microcensus¹⁰. An example of such a variable is the availability of a car. Many studies show, that car availability is a central variable in transportation research, and may reflect both the socio demographic characteristics that we included in the analysis and other ones.

⁸ We tried to add an income per hour variable in the analysis in model 3, but it turned out to be insignificant.

Indeed, males, married people and people in the middle age group tend to have an available car more than females, unmarried and young or old people (e.g. Hautzinger 1996). Once one owns a car or has one in hand, the tendency to use it is usually higher¹¹. However, this problem cannot be easily solved outside a new design of the questionnaires. As users we can either employ the microcensus with all its obvious limits, or rather use another data set. However, we do not have any data set, which is equally suitable in Germany to fulfill and address the call of Goldthorpe (1998) for an alliance between official data and rational choice theory. The drawbacks (like a selective sample) of other smaller surveys, such as the environmental surveys in Germany, have been previously discussed in this paper, especially their low response rate and their being far more biased than the microcensus data set. Future large scale data research might try to address these issues, like indeed some experimental studies already do by applying social psychological theories such as the theory of Planned Behavior to explain travel mode choice (see for example Bamberg and Schmidt, 1998, 2001) and testing them in smaller scales of data. In these studies, the explained variance is much higher. Another point, which we wish to mention, is that there might have been problems in the operationalization of the time costs. Maybe the arbitrary assignment of values for the extreme categories has led to inaccurate application of personal time costs. However, only 37 out of 1,742 had an income on the highest level, only 60 cases had a distance longer than 50 km and only 120 cases out of 1,742 needed more than one hour to go to work, and consequently the great majority of values used in the analysis are not arbitrary. Omitting cases with these extreme categories might cause another kind of bias to the data. As one of our main purposes was testing the theory, the data in hand was adequate to conduct an empirical test of the model.

Some practical implications can be drawn from our analysis, also as to what social groups are to be addressed in order to bring more car drivers to use public transportation. Apparently, it is quite a sociological question what makes people use public transportation, and what makes them rather use the car. These social

¹¹ We asked the German Central Bureau of Statistics to include this variable in future questionnaires.

mechanisms (such as place of residence or technical affinity) are to be explored more deeply, in order to find the dynamic processes, which lead some groups to a more ecological behavior in respect to travel mode choice.

When we try to model a rational behavior, the question which model to choose and which factors to incorporate in the model relates quite often to whether rational choice should be modeled and tested in a narrow version in which only objective factors such as time and money are taken into account (Preisendorfer, 2000), or in a wide version, in which subjective social-psychological as well as sociological variables should be taken into account (Opp, 1999). Our critique on Becker's approach is indeed empirically oriented. However, Becker is considered as a proponent of the hard (narrow) rational choice version according to Opp. As there are other versions of rational choice, such as the wide one as Opp defines it, it could be that the model of Becker is not sufficient. Indeed, Simon (1985) criticized Becker of making a lot of untested assumptions, but those criticisms were ignored. Our work demonstrates quite clearly, that behavior might be influenced by many different factors and explanations via bridge assumptions. It is an empirical question to be tested which factors are relevant, and whether narrow or wide rational choice is the right behavioral model. As we want to get as close as possible to a good explanation of behavior, we can conclude that for a synthesis, instead of constraining a model only to objective economy oriented explanatory factors, one should let it include in advance different theoretically based explanations from different disciplines to be tested empirically.

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¹² The authors would like to thank Nadia Granato for very helpful comments. We would also like to thank Juergen Hoffmeyer Zlotnik, our participants in the Bounded Rationality seminar conducted in Giessen University in June 2002, the transportation group including Andreas Diekmann, Ben Jann and Axel Franzen in the sociology Institute in Bern and Julia Iser for helpful comments.

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The paper is in press to be published in 2004 in *Methods of Psychological Research Online*, 8(2), 127-157.

Is There Any Interaction Effect between Intention and Perceived Behavioral Control?¹³

Abstract

Many models in social psychology, which have been developed to explain behavior, postulate interaction effects between explanatory latent variables. In the last years, there have been many new developments for estimating interactions between latent variables in structural equation modeling. However, there have been very few applications with real data from theory-driven studies. This paper provides an empirical test with real data from an ongoing research project about travel mode choice in Frankfurt, using the theory of planned behavior. We apply three statistical approaches for the estimation of interaction effects between the latent variables perceived behavioral control (PBC) and intention for predicting travel mode choice (behavior): latent variable scores, maximum likelihood and robust maximum likelihood. We compare the strengths and weaknesses of the approaches from an applied point of view. In a meta-analytic review we summarize the results of 14 articles, which estimated the interaction between intention and PBC for predicting behavior, and discuss the problems associated with such a meta-analysis.

Keywords: Interaction effects; Structural Equation Modeling; latent variable scores; maximum likelihood; meta-analysis; theory of planned behavior; robust maximum likelihood.

1. Introduction

Many models in social psychology, which have been developed to explain behavior, postulate interaction effects between explanatory latent variables (e.g. Ajzen & Fishbein, 1980; Ajzen, 1991; Triandis, 1980). In the last years, there have been many new

¹³ A joint work with Fan Yang-Wallentin, Peter Schmidt and Sebastian Bamberg.

developments for estimating interactions between latent variables in structural equation modeling (Arminger and Muthén, 1998; Bagozzi, Baumgartner, and Yi, 1992; Baumgartner and Bagozzi, 1995; Bollen, 1995; Bollen and Paxton, 1998; Busemeyer and Jones, 1993; Jaccard and Wan, 1995; Jaccard and Wan, 1996; Jöreskog, 1998; Jöreskog and Yang, 1996; Kenny and Judd, 1984; Klein and Moosbrugger, 2000; Klein, Moosbrugger, Schermelleh-Engel, and Frank, 1997; Lee and Zhu, 2000; Li Fuzhong, Harmer, Duncan, Duncan, Acock, and Boles, 1998; Marcoulides and Schumacker, 2001; Moosbrugger, Schermelleh-Engel, and Klein, 1997; Ping, 1996; Reinecke, 2002; Reinecke, Schmidt and Ajzen, 1996; Schermelleh-Engel, Klein, and Moosbrugger, 1998; Schumacker and Marcoulides, 1998; Wall and Amemiya, 2000; Yang-Jonsson, 1997; Yang-Wallentin and Jöreskog, 2001; Zhu and Lee, 1999). Many of these studies investigated interaction effects by means of Monté Carlo methods. However, there have been only few applications with real data from theory-driven studies (Yang-Wallentin, Schmidt, & Bamberg, 2001). So from a methodological point of view it would be very helpful to apply valid and reliable statistical tools on real data for the estimation of such interaction effects. When there are nonlinear relationships between latent variables, the general linear structural equation model (Jöreskog, 1973) does not hold, as pointed out by Hoogland and Boomsma (1998). It is indeed not possible to transform latent variables to make nonlinear relationships such as quadratic or interaction terms approximately linear, as can be done with observed variables.

For nonlinear structural equation models with product terms the pioneering work of Kenny and Judd (1984) is of special interest. They suggested using the product of the indicators of latent variables to control for random measurement error (Reinecke, 2002). Baumgartner's and Bagozzi's (1995) simulation results show that maximum likelihood (ML) and weighted least squares (WLS) performed well with respect to model estimation, but the chi square statistics and standard errors based on normal distribution theory may not be trustworthy. WLS estimators are most appropriate where the sample size is large enough. Yang-Jonsson (1997) compared simulations using ML and WLS estimation. They conclude that sample size greater than 400 is not a serious problem for the ML estimators although inference statistics are underestimated and the chi squares

reject the model too often. With WLS the statistical assumptions are better fulfilled and chi squared values have smaller values indicating a better model fit. Moulder and Algina (2002) suggest that two-stage least squares (TSLS) and Ping's (1996 and 1998) procedure are more likely to result with biased estimates of the interaction term than ML, whereas ML tests with corrected standard errors had convergence problems and were too conservative. Schumacker (2002) presents two approaches to latent variable interaction modeling. In the first procedure, the interaction is defined by multiplying pairs of observed variables (the ML Jöreskog-Yang approach), and in the second the latent variables scores are multiplied. Parameter estimations were similar, but standard errors were different. Future research should clarify the nature of the differences in the standard errors in these two approaches.

As Reinecke (2002) states, results often base on a limited number of cases (many times less than 500 cases) or on simulations rather than on real data (see for example Baumgartner & Bagozzi, 1995; Yang Jonsson 1997). In our study we will try to overcome this limitation by using real data with considerably more cases.

From a meta-analytical point of view it is confusing. As Moulder and Algina (2002) state, several studies have been conducted on methods for testing and estimating latent variable interactions. However, these methods have often provided results for a single method and, therefore, did not allow for a general comparison of the available methods. When we decide which estimation methods to apply, we have to answer two questions:

- a) Which estimation methods we choose and why?
- b) Which one is the best out of them?

This paper provides a meta-analytic review of studies, which tested the intention \times PBC interaction in the theory of planned behavior, and an empirical test of the interaction with real data from an ongoing research project about travel mode choice in Frankfurt, using the theory of planned behavior (Ajzen 1985, 1988, 1991).

1) In a meta-analytic review after the theory section, we summarize the results of 14 articles, which estimated this interaction, and discuss the problems associated with such a meta-analysis.

2) In the empirical test, we apply three statistical approaches for the estimation of interaction effects between the latent variables perceived behavioral control (PBC) and intention for predicting travel mode choice (behavior). The estimation methods are latent variable scores (LVS), maximum likelihood (ML) and robust maximum likelihood (RML). For example, we do not bring Klein's method (Klein & Moosbrugger, 2000; Klein, Moosbrugger, Schermelleh-Engel, & Frank, 1997) although it has very good estimation properties especially for small samples. A simulation study is needed to compare this method with LVS, as they are both useful for small samples. TSLS and WLS are not tested here, because they have been studied before (see Yang-Wallentin, Schmidt, & Bamberg, 2001). On the other hand, LVS, ML and RML are used for the following reasons:

- LVS is new and has been rarely empirically tested before. It is easy to implement and is suitable for a preliminary test for the interaction.
- ML is known to be a robust estimation method (Jöreskog, 1998; Yang-Jonsson, 1997; Yang-Wallentin & Jöreskog, 2001). Although ML requires the multinormal distribution, which we don't have because of the use of product variables, it still deserves to be considered according to simulation studies (Yang-Jonsson, 1997).
- RML is used to produce the correct standard errors and χ^2 under non-normality (Browne 1984, and Satorra 1993).
- ML and RML are complicated to implement, but they give parameter estimates and overall model fit simultaneously.

In contrast to most papers on this topic, we do not test the interaction between the constructs belief \times expectancies from the theory of planned behavior, but the interaction between the constructs intention and PBC for predicting behavior. We compare the strengths and weaknesses of the three approaches from an applied point of view. We do not provide mathematical documentation of the three methods, because we are more interested in their implementation. Therefore, we provide the input files for each method.

Finally, we give a recommendation which estimation method to use to test interaction effects.

2. Theory

The Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980), respectively the Theory of Planned Behavior (Ajzen, 1991), are not only among the most intensively empirically tested social psychological action theories (e.g. Van den Putte, 1991; Eagly & Chaiken, 1993; Conner & Armitage, 1998; Armitage & Conner, 2001), but they have also been applied successfully to the explanation of environmentally relevant behaviors (Allen, Davis, & Soskin, 1993; Bagozzi & Dabholkar, 1994; Goldenhar & Connell, 1992-1993; Jones, 1990). Very briefly, the TPB, which is an extension of the TRA, postulates that people in a decision situation consider the likely consequences of available alternatives (so-called behavioral beliefs); they weigh the normative expectations of important reference individuals or groups (normative beliefs); and they consider required resources and potential impediments or obstacles (control beliefs). These considerations or beliefs result, respectively, in the formation of attitudes towards the behavior of interest, subjective norms with respect to the behavior and PBC. It is assumed that people form behavioral intentions based on their attitudes, subjective norms, and perceptions of behavioral control, and that these intentions, together with behavioral control, are the immediate determinants of behavior. Figure 1 shows a graphical representation of the TPB.

Intention is assumed to capture the individual motivational factors, which influence behavior. It is an indicator of how much an individual is willing to try and how much energy he is willing to invest in order to perform a behavior. Generally speaking, the higher the intention the higher the chance a behavior will be performed.

It should be mentioned however, that intention determines behavior only if the person can decide at free will whether to perform or not to perform the behavior, i.e. whether the behavior is under volitional control. Whereas some behaviors may meet this requirement, they may depend on the availability of opportunities and resources (“resources” is the

word usually used in economic theory). Such resources are for example time and money in neoclassical economics (e.g. Becker, 1965) or skill and cooperation of others (Ajzen, 1985). Together, these factors represent individual's control over the behavior. The importance of actual behavioral control is self-evident: the resources and opportunities available to a person determine by some extent his behavioral performance. Of greater psychological or sociological interest are however not the actual behavioral controls or restrictions, but the perceived ones and their effect on intention and performed behavior. The Theory of Planned Behavior, as described in figure 1, places the PBC in a more general framework, where simultaneously also the effects of norms and attitudes towards the behavior are considered.

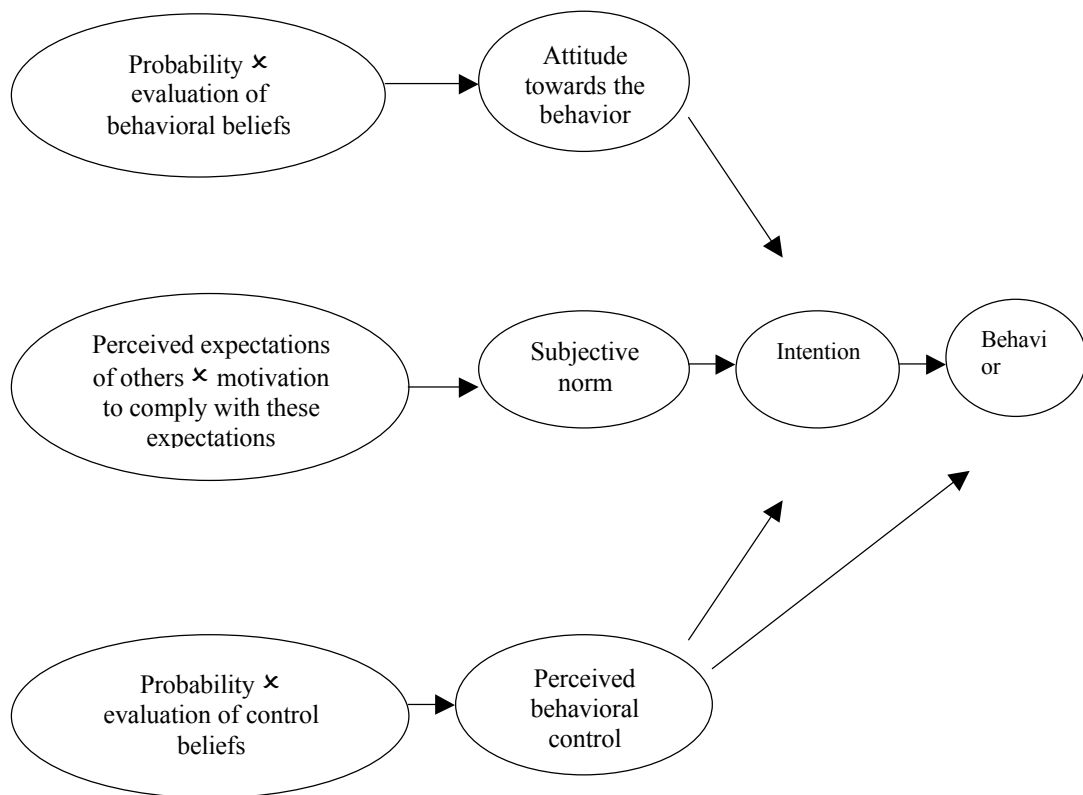


Figure 1. The Theory of Planned Behavior (TPB)

The three constructs PBC, attitude towards the behavior and perceived social norms in the TPB are believed to determine intention directly. PBC and intention are believed to determine behavior.

The joint determination of intention is quite straightforward: the basic idea is that when individuals form intentions, they take into account their attitude towards that behavior, the social norms prevailing concerning the behavior and their PBC. An individual will not form an intention to do something, unless he thinks there is some chance of converting this intention into behavior given the behavioral control. Thus, one could formulate three alternative models; one in which there could be only a direct effect of intention and PBC on behavior; a second one containing only an interaction between intention \times PBC; finally, a model with the two additive effects and the interaction effect (see equation (1) in section 6).

The interaction effect may be understood in two ways: a psychological and a non-psychological. Behavior we may believe that an individual will increase his intention to perform a behavior when his PBC is higher. Indeed, an individual will be more motivated and try to perform a behavior harder than another individual with the same intention but with more perceived limitations on the behavioral performance. Ajzen (1991) calls this the interaction hypothesis of intention \times PBC on behavior (see figure 2)¹⁴.

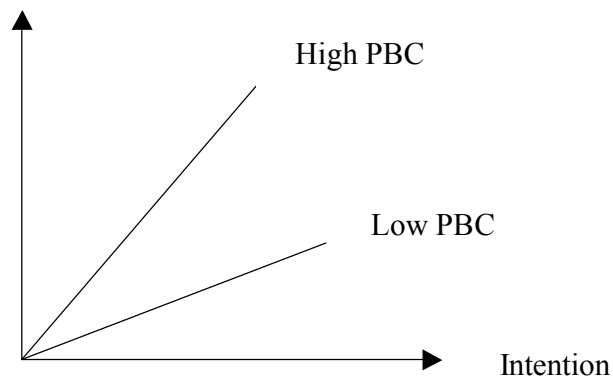


Figure 2: A description of the interaction between PBC and Intention

¹⁴ In future research, one should investigate whether this postulated interaction effect holds for both dimensions of PBC, perceived control and self-efficacy, which were described in Ajzen, 2002.

The second explanation for the role played by PBC in jointly determining behavior is less psychological in nature. In this sense, an individual with an intention will fail to perform the behavior, if his *actual* behavioral controls are lower. Here we are not speaking about a higher or a lower motivation to perform a behavior, but rather on the ability to perform it. When the ability to perform the behavior is lower simply because of lower control on the behavior, the intention to perform it will be indeed lower.

A review of twelve studies (Ajzen, 1991) confirms the hypothesis of Ajzen that in the case of behaviors, which are not under total volitional control, PBC supported a good prediction of intention and behavior. However, the empirical findings concerning the “interaction-hypothesis” of intention and behavioral control on behavior are inconsistent. Ajzen reports the findings of seven studies, which test this hypothesis. Of these studies, only one (Schifter & Ajzen, 1985) obtains a marginally significant interaction between intention and PBC. In the following section, we report an extended meta-analysis of studies, which explored empirically the interaction term $PBC \times Intention$ in the theory of planned behavior.

3. Meta-analysis of studies exploring whether there is a significant interaction term between PBC and Intention in the TPB

When deciding to include a meta-analysis in our report, we were confronted with the question of which kind of meta-analysis to include. One can think of at least two alternative sorts of meta-analyses. The first is to report a summary of methodological studies, which tried to develop techniques or test interaction effects in general (e.g. Hoogland & Boomsma, 1998). In recent years, many researchers have developed methods of estimation, and some even compared the strengths and weaknesses of different techniques. We mentioned some of them in our introduction. Such a meta-analysis would be beyond the scope of this paper. Another alternative, which is more substantive in nature, would be to include only studies, which tried to test the interaction term between PBC and Intention in the theory of planned behavior. In this paper, we are going to extend a report of Armitage and Conner (2001), which concentrated in the meta-

analysis on substantive results of the interaction effects of the TPB. We would relate to the results from a methodological point of view in order to learn about the state of the art of the study of this interaction.

Such a meta-analysis necessarily depends on the state of the art of the existing methods to test such an interaction. Jöreskog (1998) points out, that if the interaction variable is latent, the factor scores approach or the two stage least squares (TSLS) method are probably the most reasonable to use. A full information approach according to Jöreskog should be used only if one has a very large sample and one is capable of understanding how to specify the nonlinear constraints implied by the model. At that point in time (1998), this was the recommendation. However, as methods to test interaction effects rapidly develop, could it be that reasonable methods to test it might as well change? For instance, as mentioned before, Klein, Moosbrugger, Schermelleh-Engel, and Frank (1997) and Moosbrugger, Schermelleh-Engel, and Klein (1997) developed a new approach (LMS) for estimating interaction effects. According to their work, their method is better for small samples than all other methods. However, a systematic comparison of their approach with the other approaches just mentioned by using Monté Carlo simulations is missing.

Concerning the role of measurement error in a meta-analysis, Hunter and Schmidt (1990) suggest on p. 539 that: "It is our belief that many real methodological problems are captured by the rubrics "errors of measurement" and "range variations". Error of measurement in particular is universal, although some studies may have much poorer measurements than others". Thus, one of the main differences between Armitage and Conner's (2001) meta-analysis and ours is that we try to control for studies, which applied corrections for attenuation. As Scherpenzeel and Saris (1997) and Saris (2001) demonstrated, different sorts of control for measurement errors influence the results. This must be taken into account in a meta-analysis. However, we cannot do it because we have no information about the measurement errors in those studies.

Armitage and Conner (2001) located several studies that tested the intention \times PBC hypothesis. We base on their analysis and extend it. In table 1, one can find a summary of the results of this meta-analysis.

Table 1: Meta analyses of the interactive effect of intention and PBC on behavior (partly from an unpublished table of Armitage and Conner, 2001)*:

Study Num.	Study	N	Intention \times PBC ¹⁵	Estimation method used
1	Beck and Ajzen (1991)	34 (additional 46 in control group)	n.s.	Ordinary Least Squares (OLS)
2	De Vellis, Blalock, and Sandler (1990)	70	n.s.	OLS
3	Doll and Ajzen (1992)	75	n.s.	OLS
4	Dzewaltowski, Noble, and Shaw (1990)	254	n.s.	OLS
5	East (1993)	One study-75, Another study-145	n.s.	OLS
6	Kimiecik (1992)	332	b=0.24	OLS
7	Morojele and Stephenson (1994)	1 st sample-87, 2 nd -61 (sub sample)	n.s. in 1 st sample, beta=-0.72 in 2 nd .	OLS
8	Prislin and Kovrlija (1992)	53	Beta= 0.593	OLS
9	Schifter and Ajzen (1985)	83	b= 0.2	OLS
10	Terry and O'llery (1995)	146	**	SEM-ML
11	Theodorakis (1994)	395 (females only)	n.s.	OLS
12	White, Terry, and Hogg (1994)	211	Beta=0.17 (in one test), n.s. in another.	OLS
13	Yang-Wallentin, Schmidt, and Bamberg (2001)	1,115	***	Multi-group analysis in SEM (ML); WLS; TSLS.
14	Reinecke, Schmidt, and Ajzen (1996)	1,500	****	Multi-group anal. in SEM (ML).

¹⁵ Studies involving regression analyses have been done for the full TPB model. Some analyses report the beta coefficient, some the b coefficient, some the gamma coefficient (between the interaction term and behavior). More details are given for the significant interaction terms.

*Where a coefficient b or beta are reported, they were found significant in that study at least at the 5% level; n.s.- not significant;

significance is in the 5% level or higher

In some studies the b coefficient was reported whereas in others the beta.

** In a multi-group analysis estimates for the path linking intention to actual behavior were considerably higher (beta=0.65) in the high PBC group than in the low one (beta=0.18).

*** In a multi-group analysis some estimates for the path linking intention to behavior were considerably different in the high PBC group compared to the low one in different estimation methods. The path (b) for bus, bike and car was .093, 1.5 and .24 in the high PBC group compared to .25, .9 and .24 in the low one, respectively with WLS estimation (for car the difference was n.s.). With TSLS estimation, the **unstandardized** interaction term on behavior was -.076, -.061 and .015 for bus, bike and car respectively (for car n.s.). With ML estimation, the **unstandardized** interaction term on behavior was -.089, -.157 and -.001 for bus, bike and car respectively (for car n.s.).

**** In a multi-group analysis estimates for the path linking PBC to behavior were considerably higher in the high intention group (beta=.29) than in the lower one (-.33). Additionally, estimates for the path linking intention to actual behavior were considerably higher (0.55) in the high PBC group than in the low one (beta=0.18).

Indeed, the estimation techniques presented in table 1 differ substantially. One of the most frequent arguments against meta-analyses is that they mix apples and oranges (Hunter & Schmidt, 1990). That is, meta-analyses combine studies that are so different that they are not comparable (see also Lipsey & Wilson, 2001). In our case, we compare tests results of the same interaction effect in the same model. However, samples range in size, data collection techniques differ, and variables differ. Moreover, the estimation technique changes from study to study, and it is often recognized as inappropriate. As mentioned, according to Hoogland and Boomsma (1998), measurement errors should be taken into account. Therefore, according to this recommendation and to Jöreskog (1998) structural equation modeling is the preferred method for the estimation of the interaction

effect. Also Hunter and Schmidt (1990) present in detail the need for corrections for attenuation. Nevertheless, according to Hunter and Schmidt (1990), eliminating from a meta-analysis studies that are perceived as having methodological inadequacies is not a desirable practice. They contend that methodological inadequacies do not necessarily produce biased results. Therefore, we include all studies in our comparison.

However, we report the results in the voting method (details about this and other methods of meta-analyzing are presented in Hunter & Schmidt, 1990). This method counts the number of studies, which belong to one of the categories: (1) significant and positive effect; (2) significant and negative effect; (3) not significant. We have four main reasons for this: (1) Many of the samples are not random samples; (2) most studies do not control for random and nonrandom measurement errors (see Hunter & Schmidt, 1990, p.102 for correcting the variance for sampling error); (3) estimation methods used are not always the optimal ones and often apply ordinary least squares (OLS) regression analyses; (4) the content of the constructs differs. This might lead to opposite signs of the interaction effects, and thus to the impossibility of computing means of correlation coefficients. What makes our job easier is the fact that there is a relatively small number of studies to meta-analyze.

As one can see, eight of the studies found no significant interaction effect between PBC and intention in some or in all of their tests. They applied OLS techniques to test the interaction hypothesis. Eight studies found in some or in all of their tests significant interaction effects (two of them found a non-significant interaction in one test). Three of them used different estimation methods with structural equation modeling. These studies exclude our analysis, which is following this section. The interaction term in these studies ranged between -0.72 and 0.25 . Seven studies found a positive interaction effect, and two of them found also a negative one. In addition, one study found only a negative interaction effect. A possible reason for finding a negative interaction effect in contrast to the theory is multicollinearity. In the study relating to travel mode choice (Yang-Wallentin, Schmidt, & Bamberg, 2001), part of the interactions between PBC and intention (for bike and for bus use) were negative and significant. A negative sign of the

interaction might be affected by the content of the constructs as well. Thus, not controlling for estimation method, we conclude that about half of the studies found no interaction effect between intention and PBC in the theory of planned behavior. In three of them, the interaction effect was found to be negative. However, when taking into consideration only studies, which correct for attenuation, all three studies show a significant interaction effect. Two of them indicate positive and negative interaction effects, and the third only a positive one (our following analysis finds a positive interaction effect, too, and controls for measurement errors). A positive interaction effect would demonstrate that an increasing PBC intensifies the effect of intention on behavior.

According to Armitage and Conner (2001), Ajzen (1991, p.188) suggests, that failure to find an effect may be attributable to the fact that linear models provide good accounts of psychological data even when interaction effects are known to be present. Additionally, if PBC is unrelated to actual control, the extent to which PBC would moderate the relation between intention and behavior is unclear. Another reason, is that especially in regression models, computation of product terms may have led to severe multicollinearity, which leads to insignificant results and changes in the coefficient signs. Finally, according to Ajzen, strong interactions are likely only if the measures of PBC and Intention both cover the full range of the response scales. Restriction of range to either the positive or negative side of the scale will tend to attenuate observed interaction effects. In the following sections, we would report a test of the interaction effect between intention and PBC on data of travel mode choice with three different techniques, latent variable scores (LVS), maximum likelihood (ML) and robust ML (RML).

4. Propositions

As a result of the scope of our task and the methodological orientation of the paper, we do not test all propositions of the theory of planned behavior. This includes all the interactions of the beliefs and the interaction between intention and PBC. Such an inclusive simultaneous analysis has never been done (for a test only of belief products, see Yang-Jonsson, 1997 and Reinecke, 2002). We concentrate on the effects of intention and PBC on behavior, especially if there is any interaction between the effects of these

two constructs on behavior. The analyzed behavior is the percentage of public transport use in Frankfurt during one day reported by our participants. This percentage is computed from the total of car and public transport use (thus, behavior constitutes a continuous variable).

Travel mode choice is an interesting behavior, due to the fact that the impact of intention and PBC is expected to be different on behavior when different travel modes are used. The main difference between public transport and the car is that public transportation is in principal provided to the total population, and its availability depends on its quality, frequency, location of bus or train stops and destination. These are objective characteristics of the behavioral control of using public transport. On the other hand, a car is a private means of transportation, which is not available to everyone in Germany. Whereas the main obstacle of using the car is its availability, the main obstacle of using the public transport is its quality of service.

From the Theory of Planned Behavior we can derive the following propositions concerning the effects of intention and PBC on behavior:

Propositions:

1) We expect to find a positive effect of PBC on behavior.

2) We expect to find a positive effect of intention on behavior.

Concerning the interaction between intention and PBC, we expect the following:

3) We expect to find a positive and significant interaction effect between PBC and Intention on behavior.

In figure 3 we illustrate the propositions we are testing (see the results section).

5. Study design and measurement

Sample

The data were collected as the first wave of a panel study, which should evaluate travel mode choice in Frankfurt¹⁶. 5,000 randomly selected inhabitants of the city of Frankfurt received a questionnaire by mail at the end of September 2001. A reminder was posted on the 12th of October 2001. In November 2001 there was an additional reminder. 1,334 of the questionnaires were sent back by the 17th of January 2002 (and another 4 by April 2002) (a response rate of 26.7%). The analysis is based on responses of 1,328 inhabitants, who had reported at least one trip on the selected day using the car, public transport or a bike. 47% were men, and the average age was 44.3 years (with a standard deviation of 15.7). After eliminating the missing values (list-wise) in the analyzed variables, the actual sample size reduced to 912.

Measurements

In the study, all constructs of the theory of planned behavior were measured. However, these constructs do not refer to using public transport, car, bike or walking. Rather, these constructs refer to the motivation of individuals to change from using the car to using public transport. Nevertheless, we believe these constructs serve us well, because our reference group is the group of individuals using either a car or public transport. Persons using other means of transportation are not included in our analyses.

The following description includes measurement instruments for the constructs used in the analysis.

Perceived Behavioral Control (PBC)¹⁷ -direct measures:

- It would be possible-impossible for me to use public transport rather than the car for everyday purposes here in Frankfurt in the next weeks (**x1**).

¹⁶ Supported by the DFG (German Science Foundation), project number SCHM658/7-1.

¹⁷ Following the differentiation of Ajzen (2002) between perceived control and self-efficacy, according to our interpretation, our items correspond to the self-efficacy definition.

- I am sure that I can use public transport rather than the car for everyday purposes here in Frankfurt in the next weeks. Sure-not sure (**x2**).

The response range was a five-step bipolar scale from 5 (possible, true) to 1 (impossible, false)¹⁸.

Intention (Int) -direct measures:

- My intention to use public transport rather than the car for everyday purposes here in Frankfurt in the next weeks is big-small (**x3**).
- How probable is it, that I use public transport rather than the car for everyday purposes here in Frankfurt in the next weeks? Probable-improbable (**x4**).
- I intend to use public transport rather than the car for everyday purposes here in Frankfurt in the next weeks (probable-improbable) (**x5**).

The response range was a five-step bipolar scale from 5 (big, probable) to 1 (small, improbable).

Behavior (Be)- one direct measure:

The actual behavior, which was travel mode choice, was measured by the use of a standardized protocol of all routes a person had traveled on one day in a chronological order (Spiegel-Documentation, 1993). From these travels we compute the percentage of public transport use from the total use of public transport and car on the reported day to all reported destinations (**pt%**).

¹⁸ This is only partly in line with Allison's (1977) suggestion, that both components of the interaction must have a ratio scale. Whereas all the values of the indicators of PBC and Intention are positive, the lowest value of each of them is 1 and not zero.

Table 2¹⁹: Means, Standard Deviations and Correlations for the Observed Variables

	x1	x2	x3	x4	x5	pt%
x1	1.000	.738**	.660**	.711**	.659**	.407**
x2		1.000	.767**	.808**	.785**	.479**
x3			1.000	.852**	.828**	.525**
x4				1.000	.869**	.520**
x5					1.000	.557**
pt%						1.000
Means	3.8	3.51	3.24	3.36	3.19	.2671
Std. Dev.	1.37	1.54	1.58	1.59	1.58	.4128

** p<0.01 (two tail).

As one can see in Table 2, the three intention indicators are highly correlated with one another and with the behavioral variables. The two PBC indicators are highly correlated with one another, with the three intention indicators as well as with the behavioral variables. Since all the variables are interval, we do not get into the discussion on the problems that come out in the analysis of interaction effects when some of the variables are not interval (see Van den Putte and Hoogstraten, 1997). In the next section we proceed with the analysis.

6. Data Analysis

In this section, we analyze the data set from the described study of travel mode choice in Frankfurt. We start with defining the variables in the analysis denoting:

$$\eta_1 = Be$$

$$\xi_1 = PBC$$

$$\xi_2 = Int$$

The estimated structural model with the interaction is:

$$Be = a + \gamma_1 PBC + g_2 Int + g_3 IntPBC + V, \quad (1)$$

¹⁹ We checked for correlations also for the subgroup of people who use public transport in a lower frequency than “always” (which was the highest frequency for public transportation use in the questionnaire), and received the same pattern of correlations. The factor loadings with a value of 1.000 are fixed values to set the scales for the latent constructs.

Equation (1) contains in addition to the direct effects of *Int* and *PBC* on *Be* (behavior) an interaction effect of *Int* and *PBC* on *Be* (*IntPBC*). γ_1 , γ_2 , and γ_3 are the corresponding regression coefficients, and V , is the error term of *Be*. In Figure 3, the error terms are noted as e1-e12.

There are three indicators x_3 , x_4 and x_5 for *Int*, two indicators x_1 and x_2 for *PBC*, and one indicator for *Be* (pt%), thus *Be* is measured by a continuous observed variable. The indicators for the product latent variable *IntPBC* are formulated by using cross products of three observed Intention items, x_3 , x_4 and x_5 and the two PBC items, x_1 and x_2 . There are six possible choices and all of them have been used as indicators of *IntPbc*, as presented in Figure 3²⁰, x_1x_3 , x_1x_4 , x_1x_5 , x_2x_3 , x_2x_4 , and x_2x_5 .

According to Ping (1998), the number of product indicators can become large. Specifying many product variables might lead to problems in execution times, convergence and to problems in the solutions. However, for the sake of content validity it could be argued that it is needed to use all product variables when it is not clear which products can be dropped. As this was our case, we used all of them. In the case of specifying and testing the interactions in the Kenny-Judd model, the selection can be done in a theory-driven way (see Reinecke, 2002). In the following sub-sections, we will describe our three estimation methods for the interaction effect, and the results for each.

²⁰ The notation in Figure 3 is an AMOS 4.0 notation (Arbuckle, 1999).

