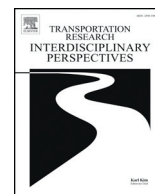




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Understanding social processes of shopping destination choice - An approach to model stability and variability

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ABSTRACT

Transport systems are affected by fundamental technical and social dynamics. For planners and researchers, travel demand models are an important tool to gain insights into possible effects of these dynamics and to find appropriate ways of dealing with them. However, most state-of-the-art travel demand models underestimate social aspects of travel choices, which we consider essential for understanding stability and variability of travel behavior. Based on a qualitative interview study, the paper presents an interdisciplinary approach to consider social aspects for modeling shopping destination choice. Starting point for our considerations is that people are social beings, moving around to build and maintain relationships, and that these relationships only unfold in relation to overall sociotechnical structures. The interview study provides evidence for relationships between stores and customers. Relationships can be distinguished in two dimensions. First, in terms of the nature of a relationship: having a relationship either with the owner of a specific store or towards specific brands. Second, in terms of the meaning: if the relationships is perceived meaningful or obligatory. Findings are represented in a first modeling approach. The results show that the more seldom relationships to owners of a store can be modeled easily, while the more typical relationships to brands require further research.

1. Introduction

Discussions about the increasing heterogeneity of transport offers, such as sharing services, intermodal information systems, or autonomous vehicles, often convey the impression that the introduction of such services will also considerably change today's transport behavior. And indeed, an increasing number of experts is convinced that large-scale changes of the transport system will become much more likely, mainly due to sociotechnical dynamics and/or broader societal megatrends (Puhe & Schippl, 2014; Truffer, Schippl, & Fleischer, 2017). Central to this understanding is that behavior changes are not only induced by technological developments, but also by social and political factors. Changes can be enabled, for example, by mobility-on-demand services, but also by sociostructural changes, for example in consumption patterns. In either case, users are no passive by-standers; they will shape new services and patterns in line with their routines, expectations, and configurations of daily life. Core of this thought is that innovations do not affect the process of change from the outside, but from within (Shove, 2010). We therefore argue that a more in-depth understanding of the determinants of stability and changeability of transport behavior is required to anticipate the dimension of change and to identify entry points for governance.

Sociotechnical transitions entail many uncertainties, in particular with regard to behavioral implications. We cannot measure precisely how users will actually adapt to new services and in which situations or how social change will affect future technologies. Uncertainties constitute a burden to traditional transport demand models, since they are optimized for analyzing and quantifying well-known cause-effect relations, which have been measured beforehand (Schippl & Fleischer, 2012). Typically, simulation studies present different scenarios entailing assumptions about the extent to which new services are available. But beyond assumptions about technical or service level performances, scenarios are often peppered with many uncertainties about interrelated societal developments and corresponding effects on the demand side. Assumptions about how new technologies could affect consumer patterns, labor markets, or family life, or the other way round, are widely missing. Since these dynamics are interwoven and influencing developments within the transport system, we argue that studies ignoring this interrelationship fall short in outlining how new technologies diffuse into society and to what extent they could transform the transport system in general and user practices in particular. To understand and anticipate how specific technologies or societal developments contribute to solving existing challenges or to what extent they may contradict potential solutions, more coherent assumptions are needed that address the

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conditions under which travel behavior remains stable and to what extent it is variable.

Change options are also increasingly reflected in transport demand models. Models are an important element for transport planning and central for assessing the impact of distinct measures and developments. By definition, models are a simplification of reality. For transport demand models, this simplification consists of a reality which is constructed from objective attributes of the built environment, the socio-demographic structure of the study area and performance characteristics of available mobility options. Agents are traditionally framed as perfectly informed utility maximizers, whose choices are only restricted by financial, spatial, and temporal constraints (Profillidis & Botzoris, 2018). Against this background, destination and mode choice behavior is assumed to be rather flexible in time and space. In this understanding, changes in parameter values – as, e.g., induced by new transport offers – trigger behavior changes quasi from the outside. However, such an approach does not recognize that individuals are likely to show rather stable travel behaviors, a well-known fact in travel behavior research (Hanson, 1980; Hilgert et al., 2018). More recently, a number of modeling frameworks have been developed to simulate stable transport choices. So far, though, approaches are rather mechanistic by modeling some kind of inertia, i.e., a destination chosen on one day receives a reward in utility for the following days. This simple method is already capable of replicating measured stability pretty well, but it does not model the causality behind (see e.g. Mallig & Vortisch, 2017a, 2017b). Mallig (2019) has outlined that the data basis significantly influences whether stable destination choice can be modeled statistically.

Aim of this paper is to present an approach to incorporate social processes into an existing travel demand model. In a first approximation to this, we will focus on grocery shopping as a transport purpose. As a first step, we will illustrate that broader societal transitions are likely to happen that cannot be described by technological innovations alone, but encompass the way people live or want to live their life. Based on findings from a qualitative research study conducted in Karlsruhe, Germany, we will outline distinct forms of relationships between different kinds of stores and their customers. Given a good understanding of the mechanisms of relationships between customers and stores, we will then present a first approach to technically model the observed phenomena.

2. Grocery shopping in Germany

Grocery shopping is deeply interwoven with everyday life. Together with private businesses, it accounts for one third of all trips in Germany (Nobis & Kuhnimhof, 2018) and is thus particularly relevant for transport planning and scientific analysis. The food retail landscape in Germany is heterogeneous, with a typically high density of large hypermarkets, supermarkets, discounters, convenience stores, independent grocery retailers, organic supermarkets, and open markets in urban environments. However, only five large companies hold a market share of around 70% of the total food trade. Over the last years, food retail in Germany experienced increasing revenues that almost all types of stores have benefited from, especially larger supermarkets and organic supermarkets. Only small independent grocery retailers are increasingly losing relevance (statista, 2019).

Looking at the demand side, a common explanation for distinct shopping patterns relates to attributes of the specific supermarket, such as price, service, proximity, or product range, which vary between the different store types. In this understanding, people make rational choices based on their financial or time resources. However, as in the case of modeling frameworks, it underestimates how consumers follow established routines. Transition research explicitly conceptualizes how consumer patterns of the food retail market appeared to be quite stable for a long time, with a clear orientation towards rationalization, efficiency, and uniformity. In their book on changes in food consumption, Spaargaren et al. (2012) outline how everyday routines “are transformed under the growing influence of food safety incidents, food security crises, public protest against food-related technological innovations, and debates about the globalization of food production and consumption” (xvii). Additionally, it has not yet

been fully understood to what extent e-commerce will transform present grocery shopping practices.

Against this backdrop it becomes clear that medium- to long-term transformations are influenced by a variety of societal and technological developments. These developments influence transport decisions (e.g., in which kind of supermarket to shop), but are currently lying outside transport model boundaries. However, attempts to model shopping destination choice, e.g. by including attractiveness, do not come close to the complexity of sociotechnical transitions. It is uncertain if future consumption patterns - and thus destination choices - will be characterized by uniformity, as the constant market consolidation suggest, or if (or to what extent) societal and environmental concerns, animal welfare, and health issues increase in significance and transform today's preferences and thus destination choices.

3. Evidence from qualitative research

In the following, we will present insights from a qualitative research study, set up to better understand social processes of mobility choices. Basic premise of the