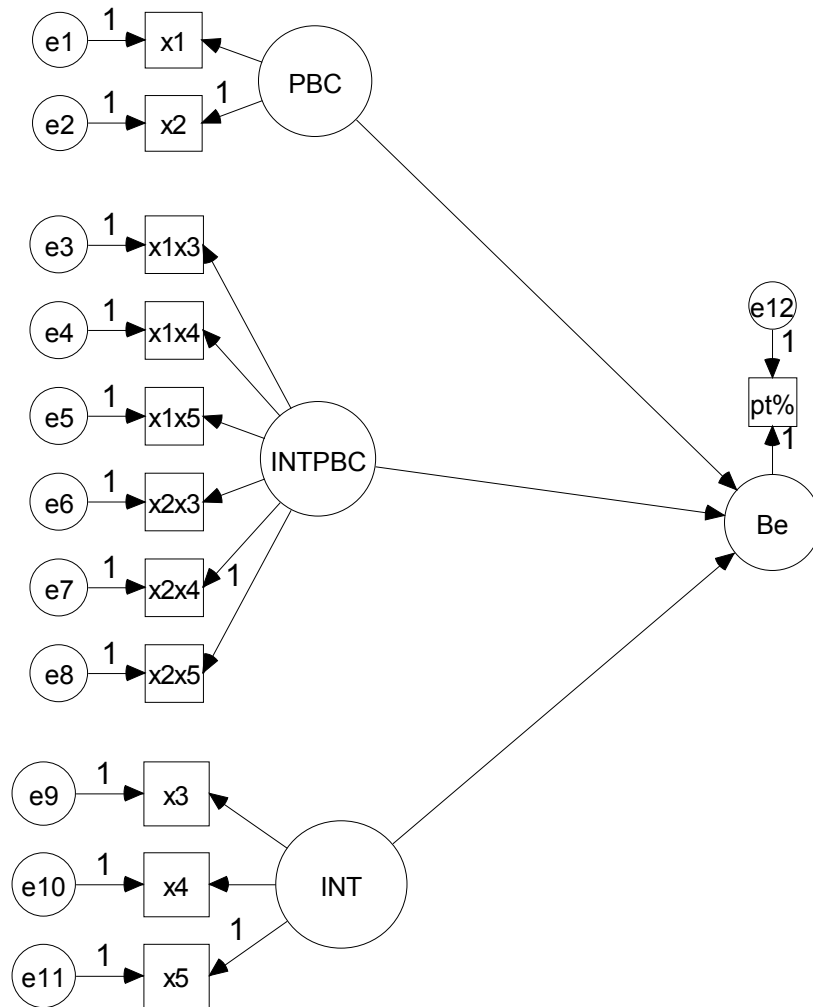


Figure 3: Path diagram of the model with six product variables

6.1 Testing the measurement model

To begin with we test the measurement model by specifying a confirmatory factor analysis model with three correlated factors.

The model is fitted by WLS. The estimates of the factor loadings and the measurement error variances are shown in Table 3.

Table 3: Parameter Estimates for Measurement Model

Measure	Be	PBC	Int	Error variance
Pt%	1.00	-	-	-
X1	-	1.00	-	0.80
X2	-	1.31	-	0.34
X3	-	-	1.00	0.48
X4	-	-	1.07	0.22
X5	-	-	1.03	0.35

6.2 Estimating the interaction effect by means of latent variable scores (LVS).

The latent variable scores are computed by an extension of a formula given by Anderson and Rubin (1956). These scores are unbiased estimates of the latent variables and their sample covariance matrix is equal to the estimated covariance matrix of the reference variable scores. Estimating the interaction effect by means of latent variable scores is new and simple (Jöreskog 2000; Jöreskog, Sörbom, Toit, & Toit, 2000, pp. 171-178). It is a two-step procedure, and the command files are presented in the body of the text and not in the appendix, since this method has not been tested before.

In the first step, one estimates the scores of the latent variables so that the scores satisfy the same relationships as the latent variables themselves. In this step, we first convert the RAW data file to a PSF (PRELIS SYSTEM FILE) running the following PRELIS file of commands:

```

Computing PSF file from rawdata
DA NI = 6
LA
BEHAV1 INT1 INT2 INT3 PBC1 PBC2
RA = LIMIT1.RAW
CO ALL
OU MA = CM RA = LIMIT1.PSF

```

These commands will also produce a DSF file (Data System File). To obtain the latent variables scores for Be, PBC and Int one uses the DSF and the following SIMPLIS file of commands:

```

Computing Latent Variable Scores
System file from file PSF1.dsf
Latent Variables Behav Int Pbc
Relationships:
INT1 = 1 * Int
INT2 - INT3 = Int
PBC1 = 1 * Pbc
PBC2 = Pbc
PSFfile LIMIT1.PSF
End of Problem

```

The latent scores for Be, PBC and Int will be listed in the LIMIT1.PSF.

In the second step one estimates the interaction effect using the latent variable scores obtained in the first step. Using LISREL 8.30 or a later version (Jöreskog, Sörbom, Toit, & Toit, 2000) and the following PRELIS input file this is easily done.

```

Estimating the Nonlinear Equation

```

```

SY=LIMIT1.PSF
NE IntPbc = Int * Pbc
CO ALL
RG BEHAV1 ON Int Pbc IntPbc
OU

```

As earlier mentioned, the latent variable scores method is new and no evaluations of it have been documented. A systematic study of this method is a task for future research. The results of our travel mode choice data are shown in Table 4.

Table 4: Estimates of γ with LVS

	γ_1	γ_2	γ_3
Estimate	0.075	0.113	0.069
Standard error	0.025	0.020	0.009
T-values	2.972	5.712	7.342

In table 4 one can see that the interaction effect between PBC and intention on Behavior is significant as well as the additive effects of Intention and PBC. The effect of PBC seems to be the weakest (in terms of significance). The effects of intention and of the interaction seem to be much stronger, and the interaction effect has the most significant impact on behavior.

6.3 Maximum Likelihood Method (ML)

ML is a full information method. It was proposed by Jöreskog and Yang (1996) and investigated by Yang-Jonsson (1997). In a full information method one simultaneously fits the moment matrix implied by the model to the corresponding sample moment matrix by minimizing a fit function with respect to all parameters (see Yang-Wallentin, Schmidt, & Bamberg, 2001). In principal, full information methods provide the best parameter estimates and standard errors. However, ML is based on the assumption that the observed variables have a multinormal distribution. This assumption does not hold because of the use of product variables. According to Yang-Jonsson (1997), ML performs often well for

sample sizes over 400, but it computes asymptotic standard errors and Chi-squares incorrectly. In section 6.3, we use the robust maximum likelihood method (RML) to correct the standard errors and the Chi-square. The implementation of ML is shown in Appendix B. The results are shown in Table 5.

Table 5. Estimates of γ with ML

	γ_1	γ_2	γ_3
Estimates	0.11	0.08	0.07
Standard errors	0.06	0.04	0.01
T-values	1.88	1.76	8.15
df = 68		$\chi^2 = 775.83$ (p=0.00)	

As can be seen in Table 5, the interaction is evidenced significantly with a t-value of 8.15. However, the other two direct effects on Be, that of *PBC* (γ_1) and that of *Int* (γ_2) are not significant at the 5% significance level. Furthermore, the fit of the model is very poor. However, according to low modification indices, this is the best model we can get.

6.4 Robust Maximum Likelihood Method (RML)

As stated earlier, ML gives incorrect standard errors and Chi-squares because of the violation of the assumption of multi-normality. To solve this problem we consider a hybrid procedure, robust maximum likelihood (RML), where we apply a ML procedure to estimate the parameters and the asymptotic covariance matrix to obtain the correct standard errors and chi-square values (for a technical explanation of the procedure see Appendix C).

Table 6 reports ML estimates with corrected standard errors and a corrected Chi-square.

Table 6. RML Estimates of γ

	γ_1	γ_2	γ_3
Estimates	0.11	0.08	0.07
Standard errors	4.63	1.54	0.93
T-values	0.02	0.05	0.08
df = 68		$\chi^2 = 328.3$ (p=0.00)	

After the correction none of the three γ s is significant. However, the Chi-square decreased quite considerably, but the model fit remained poor. Also here, low modification indices we got imply this is the best model we can get. As the results come out different from ML, one may wonder why. The explanation that we can give is that the method involved asymptotic covariance matrix that is computed from the fourth order moment for single indicators and eighth order moment for the product indicators. To get this asymptotic covariance properly estimated one really needs a very large sample size, which we don't have. It does not mean that one should not trust the results, it only shows this method is technically very difficult.

7. Conclusion

In this paper, we tested the interaction effect between Intention and PBC in the theory of planned behavior with different methods. Reviewing research on this topic in a meta-analysis, we found out that about half of the studies (8 out of 14) that tested the interaction, indicated *no significant effect*. However, those papers used OLS techniques to test it. We do not trust regression results, because they assume that there are no random and non-random measurement errors. Jaccard and Wan (1995) pointed out why structural equation modeling, which controls for measurement errors, is preferred. Three studies in the meta-analysis applied more advanced techniques based on structural equation modeling (SEM), such as a multi-group analysis or ML. All of them found a positive interaction effect (according to what the theory postulates) and two of them found evidence also for a negative interaction. As stated in the paper, one possible reason for receiving a negative interaction effect could be due to multicollinearity. Another reason could be the content and measurement mode of the constructs' items. Our own study found in two of the three estimation methods applied a positive interaction effect.

The question is whether one should consider in a meta-analysis all studies, or only those applying appropriate estimation techniques, which control for measurement errors using structural equation modeling. As Lipsey and Wilson (2001) discuss it on page 16:

“The major exceptions are findings generated by multivariate analysis, e.g., multiple regression... factor analysis, structural equation modeling and the like. Meta analysts

have not yet developed effect size statistics that adequately represent this form of research findings and, indeed, their complexity as well as diversity across studies with regard to the selection of variables involved may make this impossible". Even if one takes into the meta-analysis only studies using estimation methods which control for measurement errors, different studies may report a variety of correlations: between indicators, indices or factors. Moreover, different estimation methods may be used, such as a multi-group analysis, ML, RML, TSLS, WLS, LVS and so on. Results may not be robust over studies, and different methods may produce different results with the same data as we evidenced here.

One may conclude, that conducting a meta-analysis is an impossible mission. We believe, that all studies should be taken into account in such a report. However, one should also report the estimation methods used. One way to overcome the problem of mixed estimation methods in the future might be to recalculate the results of the studies in the meta-analysis using the same method over all the data sets.

In this study we chose LVS, ML and RML to test the interaction. We reported in the introduction our main reasons for choosing these methods for the test. The fit measures of the RML and the ML estimation methods were poor. However, as we only wanted to test the interaction model, we did not try to improve them. The results are summarized in table 7:

Table 7: summary of results:

	Additive effects		Interaction effects
	PBC γ_1	Intention γ_2	Int*PBC γ_3
LVS	0.075*	0.11*	0.069*
ML	0.11	0.08	0.07*
RML	0.11	0.08	0.07

* $P < 0.05$.

1. The LVS estimation evidenced a significant interaction between intention and PBC on behavior and significant additive terms. This is a simple method. It can be used to get a preliminary sign of an interaction effect. Since it is a two-step method, there is no overall model fit available. Although this method does not require multi-normality for the

observed variables, it does require more indicators for the latent variables. Put differently, the more indicators a latent variable has, the better the estimated score will be. Evaluation of this method is needed.

2. The ML estimation indicated an interaction effect between intention and PBC in predicting travel mode choice. However, the standard errors and Chi-squares were in principle incorrect because of the use of product variables.

3. RML was used to correct the standard errors and the Chi-square. It showed neither an evidence of a significant interaction nor significant additive effects. This method does give corrected standard errors and Chi-squares, but it requires considerably large samples. However, such samples are not always available, especially in Psychology.

From the results of the meta-analysis and from our own study we noticed that the different methods might lead to different results. Researchers may wonder which method to apply. From the simplicity point of view, we would suggest you to use multi-group analysis, (see Yang-Jonsson 1997, 1998; McArdle, 2000; Yang-Wallentin, Schmidt, & Bamberg, (2001). If the interaction variable is latent, the latent variable scores (LVS) approach or the two-stage least squares (TSLS) approach are probably the most reasonable (see Jöreskog, 1998 and Yang-Wallentin, 2001). All these three approaches have no special requirement for the distribution of variables, they are easy to implement, and they can clearly indicate whether there is an interaction or not. The disadvantage is that none of these approaches provides a model fit. In the case of a multi-group analysis, we also do not get any coefficient for the interaction effect.

The full information methods do provide a parameter estimate for the interaction and an overall model fit. However, in practice they are difficult to apply due to the complicated non-linear constraints that must be specified and the necessity to have large samples and to use an asymptotic covariance matrix. The multi-normality of observed variables is required in order to apply a ML estimation method, but most non-linear models do not fulfill it. As a result of the violation of normality, the standard errors and χ^2 are wrongly

estimated. However, according to Yang-Jonsson (1997), ML often performs well in medium and large sample sizes.

For small samples, TSLS, LVS and Klein and Moosbrugger's method (2000) are better. As LVS is very new, simulation studies that compare these methods are still missing. For large samples, RML and WLS are preferred, but further simulation studies are needed to compare them.

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Acknowledgements

The authors would like to thank Icek Ajzen for helpful suggestions and comments. We would also like to thank Karren McKernan for improving the style of the paper.

Appendix A

The measurement model is estimated by WLS. If one wants to choose an ML method instead, the asymptotic covariance matrix is not needed then.

Test Measurement Model

Observed Variables:

PBC1 PBC2 INT1 INT2 INT3 BEHAV

Sample size: 913

Latent Variables:

Pbc Int Behav

Covariance matrix from file measure.cm

Means from file measure.me

Asymptotic covariance matrix from file measure.acc

Relationships:

PBC1 = 1 * Pbc

PBC2 = Pbc

INT1 = 1 * Int

INT2 - INT3 = Int

Behav = Int Pbc

BEHAV = 1 * Behav

Set error variance for BEHAV to zero

PATH DIAGRAM

End of problem

Appendix B

When ML is used one does not need to read AC (Asymptotic covariance matrix). To run RML the exclamation mark in front of AC must be taken away.

```

Fitting Traffic Model to Mean Vector and Covariance Matrix by ML
DA NI=12 NO=912
LA
BEHAV PBC1 PBC2 INT1 INT2 INT3 PBCINT11 PBCINT12 PBCINT13
PBCINT21 PBCINT22 PBCINT23
CM=LIMITNEW.CM
ME=LIMITNEW.ME
!AC=LIMITNEW.ACC
SE
2 3 4 5 6 7 8 9 10 11 12 1
MO NX=12 NK=3 TD=SY TX=FR KA=FR
LE
Behav
LK
Pbc Int IntPbc
FR LX(2,1) LX(4,2) LX(5,2) LX(12,1) LX(12,2) LX(12,3) PH(1,1) -
PH(2,2)
FI PH(3,1) PH(3,2)
VA 1 LX(1,1) LX(3,2) LX(6,3)
FI KA(1) KA(2)
CO LX(6,1)=TX(3)
CO LX(6,2)=TX(1)
CO LX(7,1)=TX(4)
CO LX(7,2)=TX(1)*LX(4,2)
CO LX(7,3)=LX(4,2)
CO LX(8,1)=TX(5)
CO LX(8,2)=TX(1)*LX(5,2)
CO LX(8,3)=LX(5,2)
CO LX(9,1)=TX(3)*LX(2,1)

```

```

CO LX(9,2)=TX(2)
CO LX(9,3)=LX(2,1)
CO LX(10,1)=TX(4)*LX(2,1)
CO LX(10,2)=TX(2)*LX(4,2)
CO LX(10,3)=LX(2,1)*LX(4,2)
CO LX(11,1)=TX(5)*LX(2,1)
CO LX(11,2)=TX(2)*LX(5,2)
CO LX(11,3)=LX(2,1)*LX(5,2)
CO PH(3,3)=PH(1,1)*PH(2,2)+PH(2,1)**2
CO TD(6,1)=TX(3)*TD(1,1)
CO TD(6,3)=TX(1)*TD(3,3)
CO TD(6,6)=TX(1)**2*TD(3,3)+TX(3)**2*TD(1,1)+PH(1,1)*TD(3,3)+C
    PH(2,2)*TD(1,1)+TD(1,1)*TD(3,3)
CO TD(7,1)=TX(4)*TD(1,1)
CO TD(7,4)=TX(1)*TD(4,4)
CO TD(7,6)=TX(3)*TX(4)*TD(1,1)+LX(4,2)*PH(2,2)*TD(1,1)
CO TD(7,7)=TX(1)**2*TD(4,4)+TX(4)**2*TD(1,1)+C
    PH(1,1)*TD(4,4)+LX(4,2)**2*PH(2,2)*TD(1,1)+TD(1,1)*TD(4,4)
CO TD(8,1)=TX(5)*TD(1,1)
CO TD(8,5)=TX(1)*TD(5,5)
CO TD(8,6)=TX(3)*TX(5)*TD(1,1)+LX(5,2)*PH(2,2)*TD(1,1)
CO TD(8,7)=TX(4)*TX(5)*TD(1,1)+LX(4,2)*LX(5,2)*PH(2,2)*TD(1,1)
CO TD(8,8)=TX(1)**2*TD(5,5)+TX(5)**2*TD(1,1)+PH(1,1)*TD(5,5)+C
    LX(5,2)**2*PH(2,2)*TD(1,1)+TD(1,1)*TD(5,5)
CO TD(9,2)=TX(3)*TD(2,2)
CO TD(9,3)=TX(2)*TD(3,3)
CO TD(9,6)=TX(1)*TX(2)*TD(3,3)+LX(2,1)*PH(1,1)*TD(3,3)
CO TD(9,9)=TX(2)**2*TD(3,3)+TX(3)**2*TD(2,2)+C
    LX(2,1)**2*PH(1,1)*TD(3,3)+C
    PH(2,2)*TD(2,2)+TD(2,2)*TD(3,3)
CO TD(10,2)=TX(4)*TD(2,2)
CO TD(10,4)=TX(2)*TD(4,4)
CO TD(10,7)=TX(1)*TX(2)*TD(4,4)+LX(2,1)*PH(1,1)*TD(4,4)
CO TD(10,9)=TX(3)*TX(4)*TD(2,2)+LX(4,2)*PH(2,2)*TD(2,2)
CO TD(10,10)=TX(2)**2*TD(4,4)+TX(4)**2*TD(2,2)+C

```

$LX(2,1) ** 2 * PH(1,1) * TD(4,4) + C$
 $LX(4,2) ** 2 * PH(2,2) * TD(2,2) + TD(2,2) * TD(4,4)$
CO TD(11,2)=TX(5) * TD(2,2)
CO TD(11,5)=TX(2) * TD(5,5)
CO TD(11,8)=TX(1) * TX(2) * TD(5,5) + LX(2,1) * PH(1,1) * TD(5,5)
CO TD(11,9)=TX(3) * TX(5) * TD(2,2) + LX(5,2) * PH(2,2) * TD(2,2)
CO TD(11,10)=TX(4) * TX(5) * TD(2,2) + LX(4,2) * LX(5,2) * PH(2,2) * TD(2,2)
CO TD(11,11)=TX(2) ** 2 * TD(5,5) + TX(5) ** 2 * TD(2,2) + C
 $LX(2,1) ** 2 * PH(1,1) * TD(5,5) + C$
 $LX(5,2) ** 2 * PH(2,2) * TD(2,2) + TD(2,2) * TD(5,5)$
CO TX(6)=TX(1) * TX(3)
CO TX(7)=TX(1) * TX(4)
CO TX(8)=TX(1) * TX(5)
CO TX(9)=TX(2) * TX(3)
CO TX(10)=TX(2) * TX(4)
CO TX(11)=TX(2) * TX(5)
OU ME=ML AD=OFF MI SC

The paper is in press as a chapter in *Recent Developments in Structural Equation Modeling: Theory and Application* edited by K. van Montfort, H. Oud, and A. Satorra. The Netherlands: Kluwer Academic Publishers.

**Modeling Longitudinal Data of an Intervention Study on Travel Mode Choice:
Combining Latent Growth Curves and Autoregressive Models²¹**

Abstract

The following paper investigates whether there is any effect of a soft policy intervention on people moving to live in Stuttgart on their travel mode choice. The analysis is done by comparing two approaches to analyze longitudinal data: latent growth curve modeling (LC) and autoregressive modeling (AR). We apply Structural equation modeling (SEM) with real data in three measurement time-points. The intervention shows no direct effect on travel mode choice according to both models, but applying a multi-group analysis reveals an interaction effect between the initial intention to use public transport and the intervention. Finally the hybrid model suggested by Curran and Bollen is applied to the data. The difference between the approaches is discussed.

Key words: Structural Equation Modeling; latent growth curve modeling; autoregressive modeling; a hybrid model; longitudinal data; multi-group analysis.

1. Introduction

Travel mode choice has been investigated in the last decade by many researchers, (e.g. Diekmann, 1994; Franzen, 1997; Bamberg, & Schmidt 1998, 2003; Davidov, Schmidt, & Bamberg, 2003). What is common to these studies is that they all tried to find a behavioral explanation to clarify why people choose different means of transportation on

²¹ A joint work with Peter Schmidt and Sebastian Bamberg.

their way to work or to a variety of other destinations. In general, these studies differ in various aspects, methodological and substantial.

The substantial differences relate to the theory applied, to the variables used and to whether or not an intervention to change behavior took place. Some studies are not theoretically oriented (i.e. are not driven by a well established theory (for example Franzen, 1997), whereas others apply a well-known theory, especially the theory of planned behavior (TPB) (Ajzen, 1985, 1988, 1991) to explain travel mode choice (for example Bamberg, & Schmidt, 1998, 2003). Some studies collected data without trying to intervene in society and change behavior (ISSP, Umwelt Survey, for a codebook see for example Diekmann, Gautschi, Franzen, & Preisendörfer, 1996), whereas others took the initiative to actively intervene and change the environment, thus trying in this way to actively change behavior (Bamberg, & Schmidt, 2000). Some consider only objective restrictions such as monetary costs and comfort on the decision which travel-mode to use (for example Franzen, 1997; Diekmann, & Preisendörfer, 1998). Others do not restrict constraints on behavior only to monetary ones, and take into consideration also subjective restrictions as well as social norms and attitudes towards the different means of transportation (for example Bamberg, & Schmidt, 1998).

The methodological differences relate especially to the estimation methods used and to the type of data. Some studies consider a direct linear effect of various factors on behavior, applying OLS estimation methods or a logit/probit regression analysis (for example Franzen, 1997; Davidov, Schmidt, & Bamberg, 2003). Other studies apply structural equation modeling. Some studies test models with cross-sectional data, whereas others use panel data (Bamberg, & Schmidt, 1998).

So far, only a small fraction of studies in the field applied longitudinal data on travel mode choice. None of them has applied growth curve modeling. The modeling method most often applied was autoregressive modeling (AR) (for example, Bamberg, & Schmidt, 1998). Moreover, the effectiveness of prevention or intervention programs has traditionally been assessed using time-specific comparisons of mean levels between the

treatment and the control groups. However, many times the behavior targeted by the intervention is naturally developing over time, and the goal of the treatment is to change this natural developmental process. Curran and Muthén (1999) suggest, that growth curve modeling is most suitable to evaluate the efficacy of an intervention program, as they provide more information on the developmental process than other methods, which are designed to estimate models for longitudinal data.

In their concluding remarks, Curran and Bollen (2002, p. 130) provide a few valuable proposals for extensions of the cross-lagged latent curve model (LC):

- 1) One could regress the latent growth factors onto exogenous explanatory variables in order to better understand individual changes over time;
- 2) One could use the strength of the SEM framework applying multi-group analysis for the analysis of interaction effects;
- 3) Instead of using univariate latent scores, one could apply several indicators to measure latent factors;
- 4) In order to better understand the relation between different constructs over time, one could use potentially mediating constructs to account for observed effects.

The following study reports an intervention study to change travel mode choice of people moving to live in Stuttgart. In our intervention we test whether subjective changes in the environment such as providing information about the different possibilities of using public transportation in Stuttgart have any effect on travel mode choice in comparison to a control group. Thus, we apply data of an intervention study on the two modeling alternatives, AR and LC, and additionally on the hybrid model suggested by Curran and Bollen (2002). We are going to proceed in the following way. First, we will give a summary of the commonly used methods for the analysis of change: autoregressive models and latent growth models; then describe our data set and sample; and in the next step estimate the data using both approaches and the hybrid model. Additionally, we will pursue two of the extensions of the cross-lagged latent curve model:

- a) We will regress our variable which changes over time on an exogenous explanatory variable, that is the intervention dummy (topic 1 from above);

- b) conduct a multi-group analysis to test for interaction effects. We will be especially interested to investigate, whether there is any difference over time between the group with a high intention to perform the behavior and the group with a lower one (topic 2 from above)
- c) combine the hybrid model with a multi-group analysis.

Finally, we will try to identify the conditions under which each modeling strategy (AR or LC) provides useful information, to better understand the pros and cons underlying them with a real world data set. We will conclude, that since both models are rather complementary than competitive, it is useful to apply the hybrid model.

2. Theory on Longitudinal Data Analysis

There have been several techniques developed to conceptualize and statistically analyze data over time. One of the earliest techniques was to compute the change in means of individual or group variables measured over time. As Curran and Muthén (1999) argue, this technique does not allow evaluating the developmental process, or how rapidly the change takes place over time, but rather concentrates on the particular time points. As we are more interested in the changing process, we will not use this method here.

Two methods have received most of the attention in the literature: latent curve models (LC) and autoregressive models (AR). Researchers have tried to identify the main differences between the two approaches (for example, Bast, & Reitsma, 1997; Curran, 2000; Garst, 2000; Kenny, & Campbell, 1989; Little, Schnabel, & Baumert, 2000; Marsh, 1993; Rogosa, & Willett, 1985; and Urban, 2002). This research tended to accept one approach and reject the other, rather than to combine both of them. Curran and Bollen (2002) claim, that autoregressive and growth curve models are each associated with advantages and disadvantages. In this paper we will systematize these differences, test their suggested hybrid model, and combine it with a multi-group analysis.

2.1 THE AUTOREGRESSIVE MODEL (AR)

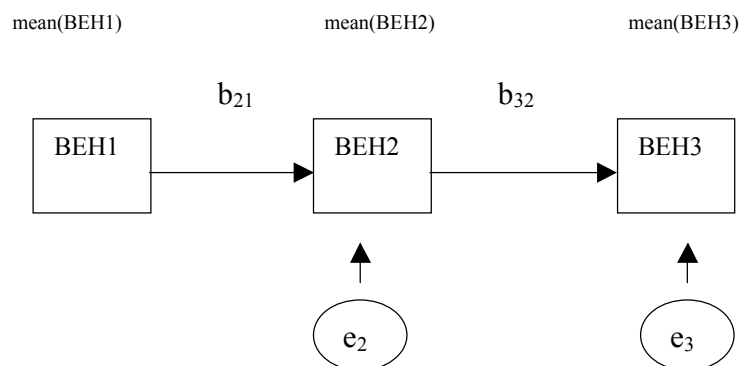
The autoregressive model, which is also called the longitudinal markov simplex model, is one of the most important approaches developed to analyze panel data. It dates back to Guttman (1954), who suggested explaining a set of time ordered observations by computing correlations between the measures. This approach was further developed by Anderson (1960), Humphreys (1960), Heise (1969), Jöreskog (1970, 1979), and also by Browne (1992), and McCloy, Campbell and Cudeck (1994). A key characteristic of the simplex model is that when longitudinal data is applied, measures at later time points have a lower correlation with earlier measures as an increasing function of the time difference. Change in a measure is a function of the effect of the previous measure added to a random error. For example, according to Figure 1,

$$(1) \text{BEH}_2 = b_{21}\text{BEH}_1 + e_2$$

$$(2) \text{BEH}_3 = b_{32}\text{BEH}_2 + e_3$$

Where the first indicator of the coefficient b points to the dependent variable's time point (2 in equation 1, 3 in equation 2) and the second to the independent variable (1 in equation 1 and 2 in equation 2).

Figure 1. Univariate Autoregressive Model:



The autoregressive model can be directly extended to include more than one variable over time. Additionally, one could test whether the errors (for example e_2 and e_3 in Figure 1) correlate. One can also test and compare the means of behavior at each time point ($\text{mean}(\text{BEH1})$, $\text{mean}(\text{BEH2})$ and $\text{mean}(\text{BEH3})$). There has been considerable attention on the development of this literature (for example, Campbell, 1963; Bohmstedt, 1969; Duncan, 1969; Heise, 1969; Jöreskog, 1979). One possible extension proposed by Curran and Bollen (2002) with an illustrative example is to include another cross lagged variable, which predicts the other variable in the following time point above and beyond the prediction of that variable by its previous measure. Another possible extension, which takes advantage of structural equation modeling techniques is to apply multiple indicators for the variables measured over time, to control for random and non-random measurement errors (Jöreskog 1970 and 1979; Jagodzinski, Kühnel, & Schmidt, 1987).

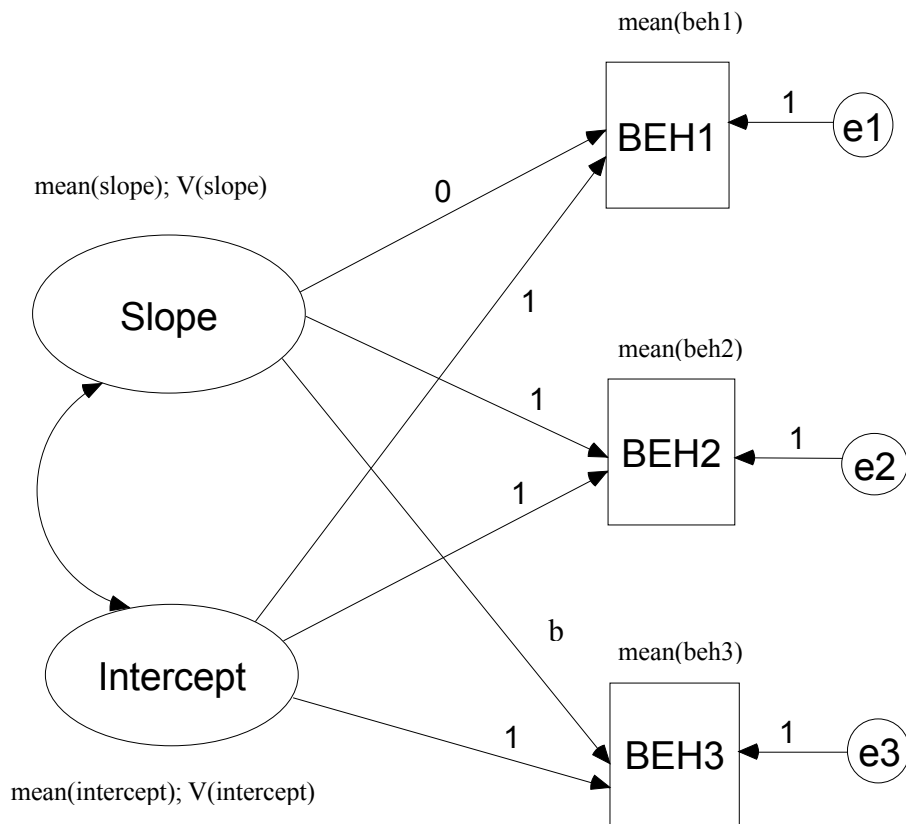
2.2 LATENT CURVE MODELS (LC)

LC models are quite different from AR models. For a more detailed overview, see Browne and Du Toit (1991), McArdle (1986, 1988, 1989, 1991), McArdle and Epstein (1987), Meredith and Tisak (1984, 1990), Muthén (1991,1994), Muthén and Curran (1997), and Willett and Sayer (1994). In autoregressive models, change over time is considered only by dependence on the previous period plus a disturbance term. As a result, feedback relations between two time points can also be tested. However, cross-lagged effects are the same for each individual. In this way, one cannot learn about individual differences in the process of change. Contrary to autoregressive models, in latent growth curve models, the process of change of each individual is taken into account in order to form an estimated single underlying trajectory for each person over time. When one has several individuals in the data, one can compute the average trajectory of the sample, that is the average starting point (intercept) as well as the average slope of change (see Figure 2). In many cases, the coefficient between the intercept latent variable and the observations is 1, corresponding to a common starting

point. One can fix a coefficient of zero between the latent slope variable and the first observation, a coefficient of 1 with the second observation, and estimate the coefficient with the third observation freely (b in Figure 2). In this way, contrary to AR models, one can test whether the change process is linear, quadratic etc. Using structural Equation modeling, one can estimate the latent intercept coefficients, the latent slope coefficients and the covariance between the latent variables (Bentler, 1980, 1983; Jöreskog, 1971a, 1971b; Jöreskog, & Sörbom, 1978). As outlined by Curran and Bollen (2002), in the SEM framework, the model relates the latent slope and the latent intercept to the observed variables over time. Standard SEM softwares (such as Amos, LISREL, EQS or Mplus) can estimate the models, including the means of the latent variables.

The means of the intercept latent variable and the slope latent variable ($\text{mean}(\text{intercept})$ and $\text{mean}(\text{slope})$ in Figure 2) represent the group parameter values of the initial group value of behavior and the slope of the developmental trajectory (i.e. the growth rate). The variances of the initial status and growth rate factors ($V(\text{slope})$ and $V(\text{intercept})$ in Figure 2) represent the individual variability of each subject around the group parameter. The variance in these growth factors can be modeled as a function of other variables. An example may be an intervention dummy variable, representing whether an individual was exposed to an intervention which was aimed at changing his observed behavior or not. Additionally, one can estimate the means of behavior in the different time points ($\text{mean}(\text{beh1})$, $\text{mean}(\text{beh2})$ and $\text{mean}(\text{beh3})$ in Figure 2). In this way, the relations across constructs are typically evaluated at the level of the growth trajectories, not at the level of the repeated measures over time (see also Duncan, Duncan, Strycker, Li, & Alpert, 1999 for a review on LC models).

Figure 2. Univariate latent curve model.



Appendix A summarizes the main differences between AR models and LC models just discussed. We add the practical aspect of the corresponding test parameter. For a comparison between AR and differential equation models see Reinecke, Schmidt and Weick, 2001. In the next section, we present the empirical setting of our travel mode choice study.

3. Empirical Setting

The marketing department of the public transportation company in Stuttgart (Germany) was interested in motivating people moving to Stuttgart, to use public transport instead of a private car. In order to achieve this behavioral target, they developed an intervention called “personal information package”, which was composed of the following components:

- 1) An official welcome and a short description of the company;
- 2) A one-day ticket for public transportation use free of charge;
- 3) A map of the subject’s quarter of residence including all available public transport lines and adjacent stations;
- 4) A timetable;
- 5) A brochure with explanations how to reach shopping and cultural centers;
- 6) Information about travel costs and ticket sale offices;
- 7) A “hotline” telephone number.

We evaluated the effect of the intervention on behavior. We tested subject’s behavior before the move (and the intervention), as well as in two time points after their move to Stuttgart. Because of the various transportation problems towns struggle with, the social and ecological importance of travel mode choice is self-obvious.

This intervention was conducted in 2001. Subjects had not lived before the intervention in Stuttgart, but planned to move to Stuttgart, and actually moved after the intervention. Mobilizing subjects was done by systematically approaching people, who published an advertisement looking for an apartment in Stuttgart in the weekend newspaper. Their

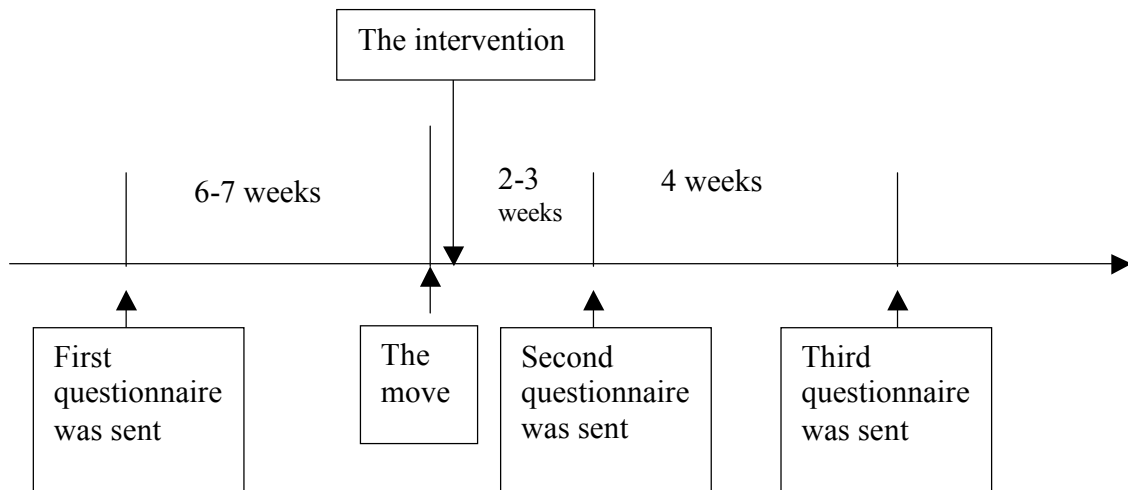
published phone numbers and email addresses were used to contact them. If they were ready to participate (the incentive was a lottery of a monetary prize), they received the first questionnaire where they were asked to answer questions regarding the investigated variables. Subjects were contacted 8-10 weeks later with the second questionnaire, namely 2-3 weeks after their move. About 4 weeks later a third questionnaire was sent, with fewer questions, relating mostly to their travel mode choice. Figure 3 describes the design of the experiment. The intervention took place shortly after the move to Stuttgart. Subjects had no idea that the marketing department of the public transport company in Stuttgart was actually cooperating with us.

So far, there have not been many experimental field studies to test SEM models. The few of them included cross sectional data. Here we have an opportunity to apply the AR and LC models on a data set of a field study, where the issue of causality can be better established (see Shadish, Cook, & Campbell, 2002).

In order to reduce selection bias as much as possible, the questionnaires were constructed as independent of the intervention. The questionnaires were delivered with the title “Decisions in moving to a new place and travel habits”. However, the real aim of the study, which was evaluating the effects of the “soft policy intervention”, was hidden. Separately, the public transport company in Stuttgart conducted the intervention itself. In that way, participants were unaware of the fact that they were taking part in an experiment.

Subjects were assigned randomly to an experimental and to a control group. Only people in the experimental group received the information package. Moreover, only people actually moving to Stuttgart participated in the study.

Figure 3. The development of the experiment before and after the move to Stuttgart



600 people received the first questionnaire by mail. 241 filled it in and sent it back. The average age was 28.5, almost 47% were women, about 81% had 12 years of schooling or more, about 95% owned a driving license, approximately 73% had an available car, and 88% had at least one car in the household. About 20% of the respondents were unemployed and lived in a household where the income was less than 1,000 Euros per month.

169 (70%) of the 241 respondents actually moved to Stuttgart and filled in the second questionnaire (out of which 90 were from the control group and 79 from the experimental group). 81 of them took part in the third questionnaire (out of which 46 were in the control group and 35 in the experimental group). Two logit analyses were conducted (where filling in the second and the third questionnaires were the dependent variables, receiving a value of 1 in case of filling it in and 0 otherwise). We wanted to test whether the 169 people who have participated in the second questionnaire and the 81 subjects who participated in the third questionnaire were systematically different from the others who

took part only in the first wave. However, none of the demographic characteristics (such as gender, marital status, age etc.) had any statistically significant effect on the dependent variable.

For our models we use three groups of variables:

1) *Behavior - travel mode choice*: it was derived from a protocol filled in by the subjects about all the travels conducted on that day and the means of transportation used. From this protocol two behavioral variables were created:

Ba- which received the value of 1 if a subject used public transportation on his second reported way on that day, and zero otherwise (ba1, ba2 ba3 for the first, second and third waves respectively). The behavioral variable of the second reported day is of interest, because the question items relate to the second way on the reported day as well. On the importance of the correspondence between the behavioral variable and the other items, see Ajzen, & Fishbein, 1977. However, using a dichotomous dependent variable in Amos should be avoided because of the assumption of multivariate normality of observations.

Therefore, we apply in our analyses only the second behavioral variable, Bb;

Bb- was the public transport use during the whole reported day expressed in percentages (bb1, bb2 bb3 for the first, second and third waves respectively).

We collected data on this variable in three waves: before the intervention, after the move to Stuttgart and the intervention, and once again a few weeks later. It should be noted that bb is a continuous variable. However, it is not normally distributed, and most of the non-missing cases in each time point receive the value of zero (151 out of 240 for bb1, 92 out of 169 for bb2, and 55 out of 81 for bb3).

2) *Intention (to conduct the behavior)* was measured by the following two items: (I1) How big or rather small is your intention, to use next time public transportation? (I11, and I12 for the first and second waves respectively) (I2) How strong or rather weak is your intention to use next time public transportation? (I21 and I22 for the first and second waves respectively).

The above items were measured on a scale of zero to ten, depending on the number of points given by the respondents to each alternative.

We collected data on this variable in the first two waves.

3) *Intervention* is a dummy variable, which receives the value of 1 in case the subject belongs to the experimental group, and zero otherwise.

4.Results

4.1 DESCRIPTIVE ANALYSIS

The correlations, variances (on the diagonal) and mean vectors for all variables and for all the participants are presented in Table 1. The correlation matrix was computed in SPSS using pairwise deletion of missing data. The maximal number of cases is 238 and the minimal number is 74. As can be seen in the table, the number of cases for each behavioral measure decreases with the wave number. Intention items within each wave correlate very highly and significantly with each other, but lower with intention items of other waves. The intervention variable correlates only with the behavioral variable of the second wave of the first measure (ba) (but not with bb). It is also interesting to note, that whereas the means of the variables ba and bb increase in the second wave and decrease in the third wave, the expected mean of bb in the third wave is lower than its initial level. This pattern was also observed separately for the experimental group (which we do not show in the table, as in the following models control and experimental group are treated by the variable intervention, which serves as an exogenous variable). In spite of the different behavioral pattern reflected in the variables ba and bb, we will conduct analyses as we have just mentioned only for the behavioral measure bb to test for the implications of the intervention.

Table 1: Correlations, variances (on the diagonal) and mean vectors for data on travel mode choice of people moving to live in Stuttgart (both groups).

	1)bb1	2)bb2	3)bb3	4)I11	5)I21	6)I12	7)I22	8)Inv ^a	9)ba1	10)ba2	11)ba3
1)bb1	.273										
2)bb2	.163*	.288									
3)bb3	.172	.316**	.249								
4)I11	.059	.051	-.037	3.56							
5)I21	.064	.071	-.061	.944**	3.54						
6)I12	.09	.067	.122	.251**	.216**	3.94					
7)I22	.112	.08	.180	.183*	.153	.919**	3.96				
8)Inv ^a	-.074	-.002	-.011	.211**	.178*	-.006	-.026	.500			
9)ba1	.106	.140	-.109	.228**	.183*	.763**	.749**	.013	.398		
10)ba2	.101	.076	-.039	.788**	.796**	.218**	.212**	.231**	.393**	.481	
11)ba3	.09	-.02	-.06	.024	.078	.247*	.292*	.036	.199	.272**	.462
Mean	.178	.220	.148	2.56	2.55	3.9	3.99	.48	.2	.36	.30
N	240	169	81	234	232	168	168	238	234	165	76

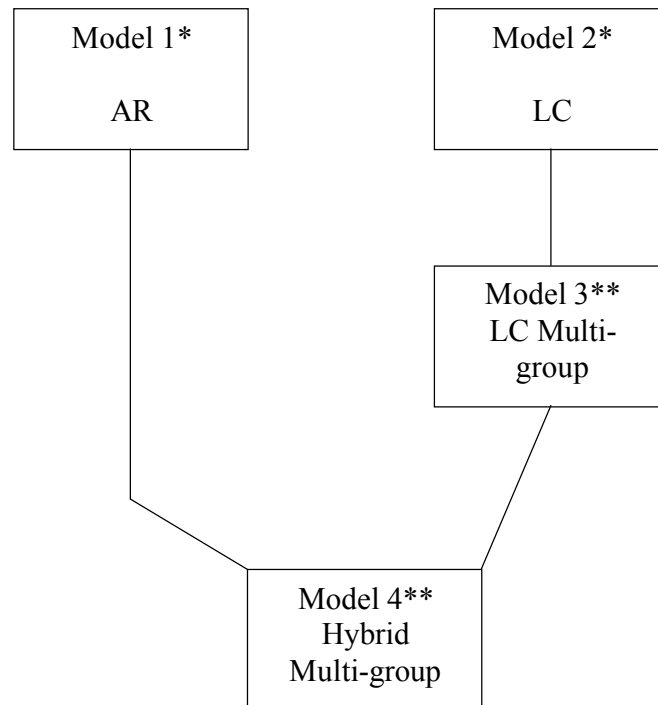
^a Inv=Intervention

* $p < .05$ ** $p < .01$

4.2 TESTING THE MODELS

In the following sections we will proceed in the following way. We will start with a test of the AR model followed by a test of the LC model. In the next step we will conduct a multi-group analysis of the LC model. Finally, we will test the hybrid model. Whereas the first AR and LC models are non-nested, the LC and the hybrid models with the multi-group analysis are. Figure 4 presents the sequence of the model testing and their relations.

Figure 4. Sequence of model testing.



*** = non-nested models; ** = nested models.**

4.2.1. The autoregressive model of travel mode choice (with bb) (all reported results of coefficients from now on are standardized)

We now present the results for the univariate simplex model with three repeated measures of bb. One of the extensions suggested by Curran and Bollen (2002) was that instead of using univariate latent scores, one could apply several indicators to measure latent factors. We could not use ba and bb as two indicators to measure the latent variable “behavior”, because as one can see in Table 1, the correlations between ba and bb are low and insignificant. At this point we face the problem how to model an intervention effect. There are two possible alternatives:

-either to use a dummy variable of intervention, which affects behavior directly at the second time-point (a mimic model);
-or to apply a multi-group analysis. Multi-group analysis has the advantage of providing a test for interaction effects.

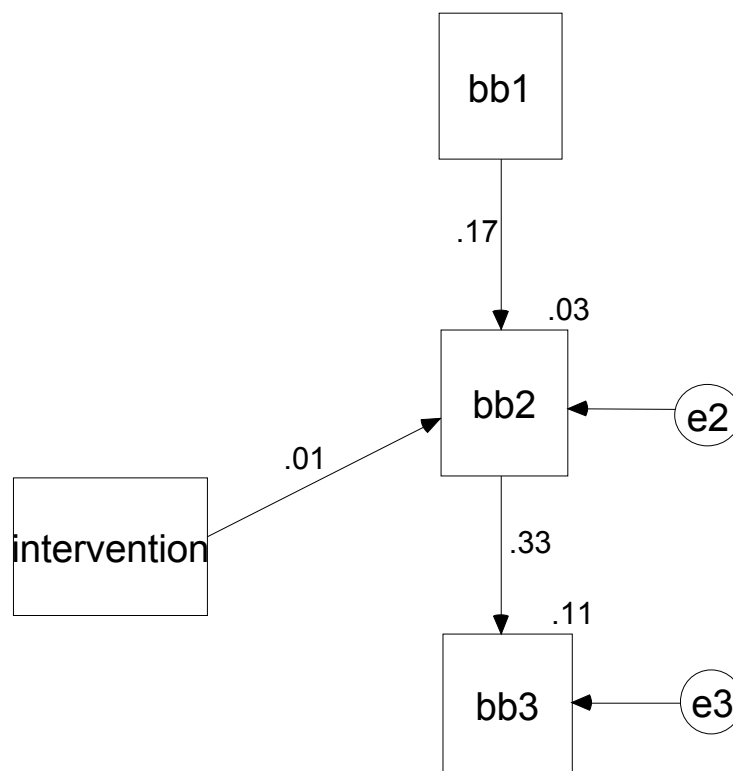
However, for an easier understanding of the AR models we decided to use a basic model with the intervention as a dummy variable. We will present a multi-group analysis with intention as an interacting variable later on. We used Amos version 4.0 to test the model (see Arbuckle, & Wothke, 1999).

Our data has missing values. The handling of missing data by FIML in Amos is an adequate estimation method when data are at least missing at random (mar), and is a good choice even when the data is to some extent non-ignorable (Arbuckle, & Wothke, 1999, p. 332-333). Therefore, we apply ML estimation with missing data to reduce distortions of the analysis.

As one can see in Figure 5, bb1 influences bb2 (stability coefficient $\beta=.17$), and bb2 influences bb3 (stability coefficient $\beta=.33$). The estimated mean of behavior 2 is .03, lower than the estimated mean of behavior 3 (.11). Additionally, the intervention has no effect on behavior 2 (.01). This model fits the data well (Chi-square=2.9; $df=3$; P-Value=0.41; RMSEA=0.000; P-close=0.638; AIC=24.9 (AIC saturated model=28.0)).

In the autoregressive model, one cannot learn much about the developmental process of behavior, and how it differs between individuals and groups. In the next step we apply the LC model on our data.

Figure 5. The simplex model with bb (standardized coefficients)



Standardized estimates
chi-square=2.887 df=3 p-value=.409
rmsea=.000 pclose=.638 aic=24.887

4.2.2. The latent curve model of travel mode choice

In many cases, behaviors that are the focus of intervention programs show a special pattern of development. Unlike the autoregressive models, growth models can track the changing process, and show a systematic development over time. LC models are meant to analyze such processes, and are able to distinguish between experimental and control groups. Moreover, many times we are interested not only in the mean difference between groups, but also in group differences in variances and covariances. Finally, discrete time-specific assessments are not consistent with the underlying principles of psychological theories of development and change. Developmental theories tend to explain change as a continuous growth process over time. Modeling time-specific comparisons cannot capture these types of relations over time.

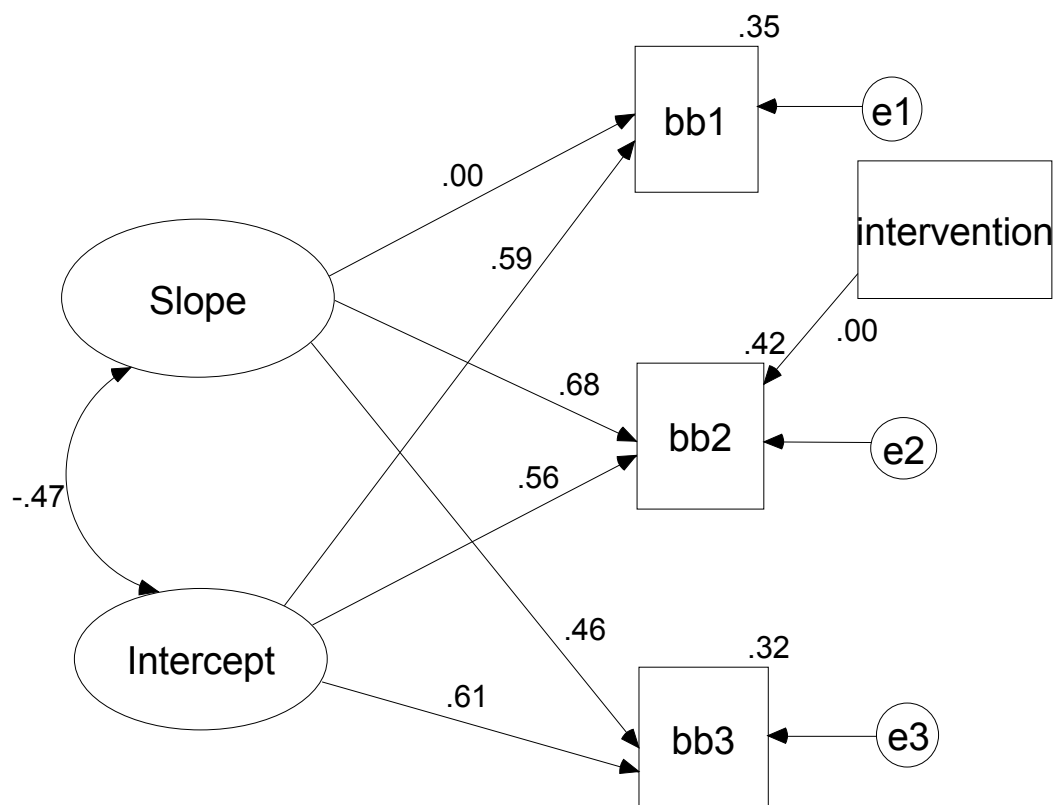
Given the limitations of the autoregressive model, we now turn to the latent curve model. We estimate the model with one intercept latent variable and one slope latent variable with the behavioral variable *bb*. One can regress the intervention variable either directly on *bb* or on the latent slope variable. We tested both options, and they yielded exactly the same coefficients and almost identical model fits. As the model fits were not exactly equal, the models cannot be regarded as equivalent. The second option needs to include an error term for the latent slope variable, and to allow a correlation between the latent intercept variable and the error term of the latent slope rather than between the latent slope and the latent intercept. Additionally, the second model is less easy to compare with the previous AR model with regard to the intervention effect. Therefore, we chose the first modeling option. Figure 6 shows the results.

The model fits the data well (chi-square=2.2; df=3; P-value=.533; RMSEA=0.000; P-close=0.736; AIC=24.2 (AIC saturated=28.0)). As one can see in Figure 6, there is no effect of the intervention on behavior 2. There is a considerable increase in the expected mean of *bb* moving from the first to the second wave, and a decrease in wave 3 beyond the initial mean (.35, .42 and .32 respectively). However, we have additional information. The coefficient from the latent slope to the behavioral variable in the second wave (.68) is

higher than the one to the third behavioral variable (.46), indicating a decrease in public transport use in the third wave. Moreover, we received a negative correlation between the latent slope and the latent intercept (-.47). This indicates, that individual differences in the initial use of public transport are negatively associated with changes over time. That is, on average, subjects with a higher initial use of public transport tended to report smaller changes (increases or decreases) in public transport use relative to participants who reported lower initial levels of public transport use.

The findings highlight the following question: how come that the intervention has no effect, whereas behavior changes so dramatically? Indeed, the intervention was especially targeted at people who did not often use public transportation. A possible explanation is that the intervention is interacting with an additional variable not specified in the model. One possible interacting variable could be intention. People with a low initial intention to use public transport may be more strongly affected by the intervention than others. Table 1 presents some high correlations between the intervention and some intention items. The negative correlation between the slope and the intercept latent variables may give us a hint that there is a negative interaction between initial willingness or intention to use public transport and change of behavior later on. To test this possibility, we will conduct in the following section a multi-group analysis.

Figure 6. The latent curve model of travel mode choice (with bb, standardized coefficients)



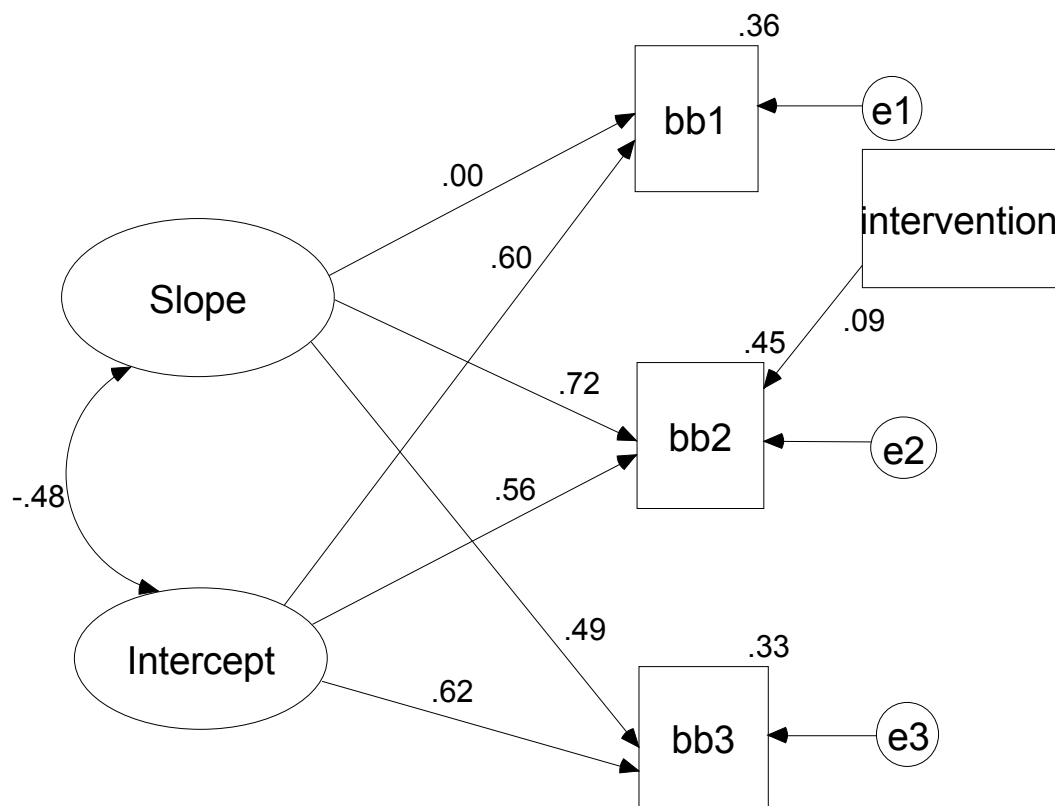
4.2.3. The latent curve model of travel mode choice with a multi-group analysis

In many cases, interventions work well for some people, but do not work for others. A multi-group analysis can allow for a comparison of intervention effects across individuals and groups to test for interaction effects. For a closer inspection of inter-individual differences, we conduct in the next step a multi-group analysis. For this purpose we divide our subjects into two groups. We have at least two alternatives to group the data: we can use the intervention variable or the intention variable. In the first case we would have a control and an experimental group, and the intention as an exogenous variable. We tried this mode, but it did not fit the data well. Such a model also makes it harder to compare the results with previous analyses in this paper. Therefore we choose the alternative option.

Subjects were divided into a group of people with a high intention to use public transport, and a group of people with a low intention to do so. The splitting point was an average of 4 or higher of both intention items in the first wave (that is, $(I11+I21)/2$). We relate only to the measures of intention in the first wave, as it would be interesting to learn how strongly the basic intentions interact with the intervention method to change behavior.

At first we followed the same procedure of an ML estimation of missing values as before. However, we received standardized regression coefficients and a correlation higher than 1. We suspect it happened because our sample size is smaller than 200 ($N=165$) and in a multi-group analysis the number of parameters to be estimated increases. Our suspicion is partly based on the results in Hoogland, & Boomsma (1998), although they do not discuss robustness issues related to ML estimation of missing values. Additionally, our observed variables are not normally distributed. As a result, the relatively small size of our sample becomes even a more critical a problem. Therefore, in the following analyses, we use the pairwise deletion, although it may bias the results, if the missing values are informative.

Figure 7a. The latent curve model with a multi group analysis for the low intention group (standardized coefficients).



Standardized estimates
 chi-square=13.199 df=8 p-value=.105
 rmsea=.054 pclose=.399 aic=53.199

As one can see in Figure 7a, where we test the model for the subjects with a low initial intention to use public transport, the coefficient between the slope and the behavior in the second wave (0.72) indicates a considerable increase in public transport use in the second wave. The higher expected mean of behavior in the second wave (0.45 compared to 0.36 in the first wave) is another indication for the increase in public transport use.

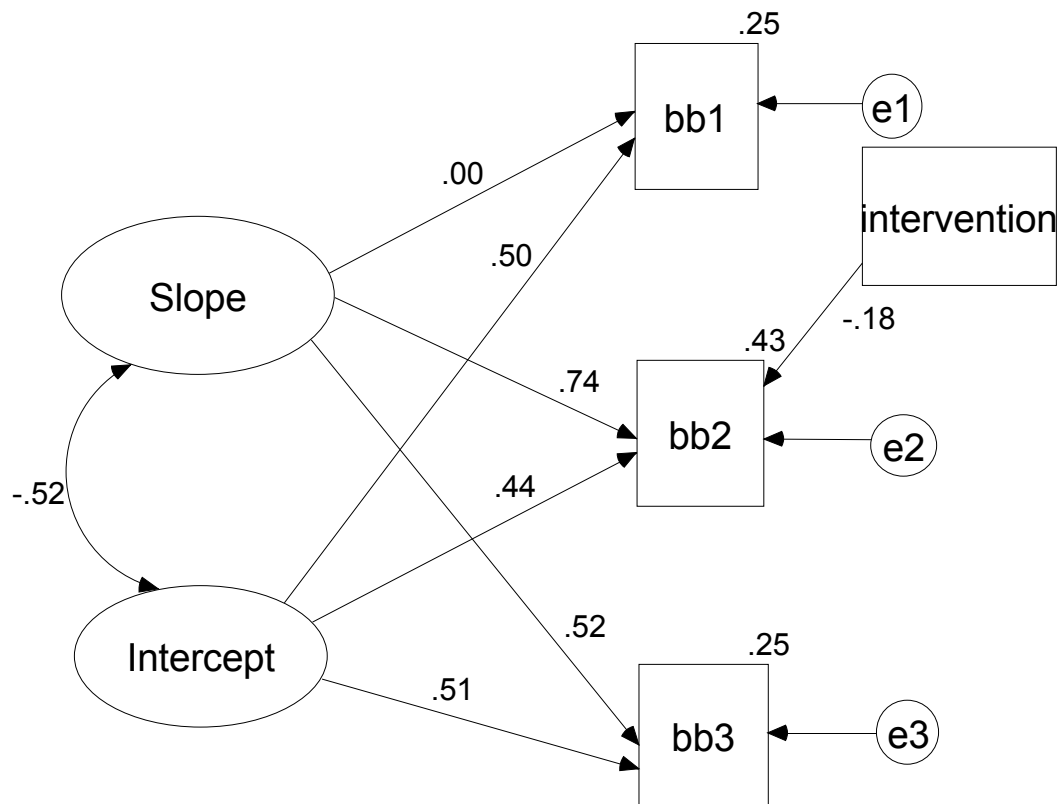
Additionally, now the intervention variable has a positive effect on bb_2 . However, the expected mean of behavior 3 (0.33) is lower than its initial expected value. Accordingly, the coefficient between the latent slope and bb_3 decreases to 0.49. The negative correlation between the latent slope and the latent intercept (-.48) suggests once again that individual differences in the initial degree of public transport use within subjects in the low-intention group are negatively associated with changes (increases or decreases) in public transport use. That is, on average, participants with a lower initial use of public transport tended to report steeper changes in behavior.

In Figure 7b, one can see the changing pattern in behavior according to the model for the subjects with a high initial intention to use public transport. The coefficient between the slope and the behavior in the second wave (0.74) indicates a considerable increase in public transport use in the second wave. The expected mean of behavior 2 (0.43 compared to 0.25 in the first wave) is another indication for the increase in public transport use. However, in this group, the intervention variable has a negative effect on bb_2 , which means that principally people in this group were negatively affected by the intervention, and did not increase their behavior due to the intervention (but probably due to other factors). This makes sense. It may well be the case, that the intervention affects intention rather than behavior directly. When one has a high intention to use public transport, then it is not possible anymore to increase his intention. Behavior may increase due to other reasons not modeled here.

The expected mean of behavior 3 (0.25) has the same expected value as in the first wave. Accordingly, the coefficient between the latent slope and bb_3 decreases to 0.52. Also here we observe a negative correlation between the latent slope and the latent intercept (-.52), which means that individual differences in the initial degree of public transport use

within subjects in the high-intention group are negatively associated with changes in public transport use.

Figure 7b. The latent curve model with a multi group analysis for the high intention group (standardized coefficients).



Standardized estimates
 chi-square=13.199 df=8 p-value=.105
 rmsea=.054 pclose=.399 aic=53.199

The model fits the data very well (Chi-square=13.2, df=8; P-value=.105; RMSEA=0.054; P-close=.399; AIC=53.2 (AIC saturated=56.0)). The findings have direct implications for our research hypotheses of interest. Namely, there seems to be a relation between intervention and behavior in the second wave. However, this relation is interacting with the initial intention. Whereas for subjects with a low initial intention to use public transport there seems to be a positive effect of the intervention on the second reported behavior, there seems to be a negative effect on the group of subjects with a high initial intention. Most importantly, on the long run the intervention in both groups has no effect, and subjects return to their old pattern of behavior in the third wave. Expected means of public transport used are either equal or lower than the initial ones in both groups. Subjects appear to be affected by the soft policy in the short run, but not in the long run.

4.2.4. The hybrid model of travel mode choice with a multi-group analysis

Curran and Bollen (2002) argue, that given the fact that the autoregressive and growth curve models are each associated with key advantages, it is logical to synthesize both approaches in a unified framework. This will allow drawing on the strengths of both approaches, and will provide us with more information than each method alone. In this section, we are going to apply the synthesized or hybrid model on our longitudinal data. In order to conduct a test of inter-individual differences we will pursue a multi-group analysis. For this purpose we divide our subjects into the same two groups.

Curran and Bollen describe the synthesized model as including two important elements.

- (a) It includes a random intercept and slope factors from the latent curve model to capture the continuous underlying growth trajectories over time.
- (b) It also incorporates the standard autoregressive simplex parameters to allow for the time specific influences between the repeated measures themselves.

Viewing the simplex and the latent growth models in such a way, they are not competing but rather complementary. Each is just a restricted variation of a more comprehensive hybrid model.

For the sake of saving space in the paper we do not provide a figure describing the general hybrid model, but proceed directly to the estimation of our longitudinal data. In Figures 8a (for the low intention group) and 8b (for the high intention group) one can see not only the results for our estimation, but also the structure of the hybrid model in detail.

As one can see in Figure 8a, where we test the model for subjects with a low initial intention to use public transport, the coefficient between the slope and the behavior in the second wave (0.88) indicates a considerable increase in public transport use in the second wave. The increase in the expected mean of behavior 2 (0.46 compared to 0.42 in the first wave) is another indication for the increase in public transport use. Additionally, now the intervention variable has a positive effect on bb_2 (0.10). However, the expected mean of behavior 3 (0.36) is even lower than its initial expected value. The coefficient between the latent slope and bb_3 decreases to 0.56. We observe a negative correlation between the latent slope and the latent intercept (-.67).

Additionally, as one can see in Figure 8a, bb_1 influences bb_2 (stability coefficient $\beta = .11$), and bb_2 influences bb_3 (stability coefficient $\beta = .12$). This is actually the additional information we get from the hybrid model when we compare it to the latent growth model with a multi-group analysis described earlier.

In Figure 8b, one can see the changing pattern of behavior for subjects with a high initial intention to use public transport. The coefficient between the slope and the behavior in the second wave (0.94) indicates a considerable increase in public transport use in the second wave. The expected mean of behavior 2 (0.56) is considerably higher than that of behavior 1 (0.35). However, in this group, the intervention variable has a negative effect on bb_2 (-0.16), which means that principally people in this group were negatively

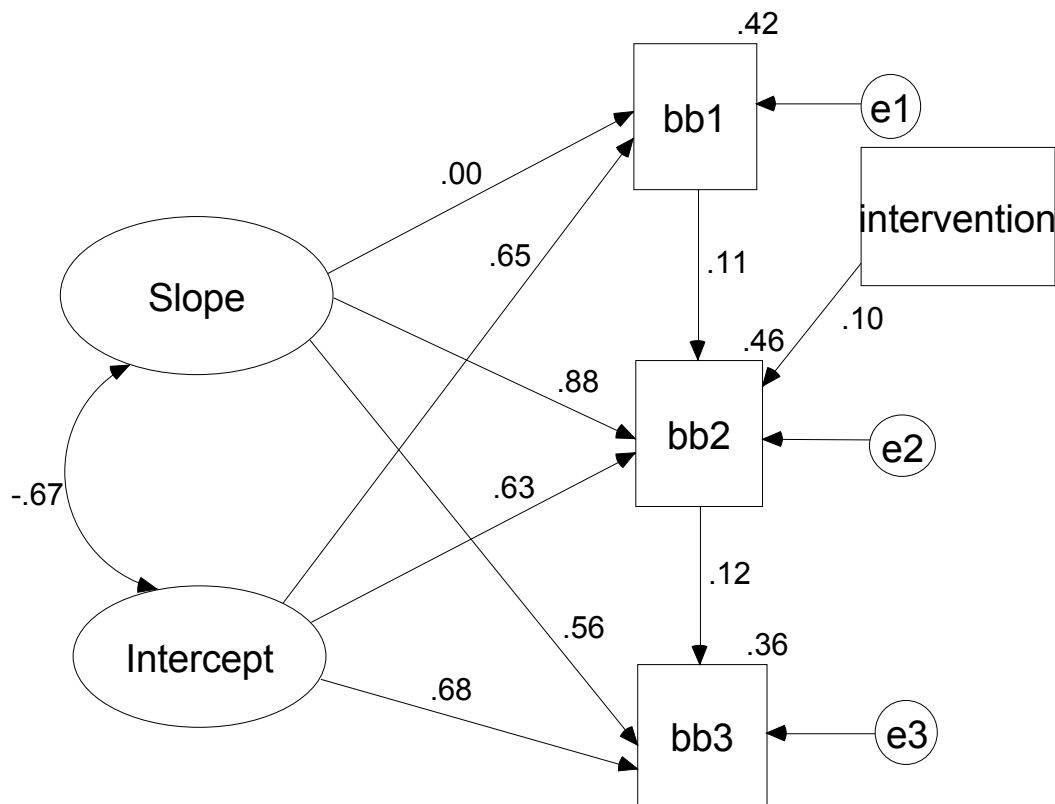
affected by the intervention, and did not increase their behavior due to the intervention (but probably due to other factors).

The expected mean of behavior 3 (0.20) is lower than in the first wave. Accordingly, the coefficient between the latent slope and bb3 decreases to 0.74. Also here we observe a negative correlation between the latent slope and the latent intercept (-.65).

bb1 influences bb2 with a higher effect than for the low intention group (stability coefficient $\beta = .21$ compared with .11). bb2 influences bb3 negatively in the high intention group (stability coefficient $\beta = -.27$) in comparison to .12 (no effect change over time) in the low intention group.

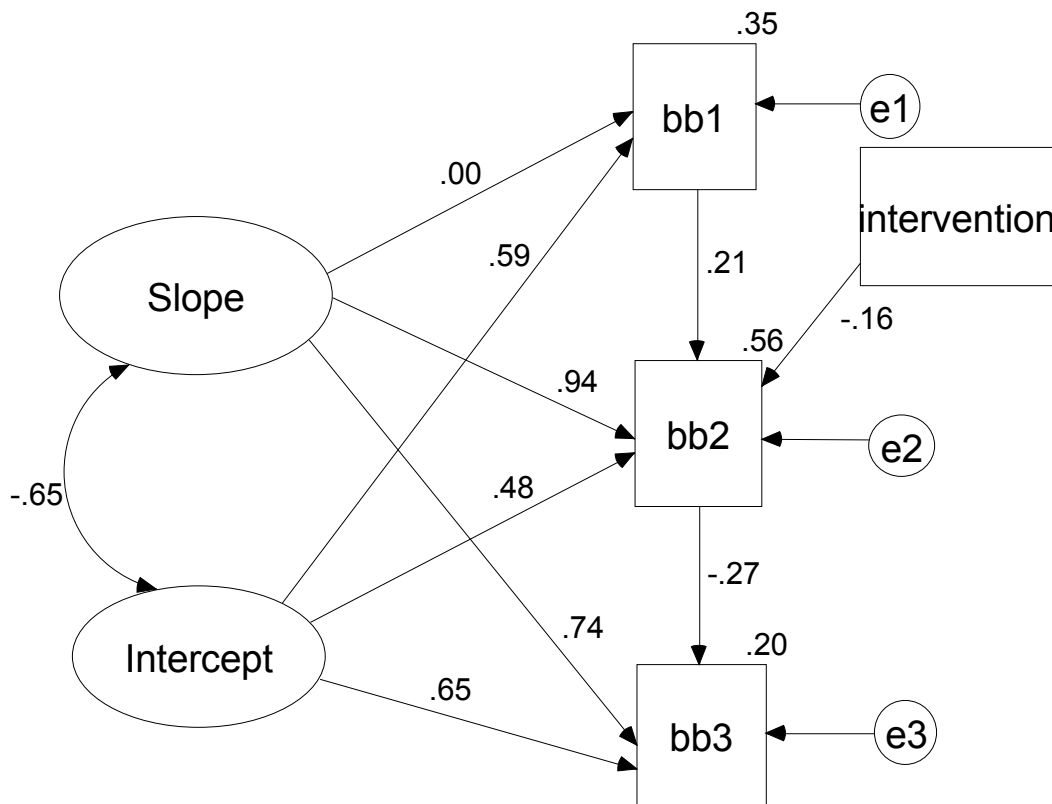
The model fits very well the data (Chi-square=4.8, $df=4$; P-value=.314; RMSEA=0.029; P-close=0.572; AIC=52.754 (AIC saturated=56.0)). Also in this model, subjects return to their old pattern of behavior in the third wave. Expected means of public transport used are lower than the initial ones in both groups. The intervention seems to have an effect on travel mode choice in the short run, but not in the long run.

Figure 8a. The hybrid model with a multi group analysis for the low intention group (standardized coefficients).



Standardized estimates
 chi-square=4.754 df=4 p-value=.314
 rmsea=.029 pclose=.572 aic=52.754

Figure 8b. The hybrid model with a multi group analysis for the high intention group (standardized coefficients).



Standardized estimates
 chi-square=4.754 df=4 p-value=.314
 rmsea=.029 pclose=.572 aic=52.754

4.2.5. Summary

To sum up the results, it would be of interest to compare the different goodness of fit measures of the models we analyzed.

Table 2: Fit measures of the different models:

Model number	Type of model	Chi-square	df	Chi-square/df	p-value	rmsea	P-close	AIC
1	AR	2.887	3	.962	.409	.000	.638	24.887
2	LC	2.195	3	.732	.533	.000	.736	24.195
3	LC-multi group	13.199	8	1.650	.105	.054	.399	53.199
4	Hybrid-multi group	4.754	4	1.189	.314	.029	.572	52.754

As one can see in table 2, all models fit the data very well. The corresponding value of chi square divided by the number of degrees of freedom is lower than 2 for all the models. Although the LC model with the multi-group analysis (3) has a higher ratio of chi-square to df than the hybrid model (4), they are not significantly different. The AIC value for all the models is lower than in the saturated model. P-value is higher than 0.5 only for the LC model (.533). The p-value of the hybrid model is higher than in the LC model with an interaction test (.314 compared to .105). RMSEA is lower than .05 for three of the models, and only slightly higher than .05 for the third. The P-value of close fit is higher than .5 for three of the models, and lower than .5 for the LC model with the multi-group analysis. In this set of analyses, models 3 and 4 are nested. Model 4, the hybrid model, performs better according to most of the fit measures presented.

5. Discussion

There were three primary goals for this paper. The first was to compare AR and LC models, to identify the pros and cons of each of them, and to introduce the hybrid model suggested by Curran and Bollen (2002). The second goal was to apply them with real data on travel mode choice. The third goal was to pursue two extensions of the LC model

suggested by Curran and Bollen: the first is regressing the variable, which is changing over time on an exogenous variable, namely the intervention variable; the second was to conduct a multi-group analysis and test for interactions.

The set of autoregressive and latent curve models provides a better understanding of the relation between the intervention (the soft policy) and public transport use. First, in both modeling approaches we found developmental changes in public transport use to be positive between the first and the second wave and to be negative between the second and the third wave according to the expected means (except for the AR model). Second, a similar development of the behavioral trajectory was found for the two groups of subjects: those with a high initial level of intention to use public transport and those with a low one. Third, we learned from the latent curve model, that individual differences in the initial degree of public transport use are negatively associated with changes (increases or decreases) in public transport use. That is, on average, participants with a lower initial use of public transport tended to report steeper changes in behavior. In addition, we observed this correlation in both groups.

It was the multi-group analysis that allowed for an interaction test between the intervention variable and the degree of initial intention to use public transport. Whereas at first we observed no effect of the intervention on behavior in the LC model, in the multi-group analysis the result was different. In the group with a low initial intention to use public transport a positive effect of the intervention on *bb2* was observed. However, in the group with a high initial intention to use public transport a negative effect was observed.

The hybrid model provided us with the strengths of the autoregressive model and the latent growth model. We received stability coefficients in the multi-group analysis for both groups, the high intention group and the low intention one. The pattern of results has not changed, but this time combined into one framework. It performed better than the LC model according to several fit measures.

To sum up, the proposed AR and LC modeling strategies are important tools for analyzing change over time. However, each approach has its own merits and disadvantages. Autoregressive models are simple, include a test for the stability of behavior, enable to estimate the mean of the observed variables over time and provide data on the whole group process. They also enable to test cross-lagged relations between two measurement time points. However, they do not provide any information on the individual level and on the whole process of change. Therefore, one cannot test whether, for instance, the process of development is linear, quadratic etc. LC models do not provide any information on the stability from one time-point to the other, and cannot check for feedback relations. However, they support us with invaluable information on the developmental process, explain individual changes over time and enable us to conduct multi-group analyses to test for interactions. As we have seen, those models are not competitive, but rather complementary, and allow for a combined test in the form of a hybrid model. Such a test is more flexible, and provides us with the strengths of both approaches to evaluate relations over time.

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Appendix A:

Differences between autoregressive and growth curve models for the analysis of change (based on Bollen and Curran (2002) and Curran and Muthén (1999)).

Autoregressive (AR) Models	Latent Curve (LC) Models
<p>The focus of interest is in particular time points</p> <p><u>Practically</u>: we estimate the test parameters b_{21} and b_{32} in Figure 1; or in general we estimate the test parameter b_{ij} where i corresponds to the dependent variable time point and j to the independent one.</p>	<p>The focus of interest is in the developmental trajectory of the targeted behavior across multiple time points.</p> <p><u>Practically</u>: we can estimate the means and variances of the latent slope and the latent intercept variables (test parameters in Figure 2 are $\text{mean}(\text{slope})$, $V(\text{slope})$ and $\text{mean}(\text{Intercept})$ and $V(\text{Intercept})$).</p>
<p>One cannot check whether the developmental process is linear, quadratic etc.</p> <p><u>Practically</u>: one can compute the mean of Y's (see Figure 1, the test parameters are $\text{mean}(y_1)$, $\text{mean}(y_2)$ and $\text{mean}(y_3)$), but it does not provide any information on the developmental process.</p>	<p>One can test whether the developmental process is linear, quadratic etc.</p> <p><u>Practically</u>: one can estimate the coefficients between the latent variables slope and Intercept and behavior in the different time points. In Figure 2 the estimation of the test parameter b would provide information whether the developmental process is linear, quadratic or a different one. Alternatively, for a specific test whether a process is quadratic, one could set the coefficients of the causal relations between the latent slope and behavior (beh_1, beh_2 and beh_3) in the three time points to be 0, b and b^2 correspondingly, and estimate them as the test parameters.</p>
<p>Only effects of the previous period count in the explanation of the current period.</p>	<p>The whole developmental process counts to explain the current period.</p> <p><u>Practically</u>: we estimate the means of the</p>

<p><u>Practically</u>: we can only estimate the test parameter b_{ij}, (or b_{32} and b_{21} in Figure 1).</p>	<p>latent slope and the latent intercept (the test parameters in Figure 2 are $\text{mean}(\text{slope})$ and $\text{mean}(\text{Intercept})$ correspondingly). Additionally we test the coefficients between the latent slope and behavior (test parameter b in Figure 2).</p>
<p>Cross lagged effects are the same for each individual. <u>Practically</u>: one can also estimate b_{ji} (in Figure 1 we would draw an arrow from Y_3 to Y_2 and from Y_2 to Y_1 and estimate b_{23} and b_{12} correspondingly, as Y_2 and Y_1 are the dependent variables in such a test). However, the test parameter b_{ji} would be the same for all individuals.</p>	<p>Cross lagged effects are the same for each individual. <u>Practically</u>: there is no direct test for that. Such a test could be done in the hybrid model. However, the test parameter b_{ji} would be the same for all individuals.</p>
<p>The parameters represent stability coefficients from one time point to the proceeding one for the whole group. <u>Practically</u>: the estimated test parameters b_{ij} (in Figure 1, the estimates b_{32} and b_{21}) are the same for everyone.</p>	<p>The means of the latent slope and the latent intercept represent the developmental process over time for the whole group; their variance represents the individual variability of each subject around the group parameters. <u>Practically</u>: the means of the slope and the intercept latent variables are our test parameters; in Figure 2 they correspond to $\text{mean}(\text{slope})$, $\text{mean}(\text{intercept})$, $V(\text{slope})$ and $V(\text{Intercept})$.</p>
<p>A cross-lagged effects test is possible between two time points. <u>Practically</u>: one can also estimate the test parameter b_{ji} (in Figure 1 we would draw an arrow from Y_3 to Y_2</p>	<p>A cross-lagged effects test is not possible between two time points. <u>Practically</u>: such a test could be done in the hybrid model similarly to the autoregressive model.</p>

and from Y_2 to Y_1 and estimate b_{23} and b_{12} correspondingly, as Y_2 and Y_1 are the dependent variables in such a test).	
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The paper is in press as a chapter in *Rational Choice: Theoretische Analysen und Empirische Resultaten* edited by A. Diekmann, K. Eichner, P. Schmidt and T. Voss.

Wie gut erklären „enge“ oder “weite” Rational-Choice-Version Verhaltensveränderungen? Ergebnisse einer experimentellen Interventionsstudie²²

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Zusammenfassung

Wie läßt sich Verhaltensveränderung empirische erklären? Reicht es aus sich auf die Veränderung objektiver Restriktionen zu konzentrieren, wie von der engen Rational Choice Version angenommen oder ist es erfolgversprechender die Veränderungen subjektiver Präferenzen und wahrgenommene Restriktionen zu untersuchen, wie von der weiten Rational Choice Variante angenommen? Im Rahmen einer experimentellen Evaluationsstudie untersucht unser Beitrag diese Frage empirisch. Dazu wird die Verhaltenswirksamkeit einer Intervention analysiert, die sich auf die Beseitigung von subjektiver Informations- und Motivationsdefizite bei Menschen konzentriert, die neu in eine Großstadt ziehen. Da durch diese Intervention keine objektiven Restriktionen verändert werden, sollte sie aus der Perspektive der engen RCT-Version wirkungslos sein. Die Ergebnisse unserer Evaluationsstudie stützen diese Annahme nicht: Nach dem Umzug zeigt sich in der Interventionsgruppe ein drastischer Anstieg der ÖV-Nutzung, während sich in der Kontrollgruppe die ÖV-Nutzung nicht signifikant verändert. Weitere Analysen zeigen, dass sich die offensichtliche Verhaltenswirksamkeit der Intervention besser durch Rückgriff auf subjektive motivationale Prozesse erklären läßt, wie von der weiten RCT-Version postuliert.

Die Rational-Choice Theorie (RCT) ist eine der wenigen theoretischen Perspektiven, die in so unterschiedlichen sozialwissenschaftlichen Disziplinen wie Ökonomie, Soziologie, Sozialpsychologie, Politikwissenschaften und Geschichte benutzt wird (z.B. Becker, 1976; Brunner, 1987; Coleman, 1990; Frey, 1990; McKenzie &

²² A joint work with Sebastian Bamberg and Peter Schmidt.

Fullock, 1978; Ramb & Tietzel, 1993; Radnitzky & Bernholz, 1987; Simon, 1997). Dies stützt zum einen den Anspruch der RCT eine allgemeine Verhaltenstheorie zu sein, zum anderen zeigt sich darin jedoch auch das transdisziplinäre Potenzial dieses theoretischen Ansatzes. Allgemein werden folgende drei Annahmen als nomologischer Kern der RCT angesehen (vgl. Coleman, 1990; Opp & Kühnel, xxx; Lakatos, xxx):

1. Die Präferenz-Annahme: Individuelle Präferenzen (oder Ziele) sind die Determinanten von Handlungen, die sich instrumentell zur Befriedigung dieser Präferenzen eignen.
2. Die Restriktions-Annahme: Alles, was die Fähigkeit eines Individuums erhöht oder verringert (d.h. Gelegenheiten oder Restriktionen), durch die Ausführung bestimmter Handlungen seine Präferenzen zu befriedigen, determiniert die Ausführung dieser Handlungen.
3. Die Nutzenmaximierungs-Annahme: Individuen wählen die Handlung aus, mit denen sie unter den gegebenen Restriktionen ihre Präferenzen am besten befriedigt.

Empirisch lässt sich diese allgemeine - und deshalb auch erst einmal inhaltsleere - RCT jedoch nur anwenden, wenn sie durch Hilfsannahmen darüber ergänzt wird, welche Präferenzen und Restriktionen einen Einfluss auf die interessierende spezifische Handlung haben sollen. Die Spezifikation dieser Hilfsannahmen wird damit zum "Knackpunkt" einer jeden empirischen RCT-Anwendung. Deshalb ist es auch nicht verwunderlich, dass die Spezifikation und empirische Messung von Präferenzen und Restriktionen Gegenstand heftiger Diskussionen innerhalb des RCT-Lagers selbst sind (vgl. Lindenberg, 1998; Opp & Friederichs, 1999). Opp (1999) fasst die in dieser Diskussion vertretenen Positionen unter den Begriffen der "engen" versus "weiten" RCT-Version zusammen. Tabelle 1 stellt dar, wie Vertretern/innen der "engen" und "weiten" RCT-Version bei der Spezifikation von Präferenzen und Restriktionen vorgehen.

Tabelle 1: Annahmen der „engen“ und „weiten“ Rational-Choice-Version (aus Opp, 1999)

Annahmen der engen RCT-Version	Annahmen der weitem RCT-Version
1a. Nur egoistische Präferenzen sind relevant	1b. Alle Arten von Präferenzen können relevante Erklärungsfaktoren sein
2a. Nur „harte“ Restriktionen sind relevant	2b. Alle Arten von Restriktionen können menschliches Verhalten beeinflussen
3a. Menschen sind voll informiert	3a. Menschen können, müssen aber nicht vollständig informiert sein.
4a. Objektive Restriktionen sind relevant	4b. Objektive und wahrgenommene Restriktionen können relevant sein
5a. Nur Restriktionen erklären Verhalten	5b. Restriktionen und/oder Präferenzen können Verhalten erklären.

Wie sich Tabelle 1 entnehmen lässt, gehen die Vertreter/innen der engen RCT-Version davon aus, dass sich Menschen bei ihrer Wahl zwischen verschiedenen Handlungsoptionen ausschließlich an ihrem eigenen Wohlergehen orientieren, d.h. egoistischen Präferenzen. Deshalb sind aus Sicht der engen RCT-Version auch nur „harte“ Restriktionen wie Belohnungen oder Bestrafungen verhaltensrelevant. Eine dritte Annahme der engen RCT-Version besteht darin, Menschen sowohl bezüglich ihrer Umwelt, wie ihres vergangenen Verhaltens als vollständig informiert anzusehen. Die vierte Annahme der engen RCT-Version folgt direkt aus dieser dritten Annahme: Weil Menschen vollständig über die objektiven Verhaltensanreize und -restriktionen informiert sind, ist bei der Verhaltensklärung der Bezug auf subjektive Wahrnehmungen unnötig. Obwohl die allgemeine RCT sowohl in Restriktionen wie Präferenzen zentrale Erklärungsfaktoren menschlichen Verhaltens sieht, geht die fünfte Annahme der engen RCT-Version davon aus, dass im Kontext der empirischen Erklärung von Verhaltensveränderungen die Berücksichtigung von Präferenzen unnötig ist. Begründet wird dieses Vorgehen damit, dass alle Menschen sehr ähnliche Präferenzen haben, die zudem über die Zeit stabil sein sollen.

Die Vertreter/innen der weiten RCT-Version hingegen gehen davon aus, dass alle (z.B. auch „moralische“) Präferenzen Verhalten beeinflussen können. Ein weiteres Merkmal der weiten RCT-Version besteht darin, dass sie sich an der zentralen Annahme der ‘bounded rationality’ (Simon, 1979) orientiert, dass die menschliche Informationsverarbeitungskapazität begrenzt ist. Wegen dieser begrenzten kognitiven

Kapazität sind fehlendes oder falsches Wissen zentrale subjektive Restriktionen. Weiter geht die weite RCT-Version davon aus, dass sich Menschen in ihren Präferenzen substantiell unterscheiden und dass sich solche Präferenzen über die Zeit auch verändern können. Aus Sicht der weiten RCT-Version ist deshalb immer eine empirische Frage, ob eine Verhaltensveränderung das Resultat von Veränderung wahrgenommener Restriktionen, von Präferenzveränderungen oder einer Kombination beider Prozesse ist.

Welche Version ist nun die "bessere" bzw. "richtigere" RCT-Version - die enge oder die weite RCT-Version? Vertreter/innen der engen RCT-Version bringen eine Reihe von Argumenten vor, die aus ihrer Sicht die Überlegenheit der engen RCT-Version stützen: (1) Präferenzen lassen sich nicht reliabel messen, (2) die weite RCT-Version ist tautologisch, zirkulär, leer oder trivial; (3) aus der weiten Version lassen sich nur schwer Vorhersagen ableiten; (4) die Annahmen der engen Version reichen zur Erklärung von Verhalten bzw. Verhaltensveränderungen aus.

Opp (1999) analysiert eingehend jedes dieser Argumente und zeigt dabei, dass sie entweder auf problematischen Annahmen bzw. Missverständnissen beruhen oder wenn sie zutreffend sind, gleichermaßen die enge wie weite RCT-Version betreffen. Ferner macht Opp deutlich, dass es sich bei der engen und weiten RCT-Version nicht um sich widersprechende Modelle handelt. Vielmehr handelt es sich bei der engen RCT-Version um einen restriktiven Spezialfall der weiten RCT-Version. Ein Vorteil der restriktiveren engen RCT-Version ist ihre Sparsamkeit und Eleganz. Nur garantieren Sparsamkeit und Eleganz nicht, dass ein theoretisches Modell auch richtig ist. Diese Frage lässt sich nur empirisch entscheiden. Opp (1999) plädiert deshalb dafür, für spezifische Anwendungsbereiche die empirische Erklärungskraft der engen versus weiten RCT-Version explizit zu testen.

Ziel unseres Beitrag ist es, für das Anwendungsgebiet individuelle Verkehrsmittelnutzung solch einen vergleichenden empirischen Test der engen und weiten RCT-Version durchzuführen. Dazu möchten wir nicht nur untersuchen, wie gut die beiden RCT-Versionen die momentane Verkehrsmittelnutzung erklären können. Vielmehr interessiert uns die Frage, welche Aussagen sich aus diesen beiden Ansätze über die potenzielle Verhaltenswirksamkeit von verkehrspolitischen Interventionen ableiten lassen und wie gut diese Vorhersagen empirische bestätigt werden. Im

Mittelpunkt unseres Papiers steht also die praktische Relevanz der engen versus weiten RCT-Version für die Entwicklung und Evaluation verhaltensverändernder Interventionen. Erklärung der individuellen Verkehrsmittelwahl im Kontext der engen RCT-Version

In der Verkehrswissenschaft war und ist die enge RCT-Version der dominierende Ansatz zur Erklärung der Verkehrsmittelwahl (siehe dazu Held, 1982; Verron, 1986; Gorr, 1997; Preisendörfer et al. 1999). Ein Grund dafür sind die bahnbrechenden Arbeiten von McFadden (z.B. Domencich & McFadden, 1975), in dem er die ökonomische Verhaltenstheorie auf die Erklärung der Verkehrsmittelwahl übertrug. Nach McFadden lässt sich der subjektive Nutzen einer Verkehrsmittelalternative j als Funktion von Eigenschaften a_j eines Verkehrsmittels und personenspezifischer Merkmale S modellieren. Bei S handelt es sich um personenspezifischer Restriktionen wie Alter, Einkommen oder Pkw-Besitz. Außerdem führt McFadden die Zufallskomponente ϵ_j in die Nutzenfunktion ein. Diese Zufallskomponente bildet Fehler bei der Messung der Attribute a_j und der Personenmerkmale S sowie nicht gemessene Nutzenargumente ab:

$$U_j = V(a_j, S) + \epsilon_j$$

Nach diesem Ansatz wird ein Individuum, das vor der Wahl steht, entweder das Verkehrsmittel j (z.B. das Auto) oder i (z.B. ÖV) für den Weg zur Arbeit zu wählen, sich für j entscheiden, wenn $U_j > U_i$, und für i wenn $U_i > U_j$ ist. Bei der Frage, welche Attribute in die Vektoren a_j und S eingehen und wie diese Attribute zu erfassen sind, orientiert sich McFadden strikt an den oben dargestellten Annahmen der engen RCT-Version. Von der Annahme eines egoistisch motivierten, vollständig informierten Entscheiders ausgehend, berücksichtigt McFadden lediglich objektive Geld- und Zeitkosten als entscheidungsrelevante Verkehrsmittelmerkmale. Soziale Normen und Präferenzen (z.B. Umweltbewusstsein) sollen keinen signifikanten Einfluss auf die Verkehrsmittelwahl haben. In den Vektor S gehen nur objektive soziodemographische Personenmerkmale wie der Pkw-Besitz bzw. die Pkw-Verfügbarkeit, Alter, Geschlecht, Haushaltseinkommen und Anzahl von Erwerbstätigen pro Haushalt ein. Die Attraktivität des von McFadden vorgeschlagenen Ansatzes beruht nicht nur darauf, dass er ein in der Ökonomie weit akzeptiertes Modell auf die Verkehrsmittelwahl überträgt, sondern auch darauf, dass er demonstriert, wie sich dieses Modell Mithilfe des damals neu entwickelten statistischen Verfahren der Logit- bzw. Probit-Analyse auf der Ebene von

Individualdaten empirisch testen lässt. Im deutschsprachigen Raum sind die Arbeiten von Balderjahn (1993), Brüderl & Preisendörfer (1995), Diekmann (1995), Franzen (1997) sowie Preisendörfer et al. (1999) und Davidov et al. (2003) neuere Beispiele für empirische Anwendungen der engen RCT-Version auf die Verkehrsmittelwahl. Tabelle 2 fasst zentrale Befunde dieser Arbeiten zusammen.

Tabelle 2:

Befunde aus Arbeiten, die die enge RCT-Version auf die Erklärung der Verkehrsmittelwahl bei Weg zum Arbeitsplatz anwenden (teilweise aus Preisendörfer et al., 1999)

Merkmal	Brüderl & Preisendörfer (1995)	Diekmann (1995)	Balderjahn (1993)	Preisendörfer et al. (1999)	Davidov et al. (2003)
Alter	0	0		0	
Alter ²					-
Frau	0	0	+	+	+
Bildung	0	0	+	0	0
Einkommen	0				
Haushaltsgröße			+		
Verheiratet					-
Umweltwissen		+			
Umweltbewusstsein	0	0	+	+	
Relative Zeitkosten	-	-	-	-	-
Relative Geldkosten	-	0	0	0	
Relative Komfortkosten	-	-		0	
Autoverfügbarkeit	-			-	
Methode	Konditionales Logit Modell	Probit-Schätzung	Mixed Logit Modell	Logit-Modell	Logit-Modell
Pseudo-R ²	0.58		0.73	0.51	0.14
Fallzahl	268	82	252	330	1,392

Erläuterung: Da die Studien unterschiedliche statistische Modelle verwenden, wird nur die Richtung der signifikanten ($\alpha \leq 0.05$) Effekte angegeben (+ = positiver Zusammenhang, d.h. höhere Wahrscheinlichkeit einer ÖV-Nutzung; - = negativer Zusammenhang; 0 = kein Zusammenhang). Eine Leerstelle besagt, dass eine Studie diese Variable nicht untersucht. Abhängige Variable ist die Wahrscheinlichkeit, den ÖV zu nutzen.

Alle in Tabelle 2 dargestellten Arbeiten weichen jedoch von dem von McFadden praktizierten Vorgehen ab, den subjektiven Nutzen einer Verkehrsmittelalternativen ausschließlich über die objektiven Geld- und Zeitkosten zu bestimmen. Weil die objektive Messung der Zeit- und Geldkosten sehr aufwendig ist, verwenden dieser Arbeiten die von den Befragten subjektiv geschätzten Geld- und Zeitkosten (z.B. "Wie viel Minuten würden Sie benötigen, wenn Sie für diesen Weg den Pkw/ÖV benutzen würden?") als Erklärungsgrößen. Legitimiert wird dieses Vorgehen durch die Annahme des vollständig informierten Entscheiders. Ferner werden neben Geld- und Zeitkosten auch sog. 'Komfortkosten' berücksichtigt. Komfort ist jedoch keine objektive Größe, sondern in erste Linie eine subjektive Bewertung. Wie sich Tabelle 2 entnehmen lässt, sind in allen Studien die Pkw-Verfügbarkeit und die relativen Zeitkosten zentrale Determinanten der Verkehrsmittelwahl zum Arbeitsplatz sind. Inkonsistenter sind hingegen die Befunde bezüglich der relativen Geldkosten: Während Brüderl und Preisendörfer (1995) einen signifikant negativen Effekt der Geldkosten berichten, ist bei Balderjahn (1993), Diekmann (1995) und Preisendörfer et al. (1999) dieser Effekt insignifikant. Uneinheitlich sind auch die Befunde zu dem Einfluss soziodemographischer Variablen, dem Einfluss umweltrelevanten Wissens / Einstellungen sowie der Komfortkosten.

Erklärung der individuellen Verkehrsmittelwahl im Kontext der weiten RCT-Version

Da die in Tabelle 1 dargestellten Hilfsannahmen der weiten RCT-Version deutlich "psychologienäher" sind als die der engen RCT-Version (vgl. z.B. Simon, 1985), verwundert es nicht, dass sich Vertreter/innen der weiten RCT-Version stärker an sozialpsychologischen Modellen orientieren. So wendet unserer Gruppe (z.B. Bamberg & Schmidt, 1993, 1994, 1999) die von Ajzen (1991) entwickelte Theorie des geplanten Verhaltens (TPB) auf die Erklärung der Verkehrsmittelwahl an. Die TPB teilt alle in Tabelle 1 aufgeführten Hilfsannahmen der weiten RCT-Version: Sie geht davon aus, dass prinzipiell alle Präferenzen und Restriktionen Verhalten beeinflussen können. Deshalb betont die TPB auch, dass für jedes spezifische Verhalten die relevanten Präferenzen und Restriktionen vorher im Rahmen einer explorativen Vorstudie ermittelt werden müssen. Ferner berücksichtigt die TPB neben den persönlichen Handlungskonsequenzen explizit

sozial-normativen Erwartungen wichtiger Bezugspersonen als unabhängige Verhaltensdeterminante. Als psychologische Theorie geht die TPB davon aus, dass in einer Entscheidungssituation nicht die objektiven, nur die subjektiv repräsentierten Handlungskonsequenzen und Restriktionen relevant sind. Diese subjektiven Repräsentationen können jedoch unvollständig und falsch sein. Weiter nimmt die TPB an, dass sich Menschen bei ihren Entscheidungen nur auf wenige (in der Regel 3-7), für sie subjektiv besonders bedeutsame Verhaltenskonsequenzen stützen. Diese Annahme begründet die TPB ausdrücklich mit der Begrenztheit kognitiver Verarbeitungskapazitäten. Abbildung 1 stellt graphisch die von der TPB postulierte Kausalstruktur dar. Wie diese Abbildung deutlich macht, beruht nach der TPB menschliches Verhalten letztendlich auf der Wahrnehmung und Bewertung folgender drei mit der Ausführung eines Verhaltens verbundenen Überzeugungsarten: Überzeugungen über die wahrscheinlichen Verhaltenskonsequenzen und der Bewertung dieser Konsequenzen (behaviorale Überzeugungen), Überzeugungen bezüglich der normativen Erwartungen anderer und der Motivation mit diesen Erwartungen übereinzustimmen (normative Überzeugungen) und Überzeugungen bezüglich Faktoren, die die Ausführung eines Verhaltens erleichtern oder erschweren können und die wahrgenommene Stärke dieser Faktoren (Kontrollüberzeugungen).

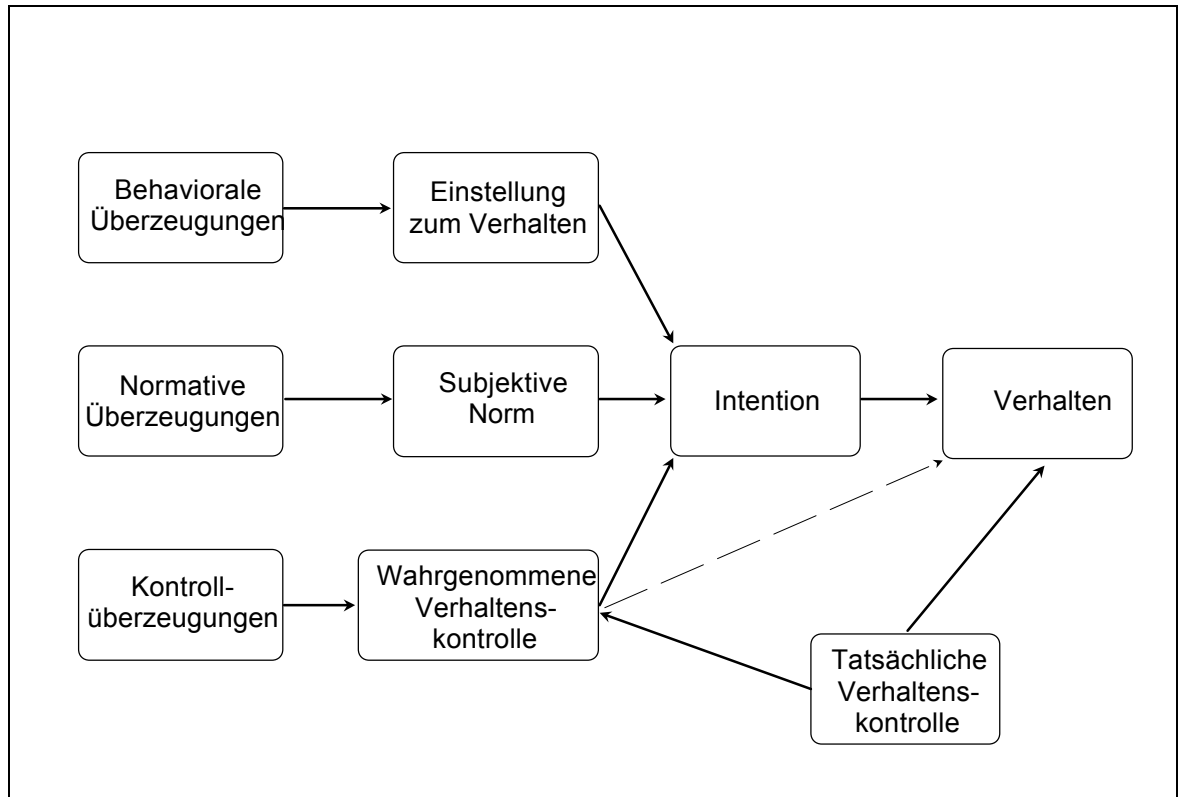


Abbildung 1: Ajzen's (1991) Theorie des geplanten Verhaltens

Die behavioralen Überzeugungen determinieren ihrerseits die Einstellung zu dem in Frage stehenden Verhalten, aus den normative Überzeugungen resultiert der wahrgenommene soziale Druck dieses Verhalten auszuführen und die Kontrollüberzeugungen determinieren das Ausmaß, in dem die Ausführung des Verhaltens als willentlich kontrollierbar wahrgenommen wird. Einstellung, subjektive Norm und Verhaltenskontrolle determinieren ihrerseits die Verhaltensabsicht (Intention): Je günstiger die Einstellung und subjektive Norm und je stärker die wahrgenommene Verhaltenskontrolle, desto stärker ist auch die Absicht einer Person, ein Verhalten auszuführen. Wenn das beabsichtigte Verhalten unter willentlicher Kontrolle steht, wird es auch ausgeführt, wenn sich die entsprechende Gelegenheit ergibt. Nach der TPB ist also die Intention die unmittelbare Ursache des Verhaltens. Weil jedoch die Ausführung eines Verhaltens oft durch objektive Barrieren eingeschränkt oder verhindert wird, d.h. die Verhaltensaufführung steht dann nicht unter willentlicher Kontrolle, ist es nach der TPB sinnvoll die wahrgenommene Verhaltenskontrolle als zusätzlichen

Verhaltensprädiktor zu berücksichtigen. In dem Ausmaß, in dem die wahrgenommene Verhaltenskontrolle zuverlässig die tatsächliche Verhaltenskontrolle abbildet, kann sie als Proxy-Variable für die tatsächliche Verhaltenskontrolle benutzt werden. In dieser Funktion kann sie dann auch einen eigenständigen Beitrag zur Verhaltensvorhersage leisten. Die TPB ist eine der am intensivsten empirisch getesteten sozialpsychologischen Theorien. Metanalysen, die auf den Ergebnissen vieler solcher empirischer Studien beruhen (siehe z.B. Armitage & Conner, 2001; Ajzen, 2000) bestätigen die von der TPB postulierte Beziehungsstruktur.

Für die individuelle Verkehrsmittelwahl bestätigen unsere Arbeiten (z.B. Bamberg & Schmidt 1993, 1994, 1999) ebenfalls die von der TPB postulierte Kausalstruktur. Wie die in Tabelle 2 dargestellten Anwendungen der „engen“ RCT-Version, zeigt sich auch in den TPB-Anwendungen, dass die Verkehrsmittelattribute ‘schnell’ und ‘bequem’ zentrale Entscheidungskriterien (behaviorale Überzeugungen) bei Wahl zwischen Verkehrsmittelalternativen sind, während die Bedeutung des Attribut ‘billig’ eher nachrangig ist. Gleichzeitig liefern die TPB-Anwendungen jedoch deutliche Hinweise darauf, dass neben ‘schnell’ und ‘bequem’ noch weitere Verkehrsmittelattribute, wie ‘flexibel’, ‘zuverlässig’ und ‘stressfrei’ vermittelt über die Einstellung die Intention beeinflussen. Auch in den TPB-Anwendungen ist die wahrgenommene Pkw-Verfügbarkeit die zentrale Determinante der wahrgenommenen Kontrolle über die Pkw-Nutzung. Gleichzeitig deuten die TPB-Anwendungen jedoch auch darauf hin, dass die wahrgenommene Qualität der ÖV-Verbindungen sowie fehlendes Wissen über Haltestellen und Abfahrtszeiten zentrale subjektive Restriktionen der ÖV-Nutzung darstellen. Ein weiterer interessanter Befund unserer TPB-Anwendungen besteht darin, dass sich neben Einstellung und wahrgenommener Verhaltenskontrolle die subjektive Norm als zusätzliche, erklärungsstarke Determinante der Verkehrsmittelnutzungsabsicht qualifiziert.

Die erwartete Verhaltenswirksamkeit einer spezifischen Interventionsmaßnahme vor dem Hintergrund der engen vs. weiten RCT-Version

Nachdem wir für das Anwendungsgebiet „Verkehrsmittelwahl“ Konzeptualisierungen der engen versus weiten RCT-Version sowie innerhalb dieser beiden Ansätze ermittelte zentrale Befunde dargestellt haben, möchten wir jetzt zu der hier besonders

interessierenden Frage kommen, welche Vorhersagen sich aus der engen versus weiten RCT-Version über die potenzielle Verhaltenswirksamkeit einer spezifischen verkehrspolitischen Intervention ableiten lassen. Stellen Sie sich dazu folgende Situation vor: Im Rahmen einer Kampagne, mit der in der Zielgruppe „Umzügler“ Neukunden gewonnen werden sollen, hat in einer bundesdeutschen Großstadt die Marketingabteilung eines öffentlichen Verkehrsunternehmens eine spezielle Intervention entwickelt. Diese Intervention „Persönliches Informationspaket“ besteht aus folgenden Bestandteilen: (1) Einem offiziellen Begrüßungsschreiben mit einer kurzen Vorstellung des Unternehmens und seiner Dienstleistungen, (2) Einem kostenlosen Tagesticket für das gesamte ÖV-Netz. In dem Anschreiben wird auf dieses Freiticket hingewiesen und zum Test aufgefordert, (3) Einer Karte des Stadtviertels, in dem die kontaktierte Person nach ihrem Umzug wohnt. In der Karte sind alle ÖV-Linien und Haltepunkte markiert. (4) Einem kleinen Faltfahrplan, der die Abfahrtszeiten aller durch das Viertel führender ÖV-Linien enthält. (5) Einer kleinen Broschüre mit beispielhaften ÖV-Verbindungen zu häufig genutzten Einkaufs-, Freizeit und Kultureinrichtungen. (6) Zentrale Informationen über Tarif und Fahrkartenverkaufsstellen und (7) einer „Hot-Line“-Telefonnummer, wo man sich bei weiteren Fragen beraten lassen kann.

Wenn man die enge RCT-Version als theoretischen Rahmen für die Erklärung der individuellen Verkehrsmittelwahl ernst nimmt, muss man davon ausgehen, dass die dargestellte Intervention keinen Einfluss auf die individuelle Verkehrsmittelwahl haben sollte. Für einen vollständig informierten Entscheider, der seine Verkehrsmittelwahl lediglich an den objektiven Zeit- und Geldkostendifferenzen von Pkw und ÖV orientiert, ist die Intervention überflüssig. Ferner werden durch die Maßnahme keine objektiven Restriktionen wie Pkw-Verfügbarkeit, fehlende ÖV-Verbindungen oder das Parkplatzangebot verändert, die nach der engen RCT-Version alleinige Ursachen von Verhaltensveränderungen sind. Entsprechende Einschätzung finden sich z.B. in den Arbeiten von Diekmann & Preisendörfer (2000) und Preisendörfer (2000).

Aus Perspektive der weiten RCT-Version spricht hingegen einiges für eine positivere Einschätzung der Maßnahmenwirksamkeit. So besteht ja eine zentrale Annahme der weiten RCT-Version darin, dass Menschen in der Regel ihre Entscheidungen nicht auf der Grundlage vollständiger und korrekter Informationen

fällen. Angesichts ihrer beschränkten kognitiven Kapazitäten können und wollen Menschen nicht alles wissen. So haben viele Menschen nur eine sehr vage Vorstellung davon, wo und wann der nächste Bus abfährt, wie lange die Fahrzeit bzw. wie hoch der Fahrpreis ist. Solange sie sich sicher sind, dass für sie der Pkw die beste Mobilitätsalternative ist, stören solche unvollständigen bzw. falschen Informationen auch nicht. Erst wenn der Wunsch auftaucht, anstatt des Pkw öffentliche Verkehrsmittel einmal ausprobieren zu wollen, werden diese fehlenden bzw. falschen Informationen zu starken subjektiven Restriktionen, die ein Ausprobieren des ÖV be- bzw. verhindern. Aus Sicht der weiten RCT-Version könnte die oben dargestellte Maßnahme dann verhaltenswirksam werden, wenn sich Menschen ernsthaft die Frage stellen, ob der ÖV nicht eine persönlich relevante Alternative zur bisherigen Pkw-Nutzung darstellt. Ein Umzug, nach dem Menschen ihre Alltagsmobilität neu organisieren müssen, ist sicherlich eine Situation, die so eine bewusste Neubewertung von Verkehrsmittelalternativen fördert. Dabei deuten die oben dargestellten Befunde der TPB-Anwendungen darauf hin, dass bei so einer Neubewertung von Verkehrsmittelalternativen nicht nur die wahrgenommenen relativen Zeitkosten eine Rolle spielen können, sondern auch Argumente wie “dann brauche ich nicht mehr einen Parkplatz zu suchen” oder “dann kann ich in Ruhe die Zeitung lesen”. Wenn also kurz nach dem Umzug ein Pkw-Nutzer Informationen erhält, die überzeugend darstellen, wie einfach, günstig, bequem und stressfrei er von seiner neuen Wohnung aus mit öffentlichen Verkehrsmitteln seine Ziele in der Stadt erreichen kann, mag ihn diese dazu motivieren, den ÖV tatsächlich einmal zu testen. Das kostenlose Testticket könnte diese Absicht noch verstärken. Gleichzeitig verringern die mitgelieferten ÖV-Nutzungsinformationen die restriktive Wirkung von Informationsdefiziten. Ob es nach dem Test zu einer dauerhaften Veränderung der Verkehrsmittelwahl kommt, hängt dann von den konkreten Erfahrungen ab, die die Person bei ihrem Test macht.

Methode

Untersuchungsdesign

In Kooperation mit dem Stuttgarter Verkehrsverbund haben wir 2001 die oben dargestellte Intervention “Persönliches Informationspaket” tatsächlich durchgeführt und im Rahmen einer experimentellen Feldstudie evaluiert. An der Studie nahmen nur

Personen teil, die vor der Intervention noch an ihrem alten Wohnort wohnten, jedoch planten in den nächsten Wochen/Monaten nach Stuttgart umzuziehen. Rekrutiert wurden diese potenziellen Umzügler anhand von Telefonnummern und E-Mail-Adressen aus Wohnungsgesuchen in Stuttgarter Zeitungen. Wenn die Kontaktierten bereit waren, an der Studie teilzunehmen (als Anreiz wurde unter den Teilnehmern Geldpreise verlost), erhielten sie den ersten Fragebogen zugeschickt, mit der Bitte, diesen bezogen auf ihren derzeitigen alten Wohnort zu beantworten. Ungefähr 10-12 Wochen nach dem erfolgten Umzug erhielten alle Untersuchungsteilnehmern denselben Fragebogen ein zweites Mal zuschicken, diesmal mit der Bitte ihn bezogen auf den neuen Wohnort auszufüllen.

Die Verhaltenswirksamkeit der Intervention wurde im Rahmen eines echten, randomisierten experimentellen Designs analysiert. Vor der Intervention wurden die Untersuchungsteilnehmer/innen, die den ersten Fragebogen am alten Wohnort ausgefüllt hatten, mittels einer Zufallsprozedur einer Experimental- bzw. Kontrollgruppe zugewiesen. Nachdem die der Experimentalgruppe zugewiesenen Personen tatsächlich nach Stuttgart umgezogen waren, erhielten sie ca. 4-6 Wochen nach dem Umzug die oben beschriebene Intervention "Persönliches Informationspaket" zugeschickt.

Mit zwei Maßnahmen haben wir versucht, die Reaktivität unseres Untersuchungsdesigns und daraus möglicherweise resultierende Selbstselektionsprozesse und Antworttendenzen gering zu halten. So haben wir den Befragten nicht mitgeteilt, dass sie an einer experimentellen Evaluationsstudie teilnehmen. Vielmehr wurde ihnen die Untersuchung als „Forschungsstudie zum Einfluss eines Umzugs auf alltägliche Mobilitätsmuster“ präsentiert. Ferner haben wir die Durchführung von Befragung und Intervention organisatorisch getrennt. Während beide Befragungen unter dem Briefkopf unsere universitären Forschungsgruppe durchgeführt wurden, wurde die Intervention selbst durch den Verkehrsverbunds Stuttgart verschickt. In den Interventionsunterlagen tauchte an keiner Stelle ein Hinweis auf unsere Befragung auf. Den Untersuchungsteilnehmern war also weder bewusst, dass sie an einem Experiment teilnahmen, noch lag ein Zusammenhang zwischen Befragung und Intervention auf der Hand.

Stichprobe

Von den ca. 800 am alten Wohnort kontaktierten potenziellen Umzüglern haben insgesamt 241 den 1. Fragebogen am alten Wohnort ausgefüllt und an uns zurückgeschickt. Tabelle 3 stellt für diese 241 Teilnehmer die Verteilung der Merkmale Geschlecht, Alter, Haushaltsgröße, Bildungsabschluss, Berufstätigkeit, Nettohaushaltseinkommen, Pkw-Anzahl im Haushalt, Führerscheinbesitz und Pkw-Verfügbarkeit dar.

Wie sich Tabelle 3 entnehmen lässt, hat eine relativ junge (Durchschnittsalter 28,5 Jahre) und gut ausgebildete (ca. 80% haben Abitur bzw. einen Hochschulabschluss) Stichprobe an der Untersuchung teilgenommen. Rund 95 % der Befragten besitzen einen Führerschein, in 88% aller Haushalte ist wenigstens 1 Pkw vorhanden und 73 % der Befragten geben an, persönlich ständig über einen Pkw verfügen zu können. Von den 241 Personen, die an der 1. Befragung teilgenommen haben, sind innerhalb des Untersuchungszeitraums 169 (70 %) tatsächlich nach Stuttgart umgezogen und haben auch den 2. Fragebogen ausgefüllt (90 aus der Kontroll- und 79 aus der Experimentalgruppe).

Tabelle 3:

Soziodemographische Merkmale der Untersuchungsteilnehmer (N = 241), die an der 1. Befragung teilgenommen haben (Prozentsätze und Mittelwerte).

Merkmal		Merkmal	
Frauen	46.9 %	Erwerbstätig	
Alter in Jahren Range (17-58)	28.5	voll erwerbstätig	60.3 %
Haushaltsgröße Range (1-12)	2.4	Teilzeit	7.5 %
Bildungsabschluss		stundenweise	12.6 %
keinen Abschluss	2.1 %	nicht erwerbstätig	19.7 %
Haupt-/Volksschule	2.1 %	Netto Haushaltseinkommen	
Mittlere Reife	15.0 %	< 1.999 DM	19.8 %
Abitur	43.3 %	2000-3999	36.6 %
FH/Uni-Abschluss	37.5 %	4000-5999	23.8 %
Pkws im Haushalt (Range 0-7)	1.4	6.000-7.999	12.3 %
Pkw jederzeit verfügbar	72.8 %	8.000-9.999	3.5 %
Führerschein	95.8 %	> 10.000 DM	3.9 %

Mittels logistischer Regression (Teilnahme an der 2. Befragung =1; Nicht-Teilnahme = 0) haben wir untersucht, ob sich die 72 Personen, die nicht an der 2.

Befragung teilgenommen haben, systematisch von den 169 Personen unterscheiden, die teilgenommen haben. Keine von den 20 in der Analyse berücksichtigten soziodemographischen und verkehrsmittelnutzungs-bezogenen Variablen aus der 1. Befragung weisen eine statistisch signifikante Beziehung mit der Teilnahme in der 2. Befragung auf.

Messinstrumente

Tatsächliche Verkehrsmittelnutzung: Die tatsächliche Verkehrsmittelnutzung wurde mittels eines standardisierten Protokollbogens erfasst (sog. KONTIV-Design, Sozialdata, 1993). In dem Protokollbogen notierten die Befragten für jeden von ihnen an einem vorgegebenen Tag außerhalb der Wohnung unternommenen Weg den Zeitpunkt und Ausgangspunkt (z.B. Montag, 1.10.2000, 8.00 Uhr, eigene Wohnung), den Wegzweck (vorgegebene Kategorien Arbeitsplatz, Einkaufen, Freizeit, Ausbildung, nach Hause, sonstiges), das benutzte Verkehrsmittel (vorgegebene Kategorien zu Fuß, Fahrrad/Motorrad, Pkw als Fahrer, Pkw als Mitfahrer, Bus, U-, S-, Straßenbahn, sonstiges), die Zieladresse, den Zeitpunkt der Ankunft sowie die geschätzte Entfernung des Weges.

Zeit- und Geldkosten: Um den Befragten eine präzisere Schätzung der mit der Pkw- bzw. ÖV-Nutzung verbundenen Geld- und Zeitkosten zu ermöglichen, haben wir sie gebeten, für den im Wegeprotokoll protokollierten zweiten Weg folgende Fragen zu beantworten: (1) Wieviel Geld (in DM) kostet Sie die Nutzung des Pkw bzw. öffentlicher Verkehrsmittel für den von Ihnen protokollierten zweiten Weg?; (2) Wie viel Zeit (in Minuten) brauchen Sie, wenn Sie für den von Ihnen protokollierten zweiten Weg den Pkw bzw. öffentlicher Verkehrsmittel benutzen? Wenn Sie es nicht genau wissen, schätzen Sie doch bitte.

Bei der Anwendung und Operationalisierung der Theorie des geplanten Verhaltens auf den Gegenstandsbereich "Verkehrsmittelwahl" haben wir uns an den Vorarbeiten von Bamberg und Schmidt (z.B. 1993, 1994, 1999) orientiert. Zur verhaltensspezifischen Messung der TPB-Konstrukte haben wir auch hier die Befragten gebeten, sich bei ihren Angaben explizit auf den von ihnen protokollierten zweiten Weg zu beziehen.

Kontrollüberzeugungen: Wenn Sie das nächste Mal wieder einen Weg, wie den von Ihnen im Wegeprotokoll als zweiten Weg protokollierten unternehmen, wie

wahrscheinlich treffen dann folgende Aussagen auf Sie zu? (1) Stände mir für diesen Weg ein Pkw zur Verfügung; (2) Wäre die Entfernung für die Radnutzung nicht zu weit; (3) Gäbe es eine ÖV-Verbindung zum Ziel; (4) Wäre diese ÖV-Verbindung zum Ziel relativ günstig; (5) Wäre ich ausreichend über die Abfahrtszeiten öffentlicher Verkehrsmittel informiert; (6) Würde ich die Einstiegshaltestelle der öffentlichen Verkehrsmittel kennen; (7) Müßte ich keine schweren Gegenstände transportieren. Die Befragten bewerteten die Zutreffenswahrscheinlichkeit jeder Aussage durch das Verteilen von Punkten. Wenn sie die Zutreffenswahrscheinlichkeit einer Aussagen als völlig unwahrscheinlich einschätzen, sollten sie 0 Punkte geben. Wenn sie hingegen die entsprechende Zutreffenswahrscheinlichkeit als völlig sicher einschätzen sollten sie 10 Punkte geben. Falls sie die Zutreffenswahrscheinlichkeit als weder wahrscheinlich noch unwahrscheinlich einschätzen, sollten sie 5 Punkte geben.

Behaviorale Überzeugungen: Wenn Sie das nächste Mal für den von Ihnen protokollierten zweiten Weg die Verkehrsmittel Pkw, Rad oder ÖV benutzt würden, wie sehr würden folgende 10 Attribute auf diese drei Verkehrsmittelalternativen zutreffen? (1) verkehrssicher; (2) vor Belästigung geschützt; (3) zuverlässig; (4) schnell; (5) bequem; (6) umweltfreundlich; (7) stressfrei; (8) flexibel; (9) sauber; (10) preiswert. Die Befragten bewerteten die relative Zutreffenswahrscheinlichkeit der 10 Attribute auf die drei Verkehrsmittelalternativen, indem sie so Punkte verteilten, dass die Gesamtsumme aller pro Attribut über die drei Alternativen verteilten Punkte 10 nicht übersteigt. Zur theoretischen Begründung für diese Vorgehensweise sowie der empirischen Evaluation der Reliabilität und Validität dieser Methode siehe z.B. Van den Putte, Hoogstraten, & Meertens (1996).

Normative Überzeugungen: Mit dem gleichen Verfahren haben wir die Einschätzung der Befragten erhoben, wie sehr folgende Personen es unterstützen würden, wenn sie das nächste Mal für den protokollierten zweiten Weg eine der drei Verkehrsmittelalternativen Pkw, Rad oder ÖV benutzen würden: (1) Partner/in; (2) Kollegen/innen; (3) Freunde/Bekannte.

Einstellung zum Verhalten: (1) Wenn Sie das nächste Mal für Wege wie den als zweiten Weg protokollierten eine der drei Verkehrsmittelalternativen Pkw, Rad oder ÖV

benutzen würden, wie gut oder schlecht wäre das Ihrer Meinung nach alles in allem ? (2) ... , wie angenehm oder unangenehm war das Ihrer Meinung nach alles in allem?

Subjektive Norm": (1) Wenn Sie das nächste Mal einen Weg wie den als zweiten Weg protokollierten unternehmen, welche der drei Verkehrsmittelalternativen sollten Sie nach Meinung für Sie wichtigen Menschen dabei benutzen? (2) ..., wie sehr würden für Sie wichtige Menschen die Nutzung der drei Verkehrsmittelalternativen unterstützen?

Wahrgenommene Verhaltenskontrolle: (1) Wie leicht bzw. schwer würde es Ihnen fallen, wenn Sie das nächst Mal für einen Weg wie den als zweiten Weg protokollierten die drei Verkehrsmittelalternativen Pkw, Rad oder ÖV benutzen würden? (2) Wie einfach oder kompliziert wäre es für Sie persönlich, ...

Intention: (1) Wie groß bzw. klein ist Ihre Absicht, das nächste Mal für einen Weg wie den als zweiten protokollierten eine der drei Verkehrsmittelalternativen Pkw, Rad oder ÖV zu nutzen ?; (2) Wie stark bzw. schwach ist Ihre Absicht, ...

Bei allen Items wurde das oben beschriebene Antwortverfahren benutzt: Die Befragten verteilten so Punkte auf die drei Alternativen Pkw, Rad und ÖV, dass die Gesamtsumme aller Punkte 10 nicht überschritt.

Ergebnisse

Verkehrsmittelnutzung am alten Wohnort (vor dem Umzug): In der 1. Befragung am alten Wohnort protokollieren die 241 Befragten insgesamt 1.039 Alltagswege. Von diesen 1.039 Wegen wurden 18,2 % zu Fuß, 12,5 % mit dem Rad, 55 % mit dem Pkw (als Selbst- oder Beifahrer) und 14,3 % mit öffentlichen Verkehrsmitteln zurückgelegt. Da sich ja die Einschätzung der Verkehrsmittelattribute durch die Befragten auf den zweiten protokollierten Weg beziehen, haben wir den entsprechenden Modal-Split für diesen zweiten Weg separat berechnet. Von den 239 protokollierten zweiten Wegen wurden 15 % zu Fuß, 12 % mit dem Rad, 53,4 % mit dem Pkw und 19,7 % mit öffentlichen Verkehrsmitteln zurückgelegt. Der für die zweiten Wege ermittelte Modal-Split entspricht also weitgehend dem über alle 1.039 Wege berechneten Modal-Split.

Einschätzung der Geld- und Zeitkosten: Am alten Wohnort schätzten die 241 Befragten dass die Nutzung des ÖV für den als zweiten protokollierten Wege im Durchschnitt (Median) 3,60 DM und die Pkw-Nutzung im Durchschnitt 3,00 DM gekostet hätte. Dieser Mittelwertsunterschied ist statistisch signifikant (t -Wert = 3.33; $p <$

0.01). Den mit der ÖV-Nutzung für den zweiten Weg verbundenen Zeitaufwand schätzen die Befragten im Durchschnitt auf 30 Minuten, während sie den mit Pkw-Nutzung verbundenen entsprechenden Zeitaufwand auf 15 Minuten schätzen. Auch dieser Unterschied ist signifikant (t-Wert = 11.36; $p < 0.00$).

Einschätzung der TPB-Konstrukte: Tabelle 4 stellt die Mittelwerte der von uns erhobenen ÖV- bzw. Pkw-bezogenen Kontrollüberzeugungen dar. Danach halten es die Befragten für relativ wahrscheinlich, dass sie das nächste Mal bei Wegen wie dem als zweiten protokollierten über einen Pkw verfügen könnten, dass sie ihr Ziel prinzipiell mit öffentlichen Verkehrsmitteln erreichen könnten, wüssten wo sie die nächste Haltestelle finden und keine schweren Gegenstände transportieren müssten. Als eher unwahrscheinlich schätzen es die Befragten jedoch ein, dass es zu ihrem Ziel eine günstige ÖV-Verbindung gäbe. Ferner sind sie sich unsicher, ob sie ausreichend über die Abfahrtszeiten der öffentlichen Verkehrsmittel informiert wären. Tabelle 4 lässt sich ebenfalls entnehmen, dass die Befragten 8 der 10 vorgegebenen Verkehrsmittelattribute deutlich stärker mit der Pkw-Nutzung als der ÖV-Nutzung verbinden. Bis auf die Einschätzung der Eigenschaft "stressfrei" sind alle Mittelwertsunterschiede statistisch signifikant ($p < 0.05$). Tabelle 4 stellt auch die mittlere Einschätzung der normativen Überzeugungen dar. Die Befragten halten es für sehr viel wahrscheinlicher, dass wichtige Bezugspersonen von ihnen erwarten den Pkw zu benutzen (für alle Mittelwertsunterschiede ist $p < 0.05$).

Tabelle 4:

Ausprägung (Mittelwerte) der Verkehrsmittelwahldeterminanten am alten Wohnort (vor Umzug), N = 241

<u>Kontrollüberzeug.</u>		<u>behaviorale Überzeug.</u>	<u>ÖV</u>	<u>Pkw</u>	<u>norm. Überzeug</u>	<u>ÖV</u>	<u>Pkw</u>
Pkw verfügbar ^a	7.5	Verkehrssicher ^b	4.7	3.3	Partner ^b	2.3	4.7
gibt Verbindung	6.9	Ohne Belästigung	1.7	6.0	Kollegen	2.7	4.8
gute Verbindung	3.8	Zuverlässig	2.8	4.4	Freunde	2.6	4.8
ÖV-Abfahrtswissen	5.0	Schnell	2.3	5.4			
Haltestellenwissen	8.1	Bequem	2.5	6.1	<u>Einstellung^c</u>	2.5	5.1
keine Transporte	8.5	Umwelt	2.8	0.6	<u>subj. Norm^c</u>	2.7	4.7
		Stressfrei	3.3	3.6	<u>PBC^c</u>	2.3	5.3
		Flexibel	0.8	6.0	<u>Intention^c</u>	2.5	4.9
		Sauber	2.3	3.8			
		Preiswert	1.5	1.9			

Anmerkung: ^a Range von 0 - 10 Punkten; ^b theoretisch möglicher Range 0-10; ^c

gemittelter Index aus 2 Items, theoretisch möglicher Range 0-10.

Wie aufgrund der Ausprägung der behavioralen und normativen Überzeugungen zu erwarten ist, sind die Einstellung und subjektive Norm bezüglich der Pkw-Nutzung sehr viel positiver und die wahrgenommene Kontrolle über die Pkw-Nutzung sehr viel größer als die entsprechenden Mittelwerte für ÖV-Nutzung. Entsprechend ist auch die Intention, den Pkw zu benutzen, sehr viel stärker als die Intention, den ÖV zu nutzen. Zusammenfassend zeigen alle am alten Wohnort erhobenen subjektiven Einschätzungen eine deutliche Präferenz für das Verkehrsmittel Pkw.

Multivariate Analysen

Test der engen RCT-Version mittels Logit-Analyse. Tabelle 5 stellt die Ergebnisse eines multivariaten Logit-Modells dar, mit dem wir für unseren Datensatz die Erklärungskraft der engen RCT-Version testen möchten. Wie die in Tabelle 2 dargestellten Arbeiten verwenden wir in diesem Modell nur die Pkw-Verfügbarkeit, die Weglänge in km, sowie die Differenzwerte der ÖV- bzw Pkw-bezogenen Geld-, Zeit- und Komfortkosten als Prädiktoren der tatsächlichen ÖV- versus Pkw-Nutzung beim dem als zweiten protokollierten Weg. Aus Vergleichbarkeitsgründen haben wir ebenfalls wie die in Tabelle 2 dargestellten Arbeiten ausschließlich Personen berücksichtigt, die den zweiten Weg mit den Verkehrsmitteln ÖV und Pkw zurückgelegt haben. Die 63 Personen, die für den zweiten Weg andere Verkehrsmittel benutzt haben, werden bei dieser Analyse nicht berücksichtigt.

Wie sich Tabelle 5 entnehmen lässt, liefert der empirische Test dieses Modells Ergebnisse, die weitgehend den in Tabelle 2 dargestellten Ergebnissen entsprechen: Lediglich die Pkw-Verfügbarkeit und die relativen Zeit- und Komfortkosten haben einen signifikanten Einfluss auf die Wahrscheinlichkeit, mit der beim 2. Weg der ÖV bzw. der Pkw benutzt wird.

Tabelle 5:
 Test der engen RCT-Version (N = 178, multivariates Logit-Modell)

	Logit	p
<u>Soziodemographische Merkmale</u>		
Geschlecht (1=Frauen)	0.82	0.09
Alter in Jahren	0.01	0.84
Haushaltsgröße	-0.06	0.80
Bildungsabschluss	-0.11	0.67
Erwerbstätig	-0.32	0.13
Nettohaushaltseinkommen	-0.16	0.40
Anzahl PKW im Haushalt	-0.02	0.95
Pkw jederzeit verfügbar	-1.67	0.01
<u>Merkmale des Wegs / der Verkehrsmittel</u>		
Entfernung in km	0.00	0.86
Differenzwert „Fahrzeit in Min.“	-0.03	0.03
Differenzwert „Fahrtkosten in DM“	0.02	0.51
Differenzwert „bequem“	0.27	0.00
Konstante	2.92	
-2LL	138.12	
Pseudo-R ²	32%	

Anmerkung: -2LL für das Konstantenmodell beträgt 203.420; ÖV-Nutzung = 1

Empirischer Vergleich der „engen“ und „weiten“ RCT-Version mittels Logit-Analyse.

Tabelle 6 (Modell 1) stellt das Endergebnisse einer Logit-Analyse (N = 178) dar, bei der wir die behavioralen und Kontrollüberzeugungen als Prädiktoren verwendet haben (Modell 1 berichtet nur die signifikanten Prädiktoren).

Bei den Verkehrsmittelattributen (behavioralen Überzeugungen) handelt es sich ebenfalls um Differenzwerte (z.B. „ÖV schnell“ - „Pkw schnell“). Wie sich Tabelle 6 entnehmen lässt, haben zwei Kontrollüberzeugungen (Pkw-Verfügbarkeit und ausreichendes Abfahrtswissen) und zwei behaviorale Überzeugungen (schnell und stressfrei) einen direkten signifikanten Effekt auf die Wahlwahrscheinlichkeit von ÖV bzw. Pkw. Weiter fällt auf, dass die empirische Erklärungskraft dieses Modells deutlich höher ist als die des in Tabelle 5 dargestellten Modells (Pseudo-R² 51% versus 32%).

Modell 2 in Tabelle 6 testet, ob die wahrgenommenen normativer Erwartungen wichtiger Bezugspersonen (Differenzwertindex aus den 3 normativen Überzeugungen) einen zusätzlichen, unabhängigen Beitrag zur Erklärung der Wahl zwischen ÖV und Pkw haben. Wie sich Tabelle 6 entnehmen lässt, steigt bei Berücksichtigung der

wahrgenommenen normativen Erwartungen Dritter die empirische Erklärungskraft des Modells drastisch an (Pseude-R² 89% versus 51%).

Tabelle 6:

Vergleichender Test der engen vs. weiten RCT-Version (N = 178; multivariates Logit-Modell)

	Modell 1		Modell 2		Modell 3	
	Logit	p	Logit	p	Logit	p
Pkw für 2. Weg verfügbar	-0.26	0.01	-0.44	0.06	-0.65	0.09
Ausreichendes ÖV-Wissen	0.44	0.00	0.42	0.03	0.39	0.06
Differenzwert „schnell“	0.43	0.00	0.40	0.02	0.61	0.04
Differenzwert „stressfrei“	0.37	0.00	0.55	0.01	0.80	0.03
Differenzwert „Norm“	---	---	0.35	0.00	0.43	0.00
Differenzwert „Fahrzeit“	---	---	---	---	0.06	0.28
Differenzwert „bequem“	---	---	---	---	-0.17	0.39
Konstante	-1.89	0.15	0.61	0.78	1.84	0.51
-2LL	61.46		22.96		21.41	
Pseudo-R ²	51%		89%		89%	

Anmerkung: -2LL für Konstantenmodell beträgt 203.420, ÖV-Nutzung = 1, Pkw-Nutzung = 0

Modell 3 in Tabelle 6 testet, ob die in Tabelle 5 signifikanten Zeit- und Komfortkostendifferenzen noch einen zusätzlichen Erklärungsbeitrag leisten. Wie sich Tabelle 6 entnehmen lässt, führt in unseren Daten die Berücksichtigung dieser beiden Variablen zu keiner signifikanten Erhöhung der Erklärungskraft.

Direkter Test der TPB mittels Strukturgleichungsansatz: Bei den bisherigen Analysen haben wir den von den Vertretern der engen RCT-Version präferierten Logit-Ansatz benutzt. Mit Eingleichungsansätze wie die logistische Regression lässt sich jedoch die von TPB postulierte Kausalstruktur nicht simultan testen. Wie oben dargestellt, postuliert ja die TPB gar nicht, dass die behavioralen, normativen und Kontrollüberzeugungen das Verhalten direkt beeinflussen, sondern nur indirekt über die vermittelnden Variablen Einstellung, Norm, Verhaltenskontrolle und Intention (siehe Abbildung 1). Strukturgleichungsmodelle erlauben einen direkten simultanen Test solcher Modelle mit kausal vermittelnden Variablen. Ein weiterer Vorteil dieser Methode besteht darin, dass sie die postulierten Beziehungen zwischen den theoretischen Konstrukten auf der Ebene latenter Variablen testet, die vorher über konfirmatorische Faktorenanalysen aus den beobachteten Indikatoren (Fragebogenitems) geschätzt werden. Diese explizite Modellierung von Messmodellen ermöglicht die Kontrolle von zufälligen

und systematischen Messfehlern, deren Nichtberücksichtigung die Schätzung der eigentlich interessierenden Beziehung zwischen den Modellvariablen verzerren kann (vgl. Bollen, 1989). Abbildung 2 stellt graphisch die Ergebnisse (standardisierte Pfadkoeffizienten und erklärte Varianzen) eines Strukturgleichungsmodells dar, das die von der TPB postulierte Beziehungsstruktur direkt testet. Bis auf die Kontrollüberzeugungen haben wir für alle Items die entsprechenden ÖV-Pkw-Differenzwerte gebildet. Um möglichst homogene und eindimensionale Messmodelle für die latenten Variablen zu bekommen, haben wir alle Indikatoritems mit Faktorladungen unter 0.50 aus der Analyse entfernt (Ausnahme die Kontrollüberzeugungen "Haltestellenwissen"). Zur Messung des latenten Konstrukts "tatsächliche ÖV-Nutzung" haben wir zwei Indikatoren erzeugt: die Dummy-Variable "Bei 2. Weg ÖV genutzt" (Ja = 1; Nein = 0) und die metrische Variable "prozentualen Anteil der restlichen protokollierten Weg, die mit dem ÖV zurückgelegt wurden". Wie sich Abbildung 2 entnehmen lässt, sind die Differenzwertvariablen "stressfrei", "schnell", "bequem" und "zuverlässig" die besten Indikatoren der latenten Variable "behaviorale Überzeugungen.

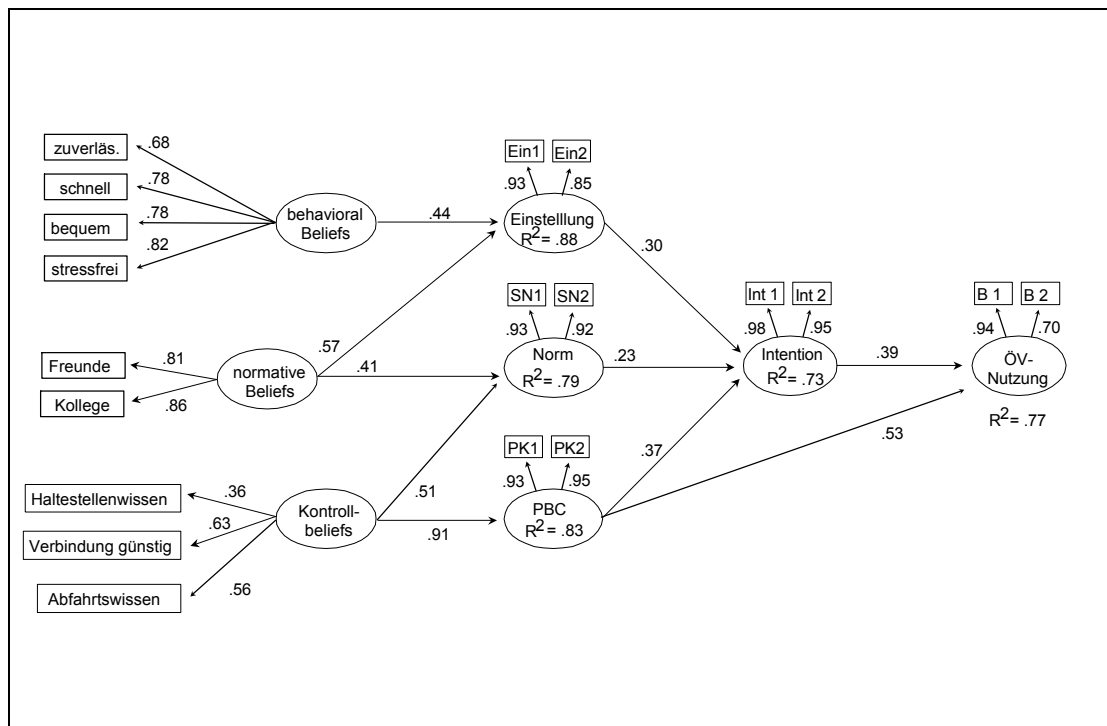


Abbildung 2: LISREL-Test der Theorie des geplanten Verhaltens, $N = 178$;
 Differenzwerte, Masse der Modellanpassung: $\chi^2 = 226.27$; $df = 135$; $RMSEA = 0.06$;
 $NNFI = 0.96$; $CFI = 0.97$

Die wahrgenommene Erwartung von Kollegen und Freunde sind die besten Indikatoren der latenten Variablen “normative Überzeugungen” und die Einschätzung, dass es eine günstige ÖV-Verbindung zum Ziel gibt sowie dass man ausreichend über die ÖV-Abfahrtszeiten informiert ist, sind die besten Indikatoren der latenten Variablen “Kontrollüberzeugungen”. Wie von der TPB postuliert, determinieren die behavioralen, normativen und Kontrollüberzeugungen ihrerseits die Einstellung, subjektive Norm und wahrgenommene Verhaltenskontrolle. Abweichend von den Annahmen der TPB zeigt sich jedoch, dass die normativen Überzeugungen nicht nur die subjektive Norm beeinflussen, sondern auch die Einstellung. Die Kontrollüberzeugungen beeinflussen nicht nur die wahrgenommene Verhaltenskontrolle, sondern auch die subjektive Norm. Einstellung, subjektive Norm und wahrgenommene Verhaltenskontrolle determinieren ihrerseits die Intention, Intention und Verhaltenskontrolle zusammen das tatsächliche Verhalten.

Wie lassen sich die zentralen Ergebnisse unserer bisherigen Analysen zusammenfassen? In Übereinstimmung mit bisherigen Anwendungen der engen RCT-Version zeigen auch die vorliegenden Daten, dass die Pkw-Verfügbarkeit und die eingeschätzten Zeitkosten wichtige Kriterien bei der Entscheidung sind, einen spezifischen Weg mit dem ÖV oder dem Pkw zurückzulegen. Hingegen scheinen die mit der Nutzung der Verkehrsmittel ÖV und Pkw verbundenen Geldkosten eine vernachlässigbare Größe darzustellen. Unserer Analysen zeigen jedoch auch, dass es neben der Eigenschaft “schnell” noch weitere Verkehrsmiteleigenschaften wie z.B. zuverlässig oder stressfrei gibt, die vermittelt über die Einstellung einen Einfluss auf die individuelle Verkehrsmittelwahl haben. Ein weiteres interessantes Ergebnis unserer Analysen ist der substantielle Effekt der subjektiven Norm auf die Intention. Anscheinend orientieren sich Menschen bei ihrer Verkehrsmittelwahl nicht nur an den wahrgenommenen persönlichen Nutzungskonsequenzen, sondern auch an den antizipierten Erwartungen wichtiger Bezugspersonen. Auf den zweiten Blick dieser Befund eigentlich nicht verwunderlich. Bei vielen Alltagshandlungen orientieren wir uns an den Einschätzungen, Meinungen und dem Verhalten der uns umgebenden Menschen. Viele Marketingkonzepte (nicht zuletzt die für Pkws) benutzen ja explizit solche sozialen Einflussfaktoren (z.B. Sozialprestige) als Ansatzpunkte. Ferne liefern unsere Analysen

deutliche empirische Belege für die Annahme der weiten RCT-Version, dass Menschen ihre alltäglichen Entscheidungen nicht auf der Grundlage vollständiger Informationen fällen. Die von uns Befragten räumen freimütig ein, nicht ausreichend über handlungsrelevantes ÖV-Wissen, wie z.B. die Abfahrtszeiten, zu verfügen. Die Analyseergebnissen belegen, dass diese fehlenden Informationen vermittelt über die wahrgenommene Verhaltenskontrolle einen starken indirekten Effekt auf die Nutzungswahrscheinlichkeit des ÖVs haben.

Hat die Intervention "Persönliches Informationspaket" einen Einfluss auf die Verkehrsmittelwahl am neuen Wohnort Stuttgart?

Bei der Beantwortung dieser Frage stützen wir uns auf die Angaben der 169 Befragten, die während des Untersuchungszeitraums umgezogen sind und den zweiten Fragebogen ausgefüllt an uns zurückgeschickt haben. Nach dem Umzug steigt bei diesen 169 Personen der Anteil der Wege, die mit dem ÖV zurückgelegt werden, deutlich an (von 12,8 % auf 29,3 %, $p < 0.001$). Entsprechend verringert sich der Pkw-Anteil am Modal-Split von 55,5 % vor dem Umzug auf 41,8 % nach dem Umzug ($p < 0.001$). Der Rad-Anteil geht von 12,7 % vor dem Umzug auf 5,8 % nach dem Umzug zurück ($p = 0.03$). Der Anteil der Wege, die zu Fuß zurück gelegt werden, verändert sich hingegen nicht signifikant ($p = 0.13$). In der Gesamtstichprobe zeigen sich nach dem Umzug also deutliche Veränderungen im Modal-Split. Wenn unsere Intervention "Persönliches Informationspaket" einen kausalen Einfluss auf die Verkehrsmittelwahl nach dem Umzug gehabt hat, sollte sich bei den Personen, die unsere Intervention erhalten haben, eine stärkere Veränderung in der Verkehrsmittelnutzung am neuen Wohnort zeigen, als bei den Personen, die diese Intervention nicht erhalten haben. Abbildung 3 stellt getrennt für die Kontroll- und Experimentalgruppe die ÖV-Nutzung beim zweiten Weg vor und nach dem Umzug dar.

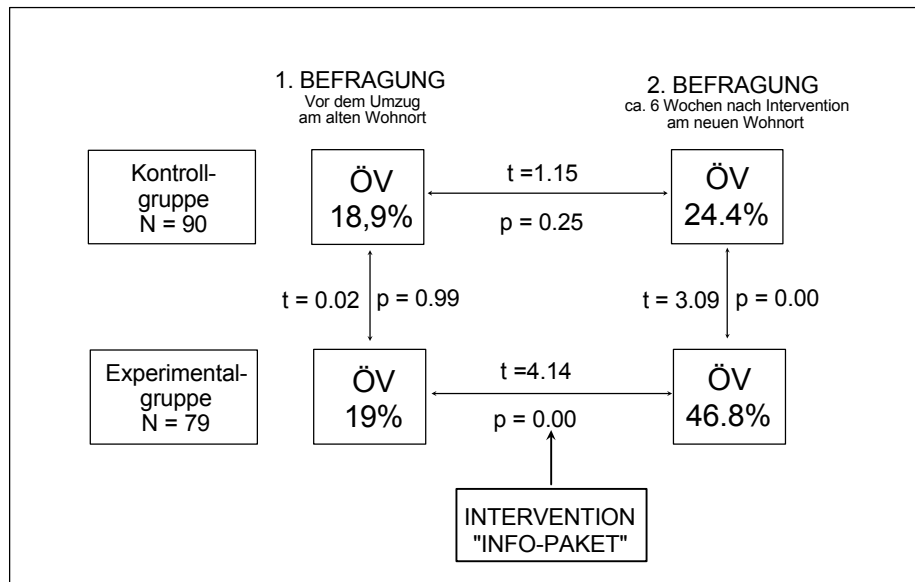


Abbildung 3: Veränderung der ÖV-Nutzung für den zweiten protokollierten Weg vor / nach dem Umzug getrennt für Kontroll- und Experimentalgruppe

Vor dem Umzug unterscheiden sich Kontroll- und Experimentalgruppe nicht signifikant in ihrer ÖV-Nutzung ($p = 0.99$). In der Kontrollgruppe zeigt sich auch nach dem Umzug keine signifikante Veränderung der ÖV-Nutzung ($p = 0.25$). Diese Befund deutet darauf hin, dass es ohne Intervention alleine aufgrund des Umzugs zu keiner bedeutsamen Veränderung in der ÖV-Nutzung gekommen wäre. Hingegen zeigt sich in der Experimentalgruppe eine drastische Veränderung der ÖV-Nutzung. Während die Experimentalgruppe am alten Wohnort 19 % alles protokollierten zweiten Wege mit dem ÖV zurücklegt, steigt nach dem Umzug dieser ÖV-Anteil auf 46.8 % an.

Analyse kausal vermittelnder Prozesse:

Wie lässt sich dieser starke Effekt der Intervention "Persönliches Informationspaket" erklären? Vertreter der engen RCT-Version könnten argumentieren, dass die stärkere ÖV-Nutzung weniger eine Folge der Intervention als vielmehr des Umzug nach Stuttgart ist: In der Landeshauptstadt Stuttgart ist das ÖV-System einfach objektiv besser und billiger, während die Pkw-Nutzung aufgrund verstopfter Strassen und knapper Parkplätze weniger attraktiv ist. Aufgrund des experimentellen Designs können

wir diese Alternativerklärung verwerfen. Wenn sie zutreffend wäre, müsste sich sowohl in der Kontroll- wie in der Experimentalgruppe die ÖV-Nutzung erhöhen. Durch den Umzug bewirkte Veränderungen der objektiven Rahmenbedingungen erklären alleine den drastischen Anstieg der ÖV-Nutzung in der Experimentalgruppe nicht.

Tabelle 7 stellt die vor bzw. nach dem Umzug/Intervention mit der ÖV- bzw. der Pkw-Nutzung verbundener behavioraler, normativer und Kontrollüberzeugungen getrennt für die Experimental- und Kontrollgruppe dar. Bei den behavioralen und normativen Überzeugungen handelt es sich wieder um Differenzwertvariablen (ÖV minus Pkw). Wie sich Tabelle 7 entnehmen lässt, sind in der Experimentalgruppe nach dem Umzug die Mittelwerte von 16 der 17 untersuchten Variablen statistisch signifikant höher als vor dem Umzug. In der Experimentalgruppe steigen besonders deutlich die Mittelwerte der Items zur Messung der Konstrukte "Einstellung", "Norm" "PBC" und Intention an. So sind nach dem Umzug die Vorzeichen die Intensionsdifferenzwerte sogar positiv, d.h. die Intention, den ÖV zu nutzen, ist in der Experimentalgruppe nach dem Umzug stärker als die Intention den Pkw zu nutzen. In der Kontrollgruppe verändern sich hingegen nur 5 der 17 Mittelwerte statistisch signifikant: Eine Veränderung betrifft die Einschätzung, inwieweit es eine günstige ÖV-Verbindungen gibt. Diese veränderte Einschätzung könnte auf den Personen beruhen, die aus kleineren Städten bzw. Dörfern nach Stuttgart umgezogen sind und jetzt davon ausgehen, dass es in einer Großstadt einfach ein besseres ÖV-Angebot geben muss. Die nach dem Umzug ebenfalls höhere Verhaltenskontrolle ist vermutlich eine Folge dieser Einschätzung. Weiter erhöhen sich in der Kontrollgruppe die wahrgenommenen normativen Erwartungen von Partner/in und Kollegen/innen, den ÖV zu nutzen. Diese Veränderung spiegelt sich jedoch nicht in einer entsprechenden Veränderung der subjektiven Norm wider. Insgesamt scheinen in der Kontrollgruppe die Veränderungen der verkehrsmittelbezogenen Überzeugungen nicht gravierend genug zu sein, um die dem Verhalten direkt vorgelagerten Intention zu verändern.

Tabelle 7:
Mittelwertsveränderungen verkehrsmittelbezogener Einschätzungen vor und nach dem Umzug /der Intervention (N = 169)

Variable	Experimentalgruppe N = 79			Kontrollgruppe N = 90		
	Vorher	Nachher	p	Vorher	Nachher	p
<i>Behavioral Beliefs</i>						
BEQUEM	-3.6	-2.7		-3.7	-3.9	
SCHNELL	-3.5	-2.0	***	-3.0	-2.6	
ZUVERLÄSSIG	-2.3	-0.6	***	-1.5	-1.0	
STRESSFREI	-1.0	0.7	**	-0.2	-0.2	
<i>Kontrolbeliefs</i>						
PKW-ERFÜGBARKEIT	7.5	6.5	*	7.1	6.9	
ÖV-VERBINDUNG	6.5	8.0	**	6.9	7.4	
GÜNSTIGE VERBINDUNG	3.2	5.7	***	3.9	5.3	**
ABFAHRTSWISSEN	5.1	6.6	**	5.1	6.0	
<i>normative Beliefs</i>						
PARTNER/IN	-2.7	-0.6	***	-2.0	-0.5	**
KOLLEGEN/FREUNDE	-2.5	-0.5	***	-2.3	-0.8	**
<i>TPB-Kernkonstrukte</i>						
EINSTELLUNG 1	-3.6	0.0	***	-1.9	-0.9	
EINSTELLUNG 2	-3.6	-1.2	***	-3.0	-2.6	
NORM 1	-3.0	0.1	***	-1.6	-0.6	
NORM 2	-2.7	-0.6	***	-1.5	-0.6	
PBC 1	-3.5	-0.2	***	-2.7	-1.5	*
PBC 2	-3.5	-0.4	***	-2.6	-1.3	**
INTENTION 1	-2.4	1.3	***	-2.2	-1.4	
INTENTION 2	-2.8	1.2	***	-2.1	-1.0	

Anmerkung: Theoretischer Range der Differenzvariablen von -10 bis +10; negative Werte bedeuten höhere Ausprägung der Alternative PKW in dieser Variablen im Vergleich mit dem ÖV, * p < 0.05; ** p < 0.01; ***p < 0.001

Die bisherigen Befunde belegen, dass sich bei den Personen, die die Intervention “Persönliches Informationspaket” erhalten haben, die behavioralen, normativen und Kontrollüberzeugungen deutlich zugunsten des ÖV verändert haben. Sind diese Veränderungen nun eine direkte kausale Konsequenz der Intervention “Persönliches Informationspaket”? Wie oben diskutiert, vermuten wir ja, dass die Intervention das Verhalten über einen anderen, indirekteren Mechanismus beeinflusst: Die Situation “Umzug” zwingt die Menschen dazu, ihre Alltagsmobilität neu zu organisieren, d.h. auch ihre bisherige Verkehrsmittelwahl bewusst in Frage zu stellen. Nach einem Umzug sind die Menschen offener für neue Informationen und auch motivierter, einmal eine andere

Alternative auszuprobieren. Wir gehen davon aus, dass die Verhaltenswirksamkeit der Intervention "Persönliches Informationspaket" darauf beruht, dass sie den Teilnehmern den ÖV wieder als potentiell attraktive Alternative bewusst gemacht hat und sie dazu motiviert ihn tatsächlich einmal auszuprobieren. Erst die dabei gemachten persönlichen Erfahrungen bewirken eine Veränderung der ÖV-bezogenen Einschätzungen.

Diese Vermutung lässt sich zumindestens ansatzweise an unseren Daten empirisch überprüfen. Wenn die Intervention direkt die ÖV bezogenen Einschätzungen verändert hat, sollte sich ein signifikanter direkter Effekt der Zugehörigkeit zur Experimental- vs. Kontrollgruppe auf die Einschätzung der behavioralen, normativen und Kontrollüberzeugungen nach der Intervention zeigen. Wenn hingegen die Intervention über den eben beschriebenen motivationalen Mechanismus wirkt, sollte die Zugehörigkeit zur Experimental- vs. Kontrollgruppe einen direkten Effekt auf die Intention haben.

Abbildung 4 stellt die Ergebnisse eines längsschnittlichen Strukturgleichungsmodells dar, mit dem wir diese Annahmen getestet haben. Um angesichts des relativ kleinen Datensatzes von $N = 169$ den Modelltest nicht zu komplex werden zu lassen, haben wir die zwischen den Überzeugungen und der Intention vermittelnden Konstrukte Einstellung, Norm und wahrgenommenen Verhaltenskontrolle aus dem Modell entfernt. Stattdessen verwenden wir die latenten Konstrukte "behaviorale Beliefs", "normative Beliefs" und "Kontrollbeliefs" als direkte Prädiktoren der Intention. Ferner sind in Abbildung 4 aus Übersichtlichkeitsgründen nicht die Messmodelle dargestellt. Zu beiden Messzeitpunkten verwenden wir jedoch dieselben Messmodelle, die wir in Abbildung 3 dargestellt haben. Um die Stabilität der Messmodelle und des Strukturmodells über die Zeit zu testen, haben wir in der 2. Welle alle Messmodell- und Strukturmodellkoeffizienten den entsprechenden Koeffizienten aus der 1. Welle gleichgesetzt. Diese sehr restriktive Modell passt recht gut zu den Daten. Anscheinend bleibt also das Verständnis der zur Messung der latenten Konstrukte benutzten Items wie auch die Beziehungsstruktur dieser latenten Konstrukte über die Zeit stabil. Auffällig sind hingegen die niedrigen Stabilitätskoeffizienten, die von Intention und Verhalten sind sogar insignifikant. Die niedrigen Stabilitäten verdeutlichen noch einmal, welchen starken Effekt die Intervention hat. Die vor dem Umzug berichtet Nutzungsintention und

tatsächliche Verkehrsmittelnutzung sind keinen signifikanten Prädiktoren der nach dem Umzug bestehenden Intention und tatsächlichen Nutzung.

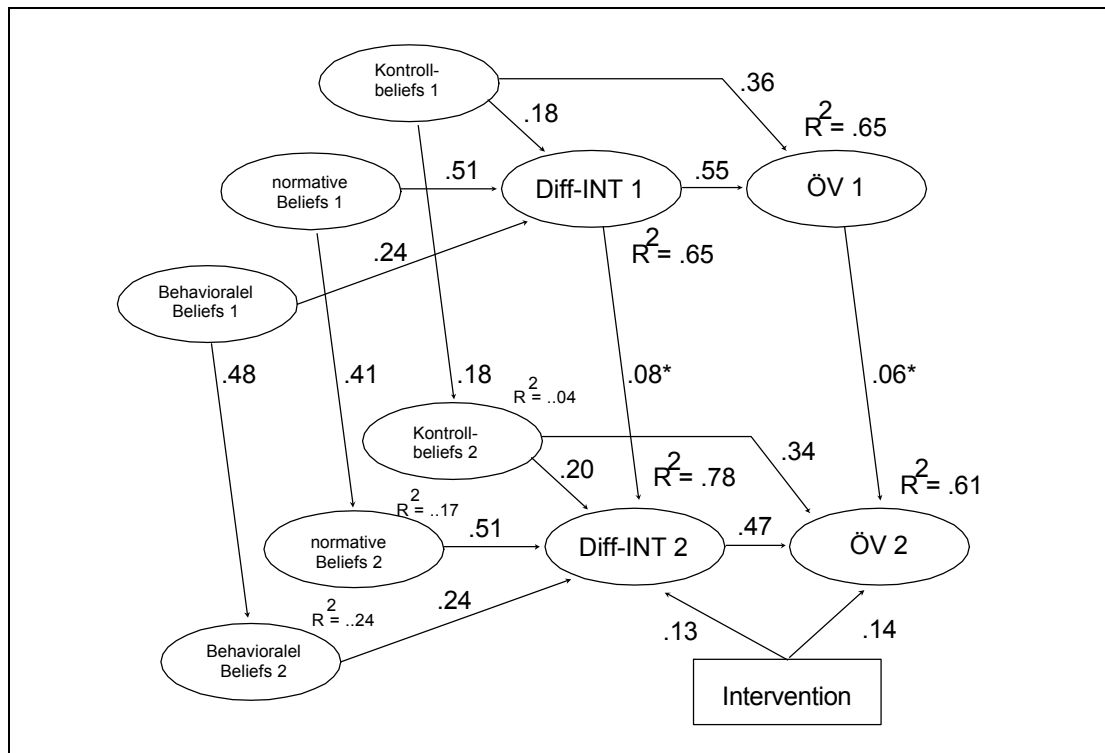


Abbildung 4: Längsschnittlicher LISREL-Test des TPB-Modells mit Interventionseffekten, N = 169; Differenzwerte, Masse der Modellanpassung: $\chi^2=581.95$; $df = 420$; RMSEA = 0.048; NNFI = 0.95; CFI = 0.95

Zur Analyse der Interventionseffekte haben wir in das Längsschnittmodell die Dummy-Variable “Zugehörigkeit zur Experimental- (1) vs. Kontrollgruppe (0)” als zusätzlichen Prädiktor mitaufgenommen. Wie sich Abbildung 4 entnehmen lässt, hat die Gruppenzugehörigkeit keinen direkten Effekt auf die in der 2. Welle berichteten behavioralen, normativen und Kontrollüberzeugungen. Stattdessen zeigen sich signifikante direkte Effekte der Gruppenzugehörigkeit auf die in der 2. Welle berichtet Intention sowie die tatsächliche ÖV-Nutzung. Dieser Befund stützt unserer Vermutung, dass die offensichtliche Verhaltenswirksamkeit der Intervention “Persönliches Informationspaket” weniger auf der sofortigen direkten Veränderung von behavioralen, normativen und Kontrollüberzeugungen beruht. Vielmehr scheint die Intervention

Menschen dazu zu motivieren, am neuen Wohnort den ÖV einmal auszuprobieren. Die dabei gemachten, anscheinend positiven, direkten persönlichen Erfahrungen scheinen dann zu einer Veränderung der mit der ÖV-Nutzung verbundenen Einschätzungen zu führen.

Diskussion

Im Mittelpunkt unseres Beitrags steht die Frage, wie fruchtbar die enge bzw. weite RCT-Version im Kontext der Entwicklung und Evaluation einer spezifischen verkehrspolitischen Maßnahme ist. Die zentrale Differenz zwischen den Vertretern der engen vs. weiten RCT-Version dreht sich um die Frage, wie notwendig die Berücksichtigung subjektiver, d.h. psychologischer Prozesse für die Erklärung von Verhalten bzw. Verhaltensveränderung ist. Konsequente Vertreter der engen RCT-Version tendieren dazu, den eigenständigen Erklärungswert subjektiver Wahrnehmungs- und Bewertungsprozesse als eher vernachlässigbar einzuschätzen. Verhalten bzw. Verhaltensveränderungen soll nach dieser Position ausschließlich durch die objektiven situativen Rahmenbedingungen determiniert werden. Die weite RCT-Version hingegen geht davon aus, dass subjektive, intrapsychische Prozesse unverzichtbare Größen für die Erklärung menschlichen Verhaltens sind.

Um nicht auf Ebene der Grundsatzdebatten Stecken zu bleiben, haben wir versucht, a priori aus beiden RCT-Versionen Annahmen über die Wirksamkeit einer spezifischen verkehrspolitischen Maßnahme abzuleiten. Bei dieser Maßnahme handelt es sich um eine typische "Soft-Policy"-Maßnahme. Solche Soft-Policy-Maßnahmen zielen nicht auf die Veränderung objektiver Rahmenbedingungen wie objektive Fahrzeit oder Fahrpreis ab. Diese Maßnahmen gehen vielmehr davon aus, dass in vielen Großstädten der schon existierende ÖV besser ist als sein Ruf. Das heißt, diese Maßnahmen betonen subjektive Informations- und Motivationsdefizite als zentrale Barrieren der ÖV-Nutzung. Konsequente Vertreter der engen RCT-Version müssen a priori die Verhaltenswirksamkeit solcher Maßnahmen als vernachlässigbar klein einschätzen. Diese Annahme haben wir im Rahmen dieser empirischen Evaluationsstudie überprüft. Eine Besonderheit unserer Studie besteht darin, dass wir ein echtes randomisiertes Experimentaldesign verwendet haben. Dieses Design ermöglicht es,

Verhaltensunterschiede zwischen Kontroll- und Experimentalgruppe kausal auf die Intervention zurück zuführen. Die Befunde des Feldexperiments sind eindeutig. In der Kontrollgruppe zeigt sich keine signifikante Verhaltensveränderung, in der Experimentalgruppe hingegen kommt es nach der Intervention zu einer drastischen Erhöhung der ÖV-Nutzung. Die Vorhersage der engen RCT-Version, Soft-Policy-Maßnahmen seien wirkungslos, wird damit in unserer Studie widerlegt.

Aus Sicht der engen RCT-Version muss dieser Befund auch deshalb überraschen, weil die Datenanalyse vor der Intervention Ergebnisse repliziert, wie sie Anwendungen der engen RCT-Version im Kontext Verkehrsmittelwahl typischerweise finden: Pkw-Verfügbarkeit und die relativen Zeit- und Komfortkosten sind wichtige Determinanten der Verkehrsmittelwahl. Obwohl die Maßnahme objektiv keinen Einfluss auf diese nach der engen RCT-Version zentralen Determinanten der Verkehrsmittelnutzung gehabt haben kann, steigen in der Experimentalgruppe Pkw-Nutzer auf den ÖV um.

Die Anwendung der TPB als sozialpsychologischen Variante der weiten RCT-Version, liefert hingegen sehr viel bessere Ansätze zur Erklärung der offensichtlichen Verhaltenswirksamkeit der Soft-Policy-Maßnahme. So zeigt die TPB-Anwendung, dass nicht nur die subjektiv wahrgenommenen relativen Zeit- und Komfortkosten wichtige Determinanten der ÖV-Nutzung sind, sondern auch Attribute wie 'zuverlässig' und 'stressfrei'. Ferner liefert sie deutliche empirische Belege dafür, dass auch die Verkehrsmittelwahl durch sozial-normative Faktoren beeinflusst wird. In unserem Kontext jedoch besonders wichtig ist der Befund, dass die Befragten selbst davon ausgehen, nur unvollständig die Informationen zu besitzen, die zur ÖV-Nutzung notwendig sind. Zusammen mit der Einschätzung, dass es eine günstige ÖV-Verbindung zum Ziel gibt, ist dieses Nutzungswissen, vermittelt über die wahrgenommene Verhaltenskontrolle und Intention eine zentrale Determinante der ÖV-Nutzung.

Wie oben diskutiert, gehen wir jedoch nicht davon aus, dass die Verhaltenswirksamkeit der Soft-Policy Maßnahme in erster Linie darauf beruht, dass sie direkt und bequem für die ÖV-Nutzung relevante Informationen liefert. Vielmehr gehen wir davon aus, dass Menschen, die sich einmal für die Verkehrsmittelalternative Pkw entschieden haben und diesen auch routinemäßig nutzen, sich kaum an diesem fehlenden ÖV-Wissen stören. Erst wenn Zweifel daran auftauchen, ob die bisherige

Verkehrsmittelnutzung eine gute Entscheidung darstellt, sind Menschen motiviert sich über mögliche Alternativen zu informieren. Der Umzug in eine neue Stadt stellt sicherlich eine Situation dar, die Menschen zu so einem Nachdenken über ihrer Verkehrsmittelwahl motivieren. Wahrscheinlich ist deshalb die spezifische Situation "Umzug" auch der Grund für die starke Verhaltenswirksamkeit der Soft-Policy Maßnahme. Nach dem Umzug sind Menschen besonders sensibel für Informationen über potenziell attraktive Verkehrsmittelalternativen und motiviert, diese einmal auszuprobieren. Aus dieser Perspektive beruht also die Verhaltenswirksamkeit unserer Maßnahme darauf, dass sie eine potenziell relevante Handlungsalternative zum richtigen Zeitpunkt ins Bewusstsein rückt und zugleich zum persönlichen Ausprobieren motiviert. Unserer Einschätzung nach wird in einem stabilen Entscheidungskontext – also bei Nichtumzügler*innen - die Verhaltenswirksamkeit von Soft-Policy-Maßnahmen deutlich geringer ausfallen. Der Befund, dass die Zugehörigkeit zur Experimental- vs. Kontrollgruppe keinen direkten Effekt auf die mit der ÖV-Nutzung verbundenen behavioralen, normativen und Kontrollüberzeugungen hat, sondern direkte Effekte auf die ÖV-Nutzungsintention und die tatsächliche ÖV-Nutzung, bestätigen diese Annahme empirisch. Vermutlich sind die bei dem ÖV-Test gemachten persönlichen Erfahrungen die direkte Ursache für die veränderten Überzeugungen.

Aus unserer Sicht belegen die Ergebnisse unserer Studie, dass im Kontext empirischer Evaluationsforschung die Anwendung der engen RCT-Version sehr problematisch ist. Die aus ihr abgeleitete Prognose, dass die Maßnahme "Persönliches Informationspaket" keinen Einfluss auf die individuelle Verkehrsmittelwahl haben sollte, ist offensichtlich falsch. Anscheinend sind ihre Annahme, was Menschen zur Verhaltensveränderung motiviert, in vielen Anwendungsbereichen zu restriktiv.

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The manuscript is being submitted for review to American Sociological Review.

**The Force of Habit and Rational Behavior.
An Empirical Test in the Context of travel-Mode Choice²³.**

Abstract

Are habits rational or automatic? For a long time the concept of habit has been neglected in the sociological literature, but in recent years it has received a growing attention. In the first part of this paper we compare approaches in sociology, social psychology and economics to view habits. Then we provide an empirical theory comparison of the economic and social psychological views we present, as the other approaches do not provide sufficient hints for an empirical operationalization. The economic approach presented is a rational choice model of Stigler and Becker. Data are collected in an intervention study to change travel mode choice, and focus on people moving to live in Stuttgart, Germany. Results confirm that habits have a strong automatic component even in a new context of a new town of residence. However, when other factors of the model and socio demographic characteristics are introduced into the regression, this effect disappears. Only a part of the rational choice model's implications regarding the rational character of habits is verified.

Key words: habits, custom and tradition; narrow and wide versions of rational choice; travel-mode choice; intervention study.

²³ A joint work with Peter Schmidt and Sebastian Bamberg.

1) Introduction

‘Are habits rational or automatic?’ Habits have been neglected for a long time in the sociological literature. Many sociologists since the beginning of the century have overlooked the role of habits. However, habits were an important component in the studies of Weber and Durkheim. In his historical study, Camic (1986) provides different reasons for this development, of which the most important one is the attempt to establish an independent discipline of sociology at the beginning of the century. This attempt for autonomy resulted with severed ties with psychology, where habits played an important role in theories (For a detailed description of the political processes see Camic 1986).

In spite of the fact that Parsons (1937:757) acknowledged the fact that sometimes it is needed to import notions from other disciplines, not including them in action theories in practice has not paved the way for their empirical test. This was also true for the exclusion of habits from action theories (Camic 1986). What remained, was decision models, which were purposive, rational, voluntaristic, decisional and reflective. This kind of models has been known as representing the narrow version of rational choice theory rather than the wider ones (Opp, 1999).

In the next section we will compare approaches to view habits in the literature. We will ask whether they were regarded as rational or automatic. We will not discuss addictions, as they are discussed in the literature as distinct from habits. Berger (2001) defines addictions as particularly strong habits, and as such they have a different behavioral function. Becker and Murphy (1988) provide as examples for addictions alcoholism or heroism (see also Becker, Grossman and Murphy, 1991). Although the literature is not always sharp in the distinction between addiction and habits, we view habits as an act of custom and tradition (Stigler and Becker, 1977).

Berger (2001) argues, that although there are different theories on habit formation and persistence, they have mainly three common properties: (1) habits are stronger the longer they already exist; (2) habits are stronger the more frequently they are repeated; (3) habits simplify actions as they economize on resources and decrease complexity. Not all these aspects are discussed by different authors. We will mention Durkheim, Weber, Bourdieu, Esser, and two views of habits in contemporary social psychology represented especially by Verplanken and Ajzen. Then we will discuss a rational choice model of Stigler and Becker to explain habits, and compare it with the other approaches. We will discuss the implications on habitual travel mode choice and on sociological theory on rational behavior.

In the second part of the paper we will conduct an empirical theory comparison. We will use data of travel mode choice for people moving to live in a new town. According to theory, a new context will provide a test whether habits are an automatic process. We test only the social psychological approaches and Stigler and Becker's model for the following reasons:

- 1) The other approaches do not provide sufficient hints how they can be operationalized. In particular, they do not imply what effect habits should have on behavior in a new context;
- 2) Linking rational choice models with empirical data is one of the goals of this study. The latter has not been challenged empirically yet.

Empirical studies in the social science literature include different approaches. One of them is often based on regression analyses to check for effects on a dependent variable, which is of interest. However, such findings (for example Franzen, 1997; Diekmann and Preisendörfer, 1998) are not based on a systematic development of a formal rational choice model. These findings have also not been applied to transform and improve a systematically developed rational choice model so that it will include these findings, and in this way serve as a better model. From such a viewpoint, they may not necessarily link rational choice with data on behavior.

Many rational choice models to explain behavior (for example Becker 1981, 1990, 1996) are indeed elegant, clear and sharp in their theoretical explanation. However, a large part of them has not been extensively empirically tested and validated. Sociological variables not incorporated in “narrow” rational choice models, such as gender, education or age, may have strong additional explanatory power. This sort of findings can be revealed in quantitative tests, which validate or falsify such models.

Opp (1998) and Simon (1985) call to pursue the hard work, which is often not done of testing rational action theory empirically. This seems especially relevant in the light of the criticism of Green and Shapiro (1994), who argued that present day rational choice applications are non-empirical or do not provide better explanations than other theoretical approaches. Goldthorpe (1998:52) has pointed out, that in present-day sociology rational action theory and the quantitative analysis of large-scale data sets are pursued largely in isolation from each other (see also Blossfeld and Prein, 1998). In this paper, we wish to fulfill and address their call by a conducting quantitative tests of models of habit.

2) Theoretical Background

Camic brings a historical overview for the broad use of habits, and their definitions. He points out, that habit was an established concept among ancient Greek thinkers, medieval scholastics, theologians and philosophers and among major figures in the Enlightenment, such as Rousseau, Hume and Kant (Camic 1986:1046-7). As a general framework, Camic defines habits as “the disposition to perform certain relatively elementary and specific activities skillfully” (p. 1045). In that sense habits are automatic but rational as the actions are performed skillfully. The action designated as habits broadens to various patterns of conduct in the social world. There could be habits of economic, political, religious and domestic behavior; habits of obedience to rules; habits of sacrifice and so on. These patterns of behavior may mix habitual and non-habitual (reflective) considerations. The habitual component has been viewed in different ways: as representing a mechanical reaction to particular stimuli (Reid 1788:114-117); as a stable behavior immune from external stimuli (for example, Hegel 1821:260); as being called

into play by the ego (for example, Hartmann 1939:88); or as comparable to a reflective process (Stewart, 1792-1827:54-57).

Early phases of Sociology

Durkheim viewed habits not only as a main determinant of human behavior in many areas, but also as a principal support of the moral fabric of modern societies. In a similar way, habit and tradition played a significant role in the studies of Weber on the modern economic and political life and on the spirit of capitalism (Camic, 1986).

Habit was often used by Durkheim throughout significant parts of his career. For example, Durkheim observed the empirical role of habit at different points of the evolutionary process. Primitive people, in his judgment, live to a large extent by the “force of habit” (1893:159; 1912:103). In his way of using the concept, habit is often automatic. A social order based on the division of labor, Durkheim claimed, requires “more and more intensive and assiduous work... [which is] habitual” (1893:242). In this sense, habit is a mechanical process, which has to be carried out.

Also in the analysis of suicide, Durkheim applies the concept. He maintains that “habits of passive obedience, of absolute submission...” increase the suicide rate among military officers. At the same time, “the habit of domestic solidarity” decreases the rate of suicide in the population (1897:238; 1888:234). Even religion in his analyses emerges as a “theory to explain and make sense of habits” (1887:35).

Weber was also using the concept of habit in his work. However, he lacked the moral aspect of it, which Durkheim had. For Weber, habit or custom was an unreflective disposition (“Eingestelltheit”) to engage in actions that have been long practiced (1908-9:93-94). It is automatic, however not at random but rather a reasoned and rational practice. Therefore it had a significant role in the basis of economic activity, because “the patterns of use and of relationship among economic units are determined by habit” (1922:67-68). However, Weber considered habits also out of the sphere of work and

economics. Habits are responsible for successes in the battlefield, intermarriage due to customs, formation of feelings of 'ethnic' identification and the existence of communities (1922:320).

In addition to promoting conformity with legal norms, Weber maintains that habit and tradition are also responsible for the creation of norms. Customs are transformed to binding norms. In the next phase, these norms produce expectations of others to abide (1922:326, 754). Such inner dispositions of habit sometimes contain inhibitions against change and innovations (1922:988). One can see that for him habit is not a residual factor to explain behavior, but an explanation in itself of economic and political behavior. However, he believes that habitual action does not occur at random. On the contrary, individuals tend to practice rationalism (1915:284).

Weber defines four types of rational behavior where he incorporated the idea of customs: "goal- and rationality-oriented", "value- and rationality-oriented", "Heat of the moment" ("affektuell" in the German literature) and "traditional" behavior (Weber, 1972:12, see also Schluchter, 1979, 2000). The type of behavior is chosen according to the situation (Esser, 1999:224-230; Esser, 1996), and reflects different types of information processing or rationality (or Heuristic) in a hierarchical order. According to the hierarchical order of the types of behavior of Max Weber, "goal- and rationality-oriented" behavior takes into account the means, goals, values and results of performing a behavior, and the "value- and rationality-oriented" behavior does not take the consequences into consideration. The "heat of the moment" behavior takes into consideration only means and goals for performing an act, and the "traditional" behavior only the means (see Schluchter, 1979:192). There are different circumstances where people may act automatically. When one performs the traditional or habitual act of entering the elevator on the way to the office every morning, one does not know anymore what it is good for (Esser, 1999:227). When one buys a soap, it is often not worth the investment of calculating what the best buy would be, and this is where tradition or habits also come into play.

Habits in recent studies in sociology

In recent years, one finds studies bringing back habits into theories of action and rational choice. We are not bringing any inclusive presentation of the different approaches, but select two scholars to shortly describe their contradictory views of habits: Bourdieu and Esser.

Bourdieu views habitus as the internalization of the structures of the social order. In this way, habitus appears in the form of social construction, and its consequence is the reproduction of social structures. In turn, social structures justify what the elite has defined as a legitimate form of social expression. It is internalized, and therefore not necessarily rational. “To speak of habitus is to assert that the individual... the subjective, is social, collective. Habitus is socialized subjectivity” (Bourdieu and Wacquant, 1992:126). The continuation of the system of domination by the elite from one generation to the other constructs habitus. Once habitus is absorbed by the society, the elite does not have to be involved anymore in dominating its definition (Bourdieu, 1977). If the dominated people in a society comply with the domination imposed by the elite, a habitus can be internalized. “If agents are possessed by their habitus more than they possess it, this is because it acts within them as the organizing principle of their actions” (Bourdieu, 1977:18). One may conclude, that Bourdieu does not view habits as a rational behavior, but as an internalized one, structured in the society. For a further review of this approach see Inglis, 1979 and Ostrow, 1981.

Esser takes quite a different approach concerning habits. He maintains, that habits are part of a rational behavior, and do not contradict it (for example, Esser, 1990, 1993, 1996, 1999), unlike other studies, where habits are viewed as a display of inertia (for example, Plutzer, 2002). When one assumes, that individuals are not fully informed, and perform a “bounded rational” rather than a fully rational behavior, then exercising habits may reflect a “satisfying” selection rule (for a discussion on ideas of “bounded rationality” see for example Simon, 1985).

Esser defines habits like Camic (1986:1044) as a “more or less self-actuating disposition or tendency to engage in a previously adopted or acquired form of action”. Very shortly, in such a process, one first identifies the type of the situation. In many cases, after receiving signals about the situation, one chooses to conduct a behavior from a present set of action alternatives, which are well known to him. In this case, there is an automatic choice of the routine applicable to this situation. Only if one arrives at a different decision, given the situation, are further activities needed. Then one proceeds with the search for further information, an accurate calculation of the consequences, careful consideration of alternatives for action etc.

In this model an individual maximizes his expected utility, like in a rational choice model. In this sense, the model includes habits in a reasoned process to explain behavior, differently from Parsons (1937: 757) who neglected the concept. The lower the utility from the new alternative, compared to that attainable from the routine action, the higher the additional cost of producing information and of the decision making, and the lower the probability of finding such a “better” alternative, the higher the probability that all will remain as it is (and vice versa)” (Esser, 1993:302).

Recent studies in Social Psychology

In the social psychological literature, two traditions have developed to view habits. In one of them, habit is defined as a behavior that has become automatic, and thus occurs without self-instruction and is not a rational process (Aarts and Dijksterhuis, 2000; Aarts, Verplanken and van Knippenberg, 1998; Bagozzi, 1981; Fazio, 1990; Ouellette and Wood, 1998; Ronis, Yates and Kirscht, 1989; Triandis, 1977 and 1980). In another definition, habit has been defined as the tendency to repeat past behavior in a stable context (Ouellette and Wood, 1998). A stable stimulus or context is therefore crucial for a habit to take place.

When a habit develops, presence in a similar situation that was in the past triggers an automatic response sequence. Even complex behaviors, once repeated over time, can

habituate and become more or less automatic. They are performed quickly, with minimal attention and at the same time with other activities (see Ajzen, 2002, and also Bargh, 1996; Ouellette and Wood, 1998, and Posner and Snyder, 1975). Verplanken and Aarts (1999) define habits as learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states

In the second tradition, scholars challenge the view, that frequent performance of a behavior leads to the formation of a habit, and that once established, this habit controls later behavior automatically without conscious cognitive mediation (Ajzen and Fishbein, 2000). If an explicit behavior is initially guided by intentions to perform it, there is no reason why these intentions, even when they become spontaneous and consistent over time, should lose their predictive validity. Thus, in this view even habitual behavior is a reasoned and rational process, which is simply repeated over time (Ajzen, 2002). Strong explanatory effects of past on present behavior may only prove that the behavior is stable over time (see Bamberg, Ajzen and Schmidt, 2003). In such a case, as long as the surrounding conditions, which determined the behavior in question in the past, do not change, there is no reason that behavior will change. Therefore, a change in the environment and in prices may challenge this explanation, if in the new surrounding past behavior will still affect behavior.

However, several studies find a residual effect of past behavior or habits on present behavior beyond the effect of other components such as components of the theory of planned behavior (see Ajzen, 1988, 1991) and even in the face of changing prices or environment. Past behavior and habits also raise the explained variance of behavior when added to the model (Ajzen, 1991; Bagozzi, 1981; Bamberg and Schmidt, 2003; Bentler and Speckart, 1979; Conner and Armitage, 1998; Fredricks and Dosset, 1983; see Ouellette and Wood, 1998 for a meta-analysis). This effect is often found to be stronger than the effect of other predictors, such as attitudes towards the behavior or intentions to perform it. Such results contradict the theory of reasoned action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975) and the theory of planned behavior. Therefore many theorists believe that a repeated behavior in a stable context is after all automatic and not

rational (e.g., Aarts and Dijksterhuis, 2000; Aarts, Verplanken and van Knippenberg, 1998; Bagozzi, 1981; Fazio, 1990; Oullette and Wood, 1998; Ronis, Yates and Kirscht, 1989; and Triandis, 1977 and 1980).

Ajzen (2002) argues, that there is no acceptable way to measure habits. Past behavior has a large common variance with present behavior, but it does not tell us anything about the cognitive process underlying behavior, and the amount of deliberation to perform it. A measure of the concept of habit reflects a reasoned process, which has been done in the past, and still prevails in the present. For that reason Verplanken et al. (see Aarts, Verplanken and van Knippenberg, 1998; Verplanken, Aarts, van Knippenberg and van Knippenberg, 1994) developed a measure of habit, which is independent of past behavior. We will briefly explain and apply it in this paper in the empirical section. This measure correlates highly with past behavior (see for example Bamberg et al. 2003).

3) The model of Stigler and Becker.

Stigler and Becker (1977) suggest another approach, which is economic in nature to explain habits. This approach belongs to a family of dynamic models of rational habit formation developed in later years, in which the strength of a habit is affected by its frequency and duration. However, these models are myopic in nature (e.g. Muellbauer 1988, Orphanides and Zervos 1998; Spinnewyn 1981). Contrary to the view that habits reflect an automated or a stable behavior, which occurs without self-instruction (see also Mill, 1972:484) in Stigler and Becker's approach habit (or 'custom' as they name it) is explained as a result of a utility-maximization process and therefore is rational. Indeed, their approach may come under the first definition of Weber of the "goal and rationality oriented" individual (Weber 1972:12). The concept of habit in this approach reflects a reasoned process. Habits are argued to constitute a generalized calculus of a utility-maximizing behavior. As decision-making is costly because it requires information, which needs to be searched, habits may be more efficient a way of dealing with changes in the environment. Thus, they claim that only monetary restrictions of the costs of search

determine behavior. Stable behavior in the face of changing prices and income might question this economic approach.

How can this search for new information be quantified? Search is costly, and requires monetary and time resources (time resources can also be quantified, see for example Becker, 1965, and its empirical test in Davidov, Schmidt and Bamberg, 2003). When a consumer buys one unit of a commodity X, he faces several options: to search at the time of each purchase to obtain the lowest possible price of X, $P(X)_{\min}$, to search less frequently and obtain a price of $P(X)$ which is higher than $P(X)_{\min}$, or not to search at all. $C(S)$ is the price or cost of search, and is a function of the amount of search, S. In such a case, the total price P is composed of two factors, $P(X)$ and $C(S)$:

$$(1) P = P(X) + C(S)$$

Legend: P= total price;

$P(X)$ = the actual purchase price;

$C(S)$ = the cost of search.

In other words, the price of using the bus for example in this model is not only the price of purchasing the ticket, but it also includes the cost of looking for information about the cheapest way to use it. "Cheapest" is also most convenient and least time consuming, and includes the search for existing bus lines, their time-table, the location of the stations etc.

In the model, in a total time period T there are K searches. A consumer minimizes his combined cost of the commodity price and search over the total time period. That is, one minimizes in the example the total cost of using the means of transportation and the cost of acquiring the information needed for using it. In the minimizing condition

$$(2) r = [(2C(S))/(\delta P(X))]^{1/2}$$

Legend:

r = number of purchases; $C(S)$ = the cost of search;

δ = rate of appreciation of prices with time; $P(X)$ = actual price of the commodity.

In Stigler and Becker's words: "In this simple model with r purchases between successive searches, r is larger the larger the amount spent on search per dollar spent on the commodity (C/P), and the lower the rate of appreciation of prices (δ)" (Stigler and Becker, 1977:83). Thus, the number of purchases depends positively on the cost invested on search for available information; the higher the resources spent on the search for information, the more often will the individual purchase this commodity.

As an implication of this model, when an individual is faced with a temporary change in the environment with new prices or income, it may not pay to reinvest resources in the capital of knowledge or skills, in order to accumulate new information. Consequently, under temporary changes we may observe no changes in behavior, and habits will prevail. Therefore, when there is a sudden and unexpected change in the environment, we do not always observe an immediate change in behavior. Individuals need the time to accumulate new information, and during this time they perform their usual habits. This results in an inelastic demand curve in the short run.

On the other hand, stable behavior in the emergence of permanent changes in prices and income, or in the structural opportunities, such as in the availability of public transportation service in a new town of residence, might contradict the approach taken in this essay. Such a stable behavior is not in line with utility maximization under the assumption of stable tastes.

In that way, Stigler and Becker constitute a substitution between information and money. Information is money, and money is information. By receiving information, for example in the form of brochures and consultation, money can be saved. By using money, information can be accumulated, for example by trying all the available means of transportation, and the investment of time (which is also replaceable by money) to learn the system. Table 1 summarizes the different approaches to view habits.

Table 1: Habits in the Sociological, Social-Psychological and Economic Literature.						
Literature field	Author	Term used	Definition	Habit- automatic or rational?	Domains of life where practiced	Measurement of habits
Sociology	Weber	Custom, habit, tradition.	An unreflective disposition (“Eingestelltheit”) to engage in actions that have been long practiced	Automatic but not at random- reasoned and rational practice.	Various domains- economic, political and religious behavior, but also for example to explain obedience, marriage, and norms.	-
	Durkheim	Habit	Habit was more of a tool in his conceptual toolbox.	Automatic (mechanical)	Various domains- such as religion, family and obedience.	-
	Bourdieu	Habitus	Habitus is socialized subjectivity	Internalized but not necessarily rational	Various domains	-
	Camic’s review- for Durk. and Weber see separate entries.	Tradition	The disposition to perform certain relatively elementary and specific activities skillfully	Automatic (habitual) and rational and reasoned (non-habitual)	Various domains.	-
	Esser	Habit	A more or less self-actuating disposition or tendency to engage in a previously adopted or acquired form of action.	Automatic but rational and reasoned	Various domains.	-
Social psychology	Different authors (for example Verplanken, Bargh, see text)	Habit; routine behav..	a “more or less self-actuating disposition or tendency to engage in a previously adopted or acquired form of action”.	Automatic	Various domains.	Past behavior; Verplanken’s measure.
	For example Ajzen, Fishbein.	Habit; routine.	They accept the following definition, but challenge it: a frequent performance of a behavior leads to the formation of a habit, and that once established, this habit controls later behavior automatically without conscious cognitive mediation	Rational and Reasoned	Various domains, since the theory of planned behavior applies to all.	Verplanken’s measure; no acceptable measure of habit
Economics	Stigler and Becker	Custom and tradition.	They use the term “stable behavior” for custom and tradition.	Rational and reasoned (result of a utility maximization process).	Various domains.	We apply Verplanken’s measure.

Implications for the use of transportation

We suggest to regard travel mode choice as a habit, which requires information on the available alternatives and their costs of use. We propose that moving to live in a new town is a possible new context and a temporary change in the environment. The total cost of transportation use in a new town of residence is the actual cost of transportation plus the cost of search and analysis of information about the public transport routes, location of stations etc. Now we will postulate the empirical implications of the models regarding the formation of habits or their persistence:

-The effect of habits on present behavior.

According to Stigler and Becker (P. 82), under permanent changes, a stable behavior might contradict the approach taken in this essay. Such a stable behavior is not in line with utility maximization under the assumption of stable tastes.

In the social psychological context, the main difference of the two approaches discussed is that one views habits as an automatic process and the other as a rational one. Therefore, the first postulates a positive effect of habits on behavior and the other postulates according to Ajzen no effect after changes in the environment.

In Durkheim's and Bourdieu's approaches, habits are viewed as a sort of an automatic process. Weber, Camic and Esser postulate that there is a rational process in the formation of habits, but that it is executed automatically. However, it is hard to conclude what their stand is concerning the effect of habits after changes in the environment regarding their persistence, and therefore we cannot operationalize their views in this context in an empirical test.

From Stigler and Becker's model one can derive some additional implications.

- The effect of information on travel mode choice.

Stigler and Becker argue that information is costly (P. 82). Following this, moving to a new town is a permanent change in the environment. It requires the accumulation of new

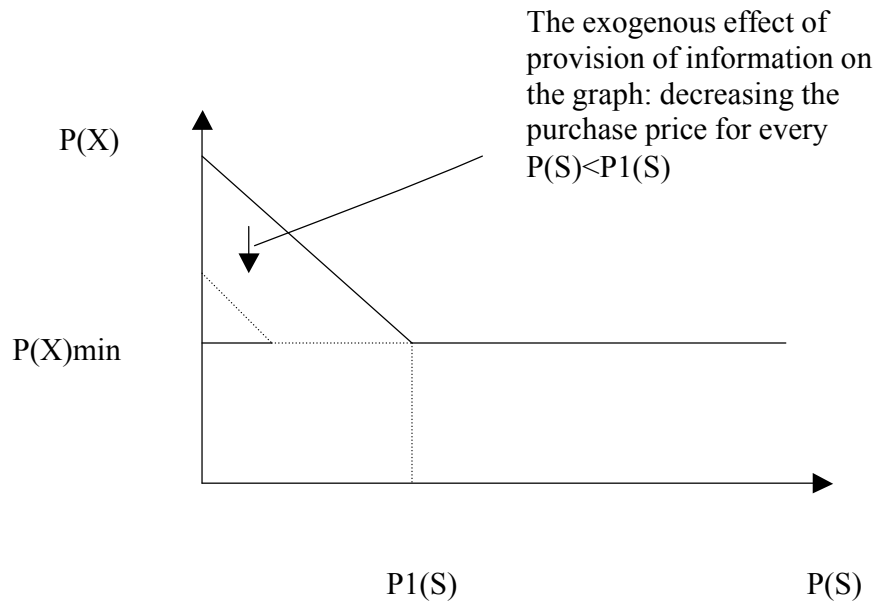
information regarding the available means of transportation. Providing people with such information decreases the purchase price “ $P(X)$ ” and increases “ $C(S)$ ” by providing external resources. According to the minimizing condition in the model, the ratio $C(S)/P(X)$ is higher for these individuals. Therefore, they are expected to use public transportation more often than others²⁴ (namely after controlling for the effect of habits).

As one can see in Figure 1, in a graph presenting the relation between the purchase price $P(X)$ and the invested cost of search for information $C(S)$, there is a negative relation between $C(S)$ and $P(X)$. The higher the investment on search for information $C(S)$, the lower the purchase price $P(X)$. However, there is a minimal purchase price possible, $P(X)_{\min}$. Providing information is an exogenous intervention that decreases the graph and enables a lower price of purchase and a lower cost of search.

²⁴ The variables in the right hand side of the minimizing condition, δ and $P(X)$, are endogenous, and each individual controls only the $C(S)$ variable. $P(X)$ may include according to our interpretation factors such as comfort or time, which have been discussed in the literature as having a significant importance on travel mode choice or as equivalent to monetary costs (see Franzen, 1997; Becker, 1965). In the experiment we increase C in the equilibrium, by providing information.

Figure 1: The Effect of Provision of Information on $P(X)$.

Legend: $P(X)$ = purchase price;
 $P(X)_{\min}$ = minimal purchase price possible;
 $P(S)$ = cost of search;
 $P1(S)$ = the minimal cost of search without any intervention needed to get the $P(X)_{\min}$.



- The effect of previous search for information.

Similarly to the effect of providing people with information, a higher previous search indicates a higher cost invested on obtaining information on available public transportation. In such a case $C(S)$ is higher, and as a result the ratio $C(S)/P(X)$ is higher for these individuals. Therefore, they are expected to use public transportation more often than others.

-The effect of habits and age on travel mode choice.

It is well-known that older people are less flexible to change their behavior. This can be explained by the model. When there is a permanent change in the environment, for example due to a move to a new town, one has to disinvest his capital of knowledge, which was accumulated in the old environment, and adjust it to the new surrounding. The incentive of older people to do so is smaller, because their time horizon in which they can collect the returns of the new investment of acquiring new information is shorter. Young people, on the other hand, are not encumbered so much by previous investments in the old environment. Therefore, even with the same motivation and with stable and identical preferences, they will be more ready to newly invest in collecting new information. The reason is that they are economically more encouraged to do so as a result of their longer expected life span. Therefore, in a new environment, habits according to the theory will have a stronger effect on present behavior in an older age.

There is a slight inconsistency in this implication of the model. Stigler and Becker argue that a stable behavior under a permanent change in the environment contradicts their approach, so that habits should have no effect on behavior. On the other hand, they do expect a stronger effect of habits on present behavior for older people. However, we will test both implications in the empirical section. Additionally, it may be interesting to know whether there is an interaction effect between habit and the intervention on behavior. However, such an interaction cannot be directly implied by the model and therefore is not included in the empirical test.

We believe that this theory does not provide a full explanation for habit formation and behavior, and there are additional social mechanisms involved in determining travel mode choice. In an empirical test of a rational choice model, one has to construct auxiliary assumptions (for a discussion see for example Kelle and Lüdemann, 1998; Lindenberg, 1992; Opp and Friedrichs, 1996; Simon, 1985). Auxiliary assumptions bridge between the reality and the model, which tries to explain it. Stigler and Becker (pp. 82-83) construct a few bridges of this sort, which connect the monetary cost of accumulating information in the model as an explanation for a habitual behavior, such as travel mode choice in reality. However, one can think of other determinants of behavior. For example, education as well as gender and availability of a private car might explain the tendency to choose public transportation. As our goal is testing the model empirically, we will offer such alternative assumptions to explain travel mode choice in the discussion section.

Rational choice models in general differ in their readiness to accept variation in preferences between and within individuals. Opp (1999) suggests this distinction as one of the main differences between “narrow” and “wide” versions of rational choice models. “Narrow” models assume that individuals also possess all the relevant information, that only “egoistic preferences” are relevant, and that objective restrictions are the sole explanation of behavior. On the other hand, in “wide” models of rational choice any preferences may explain behavior, all kinds of restrictions- perceived and objective ones- may explain behavior, and preferences might differ between people and over time. In this sense, Stigler and Becker apply a hybrid version of the narrow and wide versions of rational choice. On the one hand, they do not assume full information. On the contrary, the accumulation of information is costly according to their model, and is not necessarily done by every individual, but is a consequence of a cost minimization process. On the other hand, they assume that preferences are not only stable, but are also identical between different individuals. An analysis of the data described in the following section may provide us with more information what a better approach in this context may be.

4. Data.

We will now report the analysis of the travel mode choice of individuals with data obtained in our field study. No large-scale data has been collected so far in an experimental setting where there is an independent measure of habit. Additionally, we do not know of any data sets on a large-scale level, which include information on behavior in a new environment. Such information is necessary in order to test some implications of the model, because Stigler and Becker speak of behavior in a new context, and is also useful for testing the rational aspect of habit persistence. Therefore we will use data collected in a regional intervention study performed in Stuttgart (Germany).

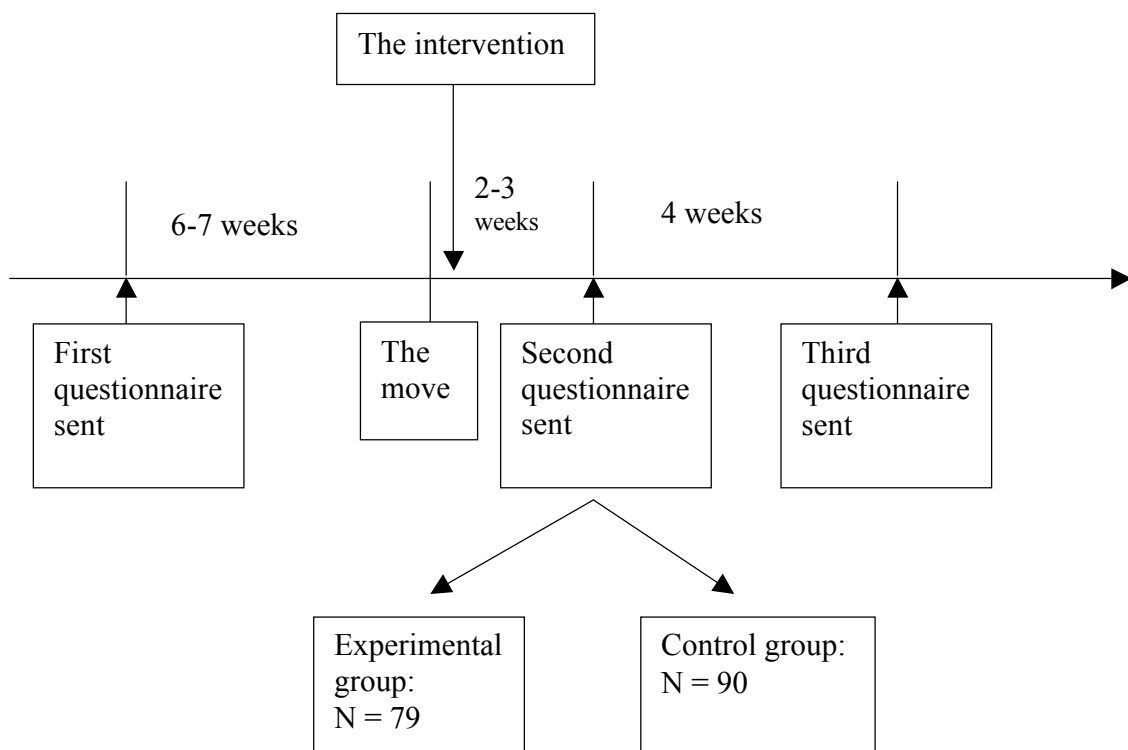
The marketing department of the public transportation company in Stuttgart (Germany) was interested in motivating people moving to Stuttgart, to use public transport instead of a private car. For that reason, they developed an intervention called “personal information package”, which was composed of the following components:

- 8) An official welcome and a short description of the company;
- 9) A one-day ticket for public transportation use free of charge;
- 10) A map of the subject’s quarter of residence including all available public transport lines and adjacent stops and stations;
- 11) A timetable;
- 12) A brochure with explanations how to reach downtown and frequently visited shopping and cultural centers;
- 13) Information about travel costs and location of ticket-sale offices;
- 14) A “hotline” telephone number.

This intervention was conducted in 2001 on an experimental group. Subjects had not lived before the intervention in Stuttgart, but planned to move to Stuttgart, and actually moved after the intervention. Mobilizing subjects was done by systematically approaching people, who had published an advertisement looking for an apartment in Stuttgart in the weekend newspaper. Their published phone and email addresses were used to contact them. If they were ready to participate (the incentive was a lottery of a

monetary prize), they received the first questionnaire where they were asked to answer questions regarding the investigated variables. Subjects were contacted 8-10 weeks later with the second questionnaire, namely 2-3 weeks after their move. About 4 weeks later a third questionnaire was sent, with fewer questions, relating mostly to their travel mode choices.

In order to reduce selection bias as much as possible, the questionnaires were constructed in such a way that they seemed not to be affiliated with the intervention. The questionnaires were delivered with the title “Decisions in moving to a new place and travel habits”. However, the real aim of the study, which was evaluating the effects of the “soft policy intervention”, was hidden. The public transport company in Stuttgart conducted the intervention itself separately. In this way, participants were unaware of the fact that they were taking part in an experiment. Figure 2 presents the design of the study. We apply the data collected on the second wave for the empirical analysis.



Time points of experiment	Experimental group	Control group
Measurement time point 1	X	X
Intervention	X	
Measurement time point 2	X	X
Measurement time point 3	X	X

Figure 2: Design of the Experiment.

Our dependent variable is ‘travel mode choice’ (‘TMC’) in the second wave, after the intervention. Data on this variable were derived from a protocol filled in by the subjects about all the travels conducted on that day and the means of transportation used. In this protocol, the participants reported dates and times of departure and arrival to their different destinations as well as the type of their destination (home, work, university, supermarket etc.), the distance and the exact means of transportation. From this protocol the behavioral variable created receives the value of 1 if a subject used public transportation on his second reported way on that day, and zero if he used the car. We apply the behavioral variable of the second reported day, because the question items relate to the second way on the reported day as well. On the importance of the correspondence between the behavioral variable and the other question items, see Ajzen and Fishbein, 1977.

‘Intervention’ is a dummy variable, which receives the value of 1 in case the subject belonged to the experimental group, and zero otherwise.

‘Habit’: To obtain a measure of habit, which is to some extent independent of past behavior, we applied the proposal of Verplanken et al. (1994). It is to the best of our knowledge the only attempt to measure habits independently. In order to obtain it, individuals are confronted with a set of destinations, and they have to indicate under time pressure the travel mode they might use for that purpose (such as car, bus or train, bicycle or walking). The hypothetical situations included: (1) summer trip with friends; (2) visit of a boyfriend/girlfriend; (3) visit of relatives or friends; (4) undertaking sports activities; (5) strolling in the town; (6) going to a bar in the evening; (7) going on a trip when the

weather is nice; (8) daily shopping; (9) going to the movies or to a concert. In this measure, the frequency of choice of some travel mode is said to indicate habit strength. We computed the percentage of public transportation choice out of the total replies of either public transport or car. This percentage reflects habit strength in the study.

'Search' is a variable representing the amount of search already invested. It represents the degree to which an individual had already obtained information how to use public transportation daily. It receives the value of 5 for respondents, who strongly admit to have obtained information, and 1 for respondents who have not. In such a way, we can control for previous knowledge of the public transport system in the new town.

'Gender' receives the value of one for females and zero for men²⁵, 'Age' is reported in years, "higher education" receives the value of 1 for respondents who have obtained higher education (higher than high school) and zero otherwise. 'Availability of a car' is the number of cars available in the household. 'lowage' is a dummy variable, which receives the value of one for respondents with an age lower than 35, and zero otherwise. We chose the cutting point '35' because approximately one-fifth of the sample is older. 'Habitage' is the interaction term between 'habit' and 'lowage'. Thus, this variable will receive a habit value only for people with an age of 35 or lower. In this way we can test whether habit has a weaker effect on behavior for respondents of lower age in the sample.

5) Descriptive overview:

In the following section we give a short description of our data. As we intend to analyze only respondents after the experimental phase of the study, all other cases are excluded. In this way, the number of cases reduces to N=169.

800 people received the first questionnaire by mail. Only 241 filled it in and sent it back. 169 (70%) respondents actually moved to Stuttgart six to seven weeks after the first questionnaire. They were randomly divided to an experimental and a control group (90

²⁵ We found no correlation in the sample between gender and behavior.

were from the control group and 79 from the experimental group). Only people in the experimental group received the information package. Two to three weeks after the intervention 169 responded and filled in the second questionnaire. This group constitutes the sample we analyze. Table 2 presents the means and standard deviations of the variables in the analysis.

Table 2: Description of Variables in the Study (Second Wave, N = 169) (Std. Errors in Brackets).

Variable	Description	Mean (and Std. Error in Brackets)
TMC (behavior)	1=public transport; 0=car use on the second reported way	0.36 (0.48)
Intervention	1=belongs to experimental group (receives information as an intervention); 0= control group	0.47 (0.50)
Habit (Verplanken's measure)	% of public transport use	0.29 (0.36)
Gender	0=males; 1=females	0.44 (0.50)
Age	In years	28.45 (6.9)
Lowage	0=35 or older; 1=younger than 35	0.82 (0.39)
Higher education	1=higher than high school; 0=otherwise	0.41 (0.49)
Availability of a car	Number of cars in the household	0.98 (0.70)
Search	Previous search of information on public transportation (5=totally true; 1=totally not true).	4.17 (1.24)

As it is presented in Table 1, 36% of the respondents use public transportation on the second wave, and 47% were exposed to the intervention. According to Verplanken's measure of habit, the average percentage use of public transportation is 29. The average age in the second wave is 28.5 (18% are 35 or older), 44% are women, 41% obtained higher education, and the average number of cars available in the household is 0.98. The average level of previous search for information on available public transportation is relatively high (4.17 on a scale of 1 to 5).

Do habits have any effect on travel mode choice, and is the effect different between different age groups? Do participation in the experimental and the control group and previous search for information affect behavior? Are there any other processes involved, embedded in different socio-economic groups? A multivariate analysis might give us an answer.

6) Multivariate analysis.

In the following section we test hypotheses regarding the effect of habits on travel mode choice in a new context according to social-psychological approaches we presented and to Stigler and Becker's theory. Some of these hypotheses are deduced from the theory, but only partly explicitly formed by Stigler and Becker. For reasons we have given previously, we could not provide an empirical test for the other approaches directly. However, we include a test of automaticity of habits. This aspect is implied by all other theories, and therefore is an indirect test of other sociological approaches. We would expect to receive the following results.

Some social psychological theories on habits viewing them as automatic expect to find a significant effect of older habits on behavior. In other words, if one reports a strong habit to use public transport, we expect to find a positive effect on the use of public transport. However, according to the other social psychological approach and to Stigler and Becker, a stable behavior in a new context will contradict their theory, but not in the short run (p.82). Assuming the "short-run-effect" to be small (or that our measurement several weeks after the move falls beyond the "short run" as Stigler and Becker (1977) do not provide any clear definition what is considered a short run), we expect no effect of habits as a result of the new context.

Therefore, to put it more precisely:

H1) We do not expect any significant effect of 'habit' on 'TMC'.

According to Stigler and Becker, there should be a significant effect of participation in the experimental group on the use of public transport. People in this group receive

information, so formally, the ratio C/P is higher, and therefore also the number of purchases.

To put it more precisely:

H2) We expect a positive and significant effect of ‘intervention’ on ‘TMC’.

Since the time horizon of younger people in the sample is longer, we expect to find a weaker effect of habit on behavior for this group, because they are not so encumbered by accumulations of capital relating to the old environment. This is where Stigler and Becker give a statement that under this context may contradict hypothesis 1. Nevertheless we test it.

To put it more precisely:

H3) We expect the interaction term “habitage” to have a negative and significant effect on behavior.

In a similar way, a higher previous investment on information will increase $C(S)$. Therefore, the ratio C/S is higher, and also the number of purchases.

To put it more precisely:

H3) We expect a positive and significant effect of ‘search’ on ‘TMC’.

Finally, according to Stigler and Becker’s theory there should be no direct effect of socio-economic variables on behavior, but only an indirect one via other variables. Variables such as age, higher education or availability of a car do not have an independent role in the model, and habits as well as information are expected to take over and reflect them. However, a variable such as availability of a car is believed to have an effect on behavior in this context, since it provides an opportunity to use it. Education might also affect behavior, because a car might have the role of a status symbol for some more educated groups. Age might reflect different income levels (income and age correlate negatively in our data). Individuals with a high income may have the resources to buy a car and use it,

as it is more expensive than using public transportation. Car is a faster mean of transportation, and their high income might reflect higher time costs (Davidov et al. 2003). Indeed, in the data we observe a significant correlation between behavior and age, higher education and availability of a car, so we suspect that these variables might have an additional independent explanatory power on behavior.

To put it more precisely:

H5) We expect the variable ‘age’ to have a significant and negative effect on behavior after controlling for ‘habit’, ‘intervention’, ‘habitage’ and ‘search’;

H6) We expect the variable ‘availability of a car’ to have a significant and negative effect on behavior after controlling for ‘habit’, ‘intervention’, ‘habitage’ and ‘search’;

H7) We expect ‘higher education’ to have a significant and negative effect on behavior after controlling for ‘habit’, ‘intervention’, ‘habitage’ and ‘search’.

We test our hypotheses in a series of logit regression models using SPSS 11.0. In each model, the dependent variable is the travel mode choice (TMC): car or public transportation. The results are presented in table 3.

In the first model we test whether ‘habit’ has any effect on ‘TMC’. We find out a positive and significant relation between ‘habit’ and public transport use (1.40). In contrary to Stigler and Becker’s expectation in new contexts, and in line with some social psychological views, the stronger the old habit to use public transport, the higher the probability that the used travel mode is public transportation. In the next step we will test whether additionally receiving information has any effect on behavior.

In model 2 in which we test whether participation in the experimental group (the ‘Intervention’ variable) has a significant effect on travel mode choice, table 3 clearly shows that both ‘habit’ and ‘intervention’ have a positive and significant effect on ‘TMC’ (1.28 and 0.79 respectively). This means that not only older habits to use public transport, but also receiving information in the new context influence as expected positively and significantly the present use of public transportation.

Table 3:
Unstandardized Coefficients from Logit Regressions to Explain Travel Mode Choice
(Dependent Variable is “TMC”) on Selected Independent Variables (Standard Error in
Brackets).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Habit	1.40** (0.51)	1.28** (0.52)	-0.55 (1.13)	-2.03 (1.69)	-1.258 (1.75)
Intervention		0.79** (0.39)	0.82** (0.40)	0.42 (0.47)	0.64 (0.50)
Habitage			2.22* (1.15)	3.05* (1.74)	1.56 (1.91)
Search				0.51* (0.27)	0.52* (0.28)
Age					-0.05 (0.05)
Availability of a car					-0.24 (0.44)
Higher education					-1.00* (0.52)
Constant	-1.04 (0.25)	-1.42 (0.33)	-1.42 (0.33)	-3.46 (1.21)	-1.48 (1.90)
-2 Log Likelihood	162.11	157.89	153.40	113.67	107.90
Goodness of Fit	7.71	11.93	16.42	13.30	19.07
Cox & Snell R ²	0.06	0.09	0.12	0.12	0.16
Nagelkerke R ²	0.08	0.12	0.16	0.17	0.24
N	131	131	131	107	107

* P < 0.1 , ** P < 0.05 (one-tailed tests).

In the third model we test whether ‘habit’ has a different effect on behavior over different age groups. As table 3 demonstrates, the interaction term ‘habitage’ does have a significant effect on ‘TMC’ on the 10% significance level, but contrary to our expectation, this effect is positive (2.22). In other words, ‘habit’ has a stronger effect on behavior for the younger respondents in our sample. In addition, ‘intervention’ still has a positive and significant effect on travel mode choice (0.82). However, ‘habit’ is no more significant. This may be a result of multicollinearity between ‘habit’ and ‘habitage’.

In the fourth model we test whether ‘search’ has an additional effect on ‘TMC’. In table 3 one can see that it is significant on the 10% level of significance with a coefficient of 0.51. In other words, the higher the previous search the higher the use of public transport after the move. The interaction ‘habitage’ is also significant on 10% level of significance and positive.

Finally, in the last model we test whether socio-demographic characteristics such as ‘age’, ‘availability of a car’ and ‘higher education’ have any additional effect on ‘TMC’. Table 3 indicates that ‘Higher education’ has a significant and negative effect on behavior (-1.00). Namely, respondents with higher education have a lower tendency to use public transportation in the new context. ‘Search’ has a positive effect on TMC. That is, the higher the previous search the higher the public transport use. Both effects are on the 10% significance level.

As one can see, after including previous search costs and socio-demographic characteristics, to test hypotheses 4, 5, 6 and 7, ‘habit’ and ‘habitage’ have no significant effect anymore on travel mode choice. We tested whether this was a result of the multicollinearity between habitage and habit, which was 0.85. However, after omitting the variable habit, we received similar results and habitage was still insignificant. Age became borderline significant. To put it differently, as different levels of habit to use the car may be reflected in the education level or in previous search²⁶, ‘habit’ becomes insignificant. Using rational choice terms, level of education and previous search may represent different preferences for public transport use: for the first it may be a feeling of ‘sunk cost’ and for the second a need for status symbols. However, the fact that education level has a stronger effect than the variable ‘intervention’ on behavior implies that the rational choice model proposed by Stigler and Becker does not hold anymore when such a socio-demographic variable is introduced.

²⁶ The correlation between habit and education level is -0.189 and between habit and search it is 0.315 , with 5% and 1% levels of significance correspondingly.

Whereas the Cox & Snell R^2 was only 6% and 9% in models 1 and 2 respectively, it improved to 12% in the third and the fourth models and to 16% in the fifth. The Nagelkerke R^2 was 8% in the first model, 12% in the second model, 16% in the third model, 17% in the fourth and improved to 24% in the fifth model.

7) Discussion.

In this paper we have restricted ourselves to maintaining three goals.

-First, we wanted to shortly present and compare various aspects of explanations of habits in the sociological, social psychological and economic literature.

-Second, we did not try to develop a better model to explain the formation of habits, but rather conduct an empirical theory comparison of these approaches.

-Third, to test a rational choice model empirically. Becker has called to test his models with real data. Green and Shapiro (1994) indicated, that proponents of rational choice theory seem to be more interested in the theory elaboration, and therefore tend to leave the messy business of testing their models empirically to others. We wanted to address their call, and try to bridge between experimental data and an important rational choice model, which has not been tested so far. Additionally we wanted to test whether socio-demographic variables reflecting alternative social mechanisms have any effect on behavior beyond the predictions of the model.

Some authors we reviewed approached habits as a rather automatic process, whether others considered them rational. Weber viewed them as automatic but not at random, Durkheim viewed them as automatic, Bourdieu as internalized, and one of the social psychological approaches as automatic. Esser and Camic understood habits as automatic but also involving a rational process, similarly to Weber. The second social psychological approach discussed (Ajzen) viewed habits as rational, and so did the economic approach of Stigler and Becker. The main difference between the economic approach and the other ones is that whereas in the rational choice model individuals are assumed to maximize consumption, the other models do not assume any maximization but just a repetition of past behavior due to different reasons.

In order to conduct the empirical theory comparison we used data from a field experiment with an experimental and a control group. To learn about the formation and persistence of habits we used a new context. Such a new environment may assist in testing whether habits involve a rational process or are rather automatic. Since only the social psychological theories and the model of Stigler and Becker gave hints how to operationalize them in an empirical context, they were the only two approaches we could directly test. This test examined the degree of automaticity of habits, and since this aspect was also discussed by the other explanations, it was an indirect test for the alternative approaches.

Becker has been trying in his work to formulate a theory, which could explain any behavior, in the economic market, in choice of partners, in family relations, in committing crimes and in social discrimination in the form of production functions. In this model, Stigler and Becker try to explain habits rather than study their role in the explanation of daily behavior. They explain habits in an economic fashion, as a utility-maximizing behavior and suggest that habits are reasoned and could make sense, when one is in a new environment where information is needed and is costly.

When formulating the hypotheses we were confronted with the question how to model and measure habits and information levels, and furthermore how to translate the model to testable hypotheses. For habits we applied the new measure of Verplanken et al. (1994). Although it correlated highly with past behavior in our data, it was independent of actual behavior. For different information levels we had two groups in the field study: an experimental group, which received information, and a control one which did not. In addition, we controlled for previous search costs individuals were engaged with, and tested their effect. The new setting of moving to a new town served as a new context for the test of the model.

At first, our results showed that in contrary to Stigler and Becker's expectation and to social psychological approaches viewing habits as rational, habits did have a positive and significant effect on present travel mode choice after a change in the environment. The

stronger the old pattern to use public transport, the higher its present use, or automatic application. A possible explanation is that the test was conducted a few weeks after the move, and respondents may have not learned the new surrounding yet.

Belonging to an intervention group and receiving information had a positive and significant effect on behavior as well. This confirmed the expectation of Stigler and Becker that information in a new context increases the tendency and frequency of the behavioral alternative to which information is given.

However, we could not confirm the second implication from Stigler and Becker's theory, that habits are expected to have a weaker effect on behavior for the younger respondents in our sample. On the contrary, for younger respondents habits had a stronger effect on travel mode choice. This could be a result of at least two factors. First, the age range was between 19 and 58 in the sample, and the average was 28. As a result, our sample was composed of mainly young and middle-aged respondents. It could well be the case, that young people had a lower income, and therefore could not afford a car. In such a case, their tendency to use public transport would be higher. On the other hand, middle-aged respondents earn more, and can afford it. In a random sample of the whole adult population like the GSS or the ALLBUS, this result might change. As we have data only on income on the household level, we could not test this correlation (the correlation between the *household's* income and 'age' was insignificant). Additionally, this result might have reflected a negative correlation between 'age' and behavior, rather than a negative effect of the interaction term. Indeed, age and behavior correlate negatively in the sample.

The third implication from Stigler and Becker's theory, that socio-demographic characteristics are mediated by habits, and minimization of costs mechanism for acquiring information, could not be fully confirmed. In our findings, 'higher education' had a significant and overwhelming effect (on the 10% level of significance) on behavior. The interaction term 'habitage' and the variable 'habit' became insignificant. We performed an interaction test between 'habit', 'habitage' and the two socio-demographic

characteristics ‘availability of a car’ and ‘higher education’, but it was never higher than 0.4. The correlation of ‘habitage’ with ‘availability of a car’ and ‘higher education’ was significant (-0.37 and -0.23 respectively). ‘Habit’ correlated with ‘availability of a car’ (-0.397) and with ‘higher education’ (-0.192) significantly. Therefore, we assume the results might indeed imply a true overwhelming effect of ‘higher education’.

Respondents with higher education indeed had a weaker tendency to use public transportation in the new town. Previous search for information correlated highly with ‘habit’, and once added to the regression, it had a positive and significant effect according to the theory on the 10% level of significance, and ‘habit’ lost its significant influence.

To answer the question we started with, we can conclude that there is reason in habitual behavior in the context of travel mode choice with our data. When controlling for other variables that may reflect alternative explanations, habits have an insignificant effect in the new context (in line with Bamberg et al. 2003). In order to have a better explanation for our results, we must turn to other disciplines and construct “auxiliary assumptions” (Kelle and Lüdemann, 1998; Simon, 1985). Auxiliary assumptions link a rational choice theory with observational terms, thus formulating alternative explanations. It would make sense here to suggest such assumptions between age and education level on the one hand, and the sociological processes, which account for the chosen travel mode on the other hand. Indeed, we have just offered such an explanation concerning age for the third model, which relates to differences in income between young and middle-aged respondents. As young people are still in an investment phase in life, their income is lower than somewhat older people. Thus, regardless of the intervention, the new context and the information provided, younger people might have a higher tendency to carry out their habit to use public transport anywhere they go more than the middle age group. They may also have a stronger preference to save money on transportation. Indeed, we found a negative correlation between age and public transport use of -0.27 in the sample. Moreover, according to Becker (1965), people with a lower income per hour have a lower time value. As public transport is usually slower and therefore more time-consuming, middle-aged people who have higher earnings will value time more highly, and therefore would use the quicker means of transportation, namely the car (see for example Davidov

et al. 2003 for a significant correlation between squared age and income per hour). As for higher education, a car as a status symbol might be a trigger for more educated respondents to purchase it and use it more often as a result of status-striving (for car as a status symbol see Preisendörfer 2001; Sheller and Urry 2000). Additionally, the effect of previous search on available public transport in the new town may be also explained by a feeling of 'sunk cost', which increases the preference for public transport. These auxiliary assumptions suggest how other variables are related to preferences and utility. They could indeed bridge the gap regarding the influence of socio economic characteristics on travel mode choice and serve as an additional plausible explanation for choosing a travel mode.

We received relatively low percentages of explained variance even in the third model. The highest explained variable we received was 24.0% (Nagelkerke). It may well be the case that there are other economic, sociological and psychological factors, which may explain travel mode choice, and nevertheless we did not include in our models. However, one of our main purposes was testing theories, rather than developing one. Additionally, using experimental data, we could overcome some of the difficulties of using large-scale data sets. One difficulty is that one cannot choose the variables in the survey, but only apply existing ones. The experimental setting enabled us to test the difference between people who received information in a new context and others who did not. Such a test is not available in survey data such as the German microcensus. However, we are aware of the fact that our data may also lead to biased results, because the sample is small, participation is not compulsory, and the sample is not representative. However, this problem cannot be easily solved outside a new design of a field study with a representative sample, which might be very costly. Future field studies might address these drawbacks.

Some practical implications can be drawn from our analysis, also as to what social groups are to be addressed in order to bring more car drivers to use public transportation. Apparently, it is also quite a sociological question what makes people use public transportation, and what makes them rather use the car. These social mechanisms

(reflected in variables such as age or education) are to be explored more deeply, in order to find the dynamic processes, which lead some groups to a more ecological behavior in respect to travel mode choice.

When we try to model a rational behavior, the question which model to choose and which factors to incorporate in the model relates quite often to whether rational choice should be modeled and tested in a narrow version in which only objective factors such as monetary restrictions (Preisendörfer, 2000) are taken into account, or in a wide version, in which subjective social-psychological as well as sociological variables should be taken into account (Opp, 1999). Becker calls to release some of the assumptions on individuals' preferences, and include in this broader approach altruism, past experiences, culture, social interactions and habits (see for example Becker, 1996:5-7). Becker did not release all the assumptions of traditional economic theory in this model, and in this way constituted a hybrid model of the narrow and wide versions of rational choice.

Our empirical findings suggest that the Stigler and Becker's model on habits may be insufficient. Indeed, Simon (1985) criticized Becker of making a lot of untested assumptions, but those criticisms were often ignored. At the same time, other sociological theories on habits have not provided many hints how they could be put into test. It may be the case that the way to a good theory to explain habits and rational behavior may be through a dialogue between improvement of existing theoretical explanations and empirical findings, which test the theoretical implications and the assumptions of the theory. In Becker's own words, "a close relation between theory and empirical testing helps prevent both the theoretical analysis and the empirical research from becoming sterile. Empirically oriented theories encourage the development of new sources and types of data...At the same time, puzzling empirical results force changes in theory" (Becker 1996:156). Once these conditions are fulfilled, the way is opened for such a dialogue between data and theory in order to reach a better explanation of behavior in general, and of habitual behavior in particular.

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The manuscript is being submitted for review to *Rationality and Society*.

A Note:

A Bridge between ‘Bridge Assumptions’: Some Clarifications²⁷

Abstract

Rational choice theory has no empirical content, because its terms consist of theoretical concepts, which have to be linked to observational terms. ‘Bridge assumptions’ are propositions developed to bridge the gap between reality and the model, which explains it. However, when applied, different authors have attributed to the term different interpretations, and this has caused confusion regarding its appropriate use and understanding. In this paper we first clarify the different meanings of ‘bridge assumptions’, and then draw the relation between ‘bridge assumptions’ and ‘auxiliary assumptions’. We argue that: (1) bridge assumptions have a time dimension; (2) there are several layers on the macro level of analysis; (3) production functions are a fruitful tool for theory elaboration, but their contribution for the formation of empirically testable hypotheses is questionable. Finally, we propose to separate the terms ‘auxiliary assumptions’ and ‘bridge assumptions’ to reduce confusion.

Key words: Bridge assumptions; auxiliary assumptions; rational choice theory; the micro-macro link; production functions.

²⁷ A joint work with Peter Schmidt.

Introduction

Rational choice theory has been increasingly used in the social sciences in the last two decades. However, its impact on empirical research has been small (Green and Shapiro, 1994; Blossfeld and Prein, 1998). The question whether rational choice is a fruitful strategy to explain reality and relate theory with empirical content has become a central controversy. Indeed, Green and Shapiro argue that rational choice theorists have been more concerned with theory elaboration than with theory testing.

Rational choice theory has no empirical content, because its terms consist of theoretical concepts, which have to be linked to observational terms (see Hempel 1962, 1965 and 1973 for a discussion on relating theoretical and observed terms). Correspondence rules (Sneed, 1971, Hempel, 1962) connect latent variables with observational terms, whereas bridge assumptions and also auxiliary assumptions have been regarded in the literature as connecting more abstract theoretical concepts with latent variables. These two relations are similar, but should be differentiated (see figure 1)²⁸. Theoretical concepts in rational choice theory, such as alternatives, goals or utilities, preferences and restrictions are meaningless before they are related to measurable latent terms, such as “achieving a high status” for goals or “confronting monetary limits” for restrictions. The latent terms “achieving high status” and “monetary restrictions” can in turn be measured empirically. In order to link observations and theory different scholars have introduced bridge assumptions in the rational choice literature. In that sense, bridge assumptions are propositions developed to bridge the gap between reality and the theoretical concepts of a model, which tries to explain reality, and therefore are central to rational choice theory and empirical studies.

²⁸ This is a second order structural model.

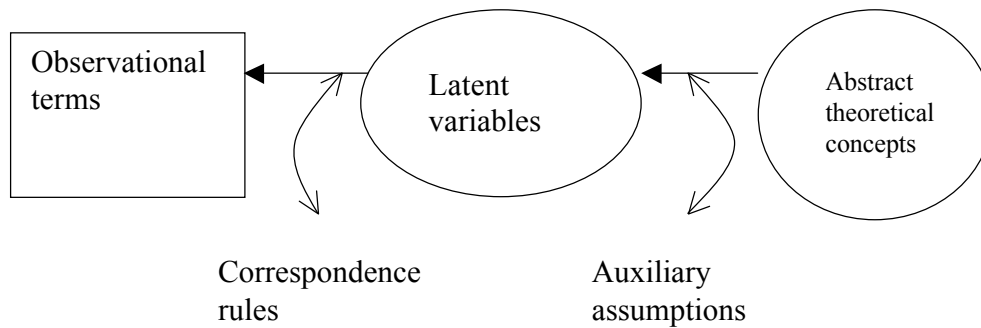


Figure 1: Observational terms, latent variables, abstract theoretical concepts, correspondence rules and auxiliary assumptions.

However, when applied, different authors have attributed to the term different interpretations, and this has caused confusion regarding its appropriate use and understanding. In this paper we first clarify the different meanings of ‘bridge assumptions’, and then draw the relation between ‘bridge assumptions’ and ‘auxiliary assumptions’. We argue that:

- (1) bridge assumptions have a time dimension;
- (2) there are several layers on the macro level of analysis;
- (3) production functions as a type of auxiliary assumptions are a fruitful tool for theory elaboration, but their contribution for the formation of empirically testable hypotheses is questionable.

Finally, we propose to separate the terms ‘auxiliary assumptions’ (Simon, 1985) and ‘bridge assumptions’ to reduce confusion, because these two terms do make a difference.

A link between the macro and the micro levels of explanation

Table 1 summarizes the different approaches to view bridge assumptions. In one approach (adopted by Coleman, Lindenberg, Esser and Opp/Friedrichs), bridge assumptions connect the macro level, namely the social structure with the micro level, namely the individual actors (see Esser, 1994, 1998). They describe the logic of the actors’ situation, similarly to examples described by Coleman in his book (1990, P. 8-10),

and with their absence, there would be a gap in the explanation. Indeed, they are not general law propositions, but situation specific and empirically based. Coleman argues that they are constructed by finding the theoretical links of two macro level phenomena with micro level processes, such as auxiliary ‘rules of the game’ enforced by actors in a social system (Coleman 1990, p.21).

Table 1: Bridge assumptions: definitions of different authors

Author	A macro-micro bridge	A bridge between model and reality	How should they be constructed?	Should they be empirically based?	Term used
Coleman	Yes	No	By finding the theoretical links of two macro level phenomena through the micro level processes	His examples are empirically based (see for example Coleman, 1990, Pp. 19-20).	Auxiliary (Coleman, 1990, p.21).
Esser	Yes	Yes	By social production functions	Not clear	Bridge assumptions and auxiliary assumptions
Lindenberg	Yes	Yes	By social production functions and common sense (but provides no concrete guidance)	No	Bridge assumptions
Opp and Friedrichs	Yes	Yes	One possible method (but not the only one) is interviews.	Yes	Bridge assumptions
Kelle and Lüdemann	No	Yes	Interviews, or qualitative computer based coding methods (empirically based production functions).	Yes	Bridge assumptions
Simon	No	Yes	Empirically, but gives no concrete guidance.	Yes	Auxiliary assumptions
Our definition for: bridge assumptions	Yes	No	Interviews for example or large scale data.	Yes	Bridge assumptions
And for auxiliary assumptions	No	Yes	Interviews for example or large scale data.	Yes	Auxiliary assumptions

Esser uses the terms ‘auxiliary assumptions’ firstly used by Simon (1985) and ‘bridge assumptions’ (see table 1). According to Esser’s view, bridge assumptions link the objective structure of society, in other words the macro level, with the subjective ideas and goals of actors, in other words the micro level. The macro structural features are a cause or a set of independent variables in the model, and individuals’ characteristics become dependent variables. In the individual process, those individual characteristics are in turn a cause of individual behavior, which becomes a dependent variable. From such a viewpoint, bridge assumptions are needed for the transition between macro and micro levels of explanation.

Figure 2 illustrates an everyday life example of travel mode choice in a region.

- 1) A region with an improved public transport service and infrastructure (macro-level) offering it with an increased velocity (high speed trains for example) has a high rate of public transportation use (a macro-level proposition, linked by a causal relationship, Arrow 1).

Therefore, according to Figure 2, an explanation involving the micro-level takes the following form:

- 2) At first, a high-speed public transportation system in a region (macro level) is a cause for a lower perceived travel time with public transport compared with other transportation means on the individual level (micro-level) (Arrow 2).
- 3) A lower perceived travel time on the individual level stimulates individuals to use public transport often (a process which takes place on the micro-level) (Arrow 3 for a causal relationship on the individual level).
- 4) An aggregation of individual public transport use forms a high percentage of use in the region on the macro level (Arrow 4, linking the micro level with the macro-level).

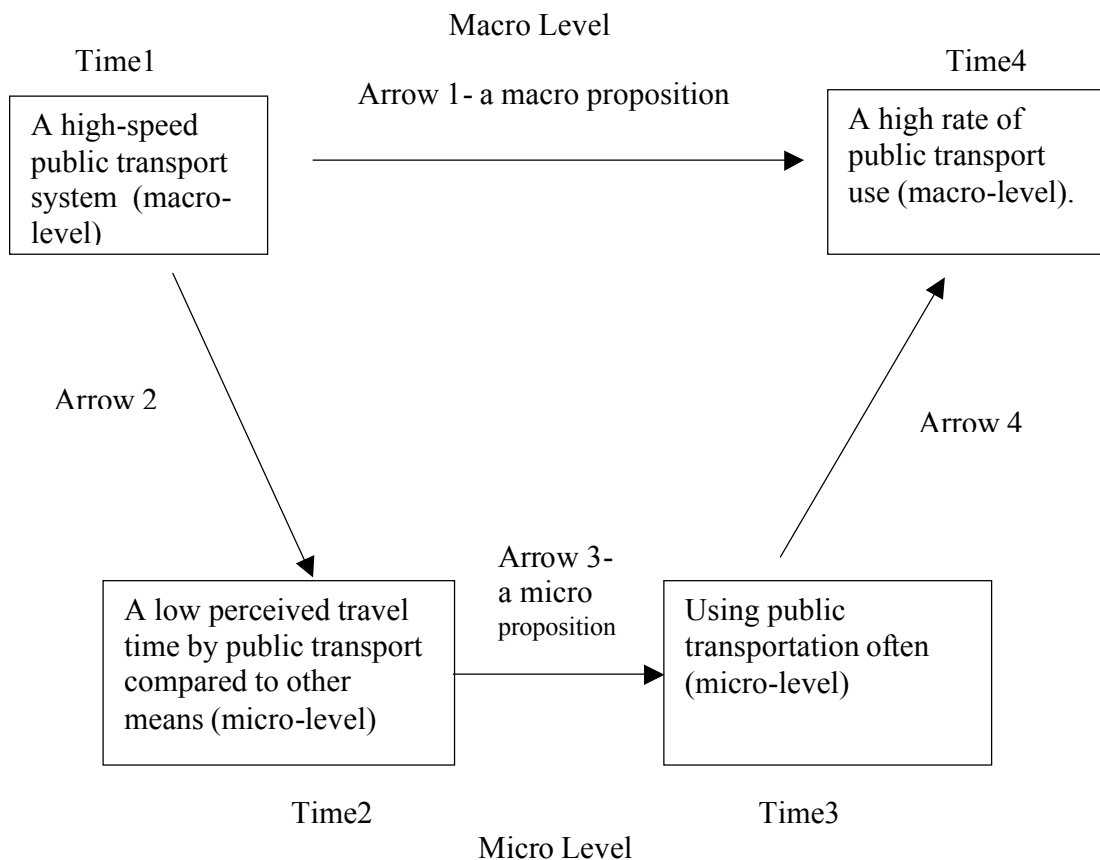


Figure 2: Macro and micro-level propositions on public transport use: Effect of high-speed public transportation infrastructure on its rate of use (modified from Coleman, 1990 (P. 10)):

In spite of the fact that the discussion on bridge assumptions often concentrates on static explanations of behavior, bridge assumptions impose a time dimension of explanation. In modeling relations between macro structures and micro processes, a macro structure at time point t_1 may impose a certain attitude towards the behavior at time point t_2 on the individual level. The individual may react later, at time point t_3 . Consequently, on the aggregate level we may observe a change at time point t_4 . Although often ignored, it should be taken into account in the construction of questionnaires in empirical studies.

Lindenberg (1989a, 1989b, 1990a, 1990b, 1991, 1992a, 1992b, 1996a, 1996b) follows a similar view of bridge assumptions, and imports from Economics the use of social

production functions (see for example Becker, 1976, 1981 and table 1). Accordingly, he defines three general (higher/principal) human goals: physical well-being, social approval and loss avoidance. In his work there is one utility function for all mankind, but there are systematically different production functions for different people (Lindenberg and Frey, 1993). There might be other sub-goals, which are tools for achieving higher-level goals (see figure 3). For example, people strive to achieve physical well-being. Therefore, they try to attain a high income. With that income they try to attain a comfortable car, if they consider a car as a mean to gain physical well-being. Buying a car is no more an act of consumption, but a means of production to achieve a goal. Thus, Lindenberg and Esser maintain that there is a hierarchical relation between the different goals. Social production functions include the goals as dependent variables, and different macro-level (such as price) or micro-level (such as income) factors as restrictions and independent factors. These factors determine behavior given the goals shared by all mankind, thus forming a very elegant way of explanation.

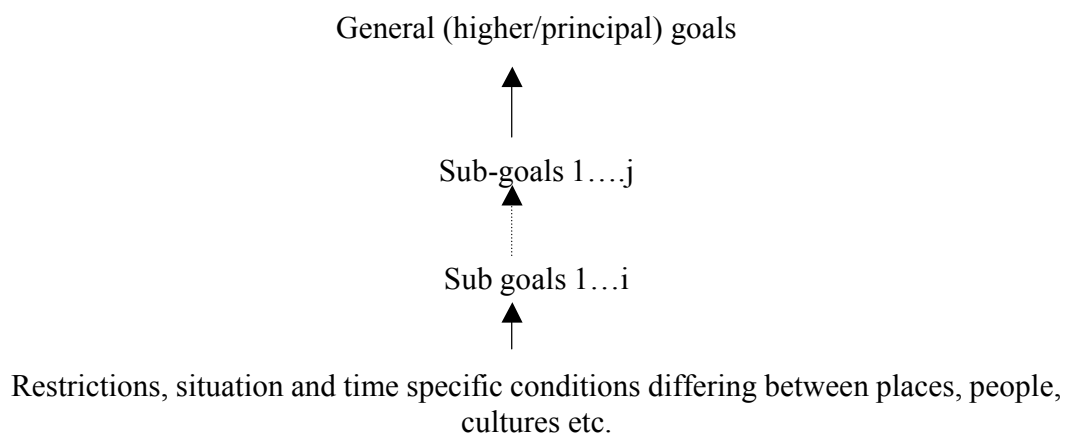


Figure3: A graphical representation of Lindenberg's explanation of human behavior

A link between abstract theoretical concepts and latent variables

Lindenberg and Esser's use of the term 'bridge assumptions' points to another interpretation of it (see table 1). They suggest, that one must connect the variables in a theory with real life parameters to provide the theory with content. For example, one

should have assumptions about the actors' goals. Additionally, one must link individual behavior with the model. Lindenberg argues, that for the theoretical construction of the link between the model and actual behavior, social production functions are very useful in order to construct bridge assumptions. However, no concrete guidance is provided how to construct them.

Simon (1985) introduced the term 'auxiliary assumptions' as "empirical assumptions about goals and, even more important, about the ways in which people characterize the choice situations that face them" (P.301). According to Simon (see table 1), while differentiating between the "real" situation and the situation perceived by the actors, "it must be assumed what the goals of the actors are, what kind of beliefs they have and how they can achieve these goals. In that sense, auxiliary assumptions are not general law propositions but situation specific, and translate terms such as "behavioral outcomes", "utility" and "Subjective Expected Utility value" into observational terms. Indeed, they have a similar sense to the one given by Lindenberg and Esser to bridge assumptions. However, they use the same term for different natures of it.

According to Simon, auxiliary assumptions about utility and expectations must usually be supplied before the theory of objective rationality can be applied to real situations. These auxiliary assumptions are introduced to provide limits to those rationality assumptions about the process of decision. Therefore, we can infer from this statement, that as auxiliary assumptions relate to a process of decision, they do have a time dimension, and that there is a time gap between the different stages of decision, to which auxiliary assumptions are supplied.

Let us give an example to illustrate this interpretation. If a theory which explains travel mode choice forecasts, that one would use public transportation only if such a choice would maximize utility, auxiliary assumptions will have to state observational expressions regarding the available alternatives, their costs, the needs of the actor, and the available resources. Such auxiliary assumptions might suggest, that an actor may use two alternative means of transportation to go to work: a bus or a car. In the next step, she/he

might consider three factors in the decision whether to use bus or car: comfort, ecological concerns and monetary and time costs. He/she will weigh each factor according to its importance and the available alternatives, take into account whether the resources allow choosing one alternative or another and in the final chronological step choose accordingly (see as an example Domencich and McFadden 1975, pp. 34-46). Such assumptions link an actor in a theoretical model with a “real-life” actor, who has aspirations and limited resources and faces different costs. Such assumptions are treated as auxiliary assumptions, as they make the maximization of utility meaningful as well as testable. These assumptions do not link the macro and the micro levels of explanations, but concentrate either on the micro level or on the macro one.

Criticisms and Alternatives

Opp and Friedrichs (1996) acknowledge the two meanings of bridge assumptions (see table 1). However, they disagree with the definition of the three highest goals suggested by Lindenberg. As these goals are not empirically based, they can be easily falsified as certain people may have different “higher goals”. For that reason they find Lindenberg’s position against an empirical measurement of preferences and goals hard to be defended. They raise several questions, for example: What do the behavioral alternatives of an actor depend on? How does the actor evaluate the probabilities for the different outcomes? Accordingly, they argue that preconditions are not a part of a theory, and cannot be logically deduced from it, but rather can only be obtained empirically (Opp, 1979, P. 78-79 and 1998). For that purpose, a possible method (but not the only one) is to apply questionnaires and interviews. Following the same line, Simon (1997, p. 288) argues, “that the progress of economics and especially the prospects for adequate empirical testing of economic theories would seem to depend, therefore on finding new kinds of data to supplement the thoughts of aggregative evidence now typically employed.”

Lindenberg does not call for an empirical test of the validity of the empirical content of bridge assumptions²⁹. Kelle and Lüdemann (1998) assert that in this way Lindenberg encourages researchers to use “heuristics of common sense knowledge”. Such heuristics are unsystematic, and might be harmful to the formulation of bridge assumptions, when the researcher’s world is not involved with the research field. Kelle and Lüdemann (e.g. 1995) maintain, that in order to formulate a deductive and falsifiable rational choice model, it must contain concrete and falsifiable bridge assumptions about the behavioral alternatives; behavioral outcomes or goals; subjective evaluation of the different outcomes or goals; subjective probabilities of each outcome; and restrictions on behavior (see also table 1). Indeed, bridge assumptions cannot be understood as general law propositions. They maintain that the researcher needs to enter the empirical field and find out which behavioral alternatives the actors perceive, and which outcomes they expect for these behavioral alternatives in order to formulate valid bridge assumptions. Kelle and Lüdemann assert that in order to construct bridge assumptions, which concern the specific subjective probabilities and utilities of these outcomes, one should use measurement instruments such as rating scales (Kelle and Lüdemann, 1998). Such a study may include open-ended questions. For that purpose, they offer two strategies: in one strategy, an empirically based generation of production functions should involve standardized elements applying interviews. In another qualitative strategy, computer based coding will evaluate verbal data (Kelle and Lüdemann, 1995). As a consequence, such data will serve as correspondence rules and/or as auxiliary assumptions.

We argue, that whereas the micro processes were examined carefully, the macro processes are often over-simplified. Beyond the importance of the micro-macro link, there are several important processes linking different macro levels. That is, the same link describing the connection between individuals and structures can be described to link higher macro level structures with lower macro level structures. The ongoing richness of

²⁹ On the importance of empirically testing such assumptions about actors’ goals, alternatives, beliefs and decision processes see for example Simon 1985 and 1997, p. 285.

possible causal processes on higher macro levels should be taken into account when constructing bridge assumptions.

There is no doubt that production functions are a valuable tool for theory elaboration. Production functions are elegant and provide a systematic explanation of behavior. However, we ask whether they improve the systematization of hypotheses generation when they come in the form of a mathematical maximization of the utility function. We are not sure what the answer is. The maximization of utility³⁰ (which is assumed by Lindenberg to be equal across individuals as utility cannot be measured, see also Diekmann, 1996 and Becker 1996, p. 5) is a tool to predict which restrictions will determine behavior and in which direction. However, often this is already known in advance at the very beginning of the construction of social production functions. Hypotheses, which are to be tested empirically, can be formulated also from the basic hypothesized relation between the situation and individual's behavior and utility, without any need to go through a maximization process. Instead, one could directly test these hypotheses empirically.

Conclusion

Finally, the different meanings of the term 'bridge assumptions' create confusion. Therefore, we believe that a distinction of the two practices of the concept by different terms might solve the confusion prevailing nowadays with it. We propose the following distinction:

- c) 'Bridge assumptions' (hypotheses) to represent only assumptions constructed to connect the macro level with the micro level of explanation (which is in line with Coleman, Lindenberg and Esser); and
- d) 'Auxiliary assumptions' (hypotheses) as Simon originally termed them, that is assumptions about behavioral alternatives, behavioral outcomes or goals, subjective evaluation of the different outcomes or goals, subjective

³⁰ On the critical view of maximization of utility to explain behavior see Simon, 1985.

probabilities of each outcome, and restrictions on behavior (in line with the second interpretation).

In this sense, 'Auxiliary assumptions' link abstract theoretical concepts with latent variables (see figure 1). 'Correspondence rules' link latent variables with observational terms. In order to construct 'auxiliary assumptions' and 'bridge assumptions' one must enter the empirical field, and apply for example large-scale data or interviews. In this way one can find the real links between theory, models and individual behavior. These links may occur on the macro level and on the micro level of analysis. 'Bridge assumptions' connect the two levels into one framework of explanation.

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Acknowledgements:

We would like to thank Sebastian Bamberg, Christian Lüdemann and Karl-Dieter Opp for very helpful comments.

Conclusions from the Dissertation:

Rational choice theory has been an increasing research field in the social sciences in the last two decades. However, its impact on empirical research has been small. This work has tried to contribute to the literature testing rational choice models empirically. Apart from encouraging to test action theories with data (Goldthorpe 1998: 33), researchers have argued that it may develop changes in theory in light of contradictory empirical results (Becker 1996:156). From such a viewpoint it is apparent that for exploring the sociological mechanisms of individual choices in general, and in the context of travel mode choice in particular, an affinity between rational action theory and data is to their mutual benefits.

Results of the theoretical arguments and empirical tests conducted in this dissertation leave several questions open. In the paper on “Time and Money” (Davidov, Schmidt and Bamberg 2003) we tested empirically some hypotheses from Becker’s work (1965) regarding the effects of monetary and time restrictions on travel mode choice on a representative sample of the German population, the microcensus. Results of introducing socio-economic variables in addition to variables postulated by Becker’s theory succeeded to show that these variables have an overwhelming effect on travel mode choice in Germany, offering alternative sociological explanations to those suggested by Becker and in traditional economic theory. Are these results multi-cultural, do social determinants have an overwhelming effect also in other countries on travel-mode choice? How do such results change existing models on time and money regarding the choice of travel mode? These are open questions for future research, which I would like to carry out by conducting more severe tests, applying other representative large-scale data.

What are the socially structured mechanisms and social background, which operate “behind-the-back” to restrict rationality? (Goldthorpe 1996; Breen and Goldthorpe 1997). In testing Stigler and Becker’s (1977) model on habit formation (Davidov, Schmidt and Bamberg, in progress) we use data of a field experiment, and succeeded in showing that education has an overwhelming effect on car use, presumably due to status seeking and contrary to theory. I would like to replicate the test with large-scale data. The relation

between rational choice theories and large-scale data may bridge macro social regulations and micro individual acts, social mobility, professional status, class-linked resources on the one hand, and traffic mobility and aggregated decisions on the other hand (for the link between the decision to own a house and macro social regulations see Semyonov, Lewin-Epstein and Davidov 2003). Such a connection may further elucidate the micro to macro link, and enable to restrict rationality assumptions.

Advances in modelling and estimation techniques steadily improve the chances of making effective evaluations (Goldthorpe 1998:50). To model structural equations on traffic behaviour and its determinants, we have carried out analyses of interaction effects with Lisrel, and an application on longitudinal data to test the autoregressive, latent curve growth and hybrid models with Amos. Future research should carry out tests of discrete behavioural choices with Mplus and heterogeneity in samples with Streams and Mplus, because these methods are promising for such types of data.

Can all the different approaches to model choice be empirically validated? Data has challenged contradictory theoretical approaches regarding the rationality of decision-making: Gary Becker's models of time (1965) and habits (1977); Ajzen's theory of planned behaviour (e.g. 1991); wide and narrow versions of rational choice (Opp 1999). In conducting an empirical test of the narrow and wide versions of rational choice defined by Opp, we succeeded to show that the wide version is more valid. However, it is still not obvious whether the wide version is empirically more valid than the bounded version defined by Simon (for example 1985) for several reasons. First, it is still not clear what exactly constitutes the main differences between the wide version and the bounded one. Before such an empirical test can be conducted, the theoretical relation between both terms has to be clarified. Are there any bridge assumptions and auxiliary assumptions, which are in line with one version, and are not in line with the other? Are there any different processes of decision-making involved? Is maximization of utility allowed? Do satisfactory rules exist also in the wide version? Do we have enough data to test the different versions? Only after some of these questions are answered, can an empirical test

be carried out, to link decision theories that also include the bounded version of rational choice with an empirical theory comparison.

The term “choice theory” may be useful to replace the term “rational choice theory”. Whereas the different theories about choice deal with decision-making, not all of them include exclusive “narrow” rational choice mechanisms. Does a rational decision consist of social norms, altruism, subjectivity and diversity among individual preferences and likings? Indeed, such factors are taken into account in the wide version of rational choice. Therefore, the term “choice theories” may be more adequate, as it does not necessitate a decision theory to be rational, and at the same time does not prevent it of being so. It may achieve the goal of reducing confusion regarding the meaning of “rational choice”, because it is more general and is not bound to any definition of rationality, which is still a large and opened field in the literature to be better defined, and closely explored theoretically as much as empirically.

Do the two terms often used: “rational choice theory” and “rational action theory” (for example Goldthorpe 1998) differ? The different terms may reflect different approaches of the use of the latent variable “intention”. Social psychologists and some sociologists often argue that the explored decisional mechanisms affect an *intention* to perform a behavior and not behavior directly (for example the theory of planned behavior, Ajzen 1991). From such a viewpoint, the term “choice” might reflect the fact that “choosing” does not automatically result in “action”. Other sociologists often do not consider “intention”, and believe that decision mechanisms affect behavior directly. From such a viewpoint “action” is more appropriate a term. Whereas we could not conclude based on some advanced techniques of testing interaction, whether there is an interaction effect between perceived restrictions and intention, we succeeded in finding out using our experimental data that intention has a significant effect on behavior, and plays an intermediating role.

In this dissertation I have tried to link data analysis and theory in the context of travel mode choice. Linking large scale and experimental data with choice theory in general and

with models of travel mode choice in particular addresses Goldthorpe's call for an alliance between the two. Moreover, it encourages rational choice "to be clear about its own limits" (Elster 1989:36). Testing different versions of theoretical approaches may urge changes of action or choice theories due to "puzzling empirical results" (Becker 1996:156). At the same time it may stimulate the development of new sources of data, especially panels, and the incorporation of sociological mechanisms in addition to monetary ones. Such a bridge between data, sociological mechanisms and theory might pave the way to a more integrated and powerful choice theory in the context of travel mode choice.

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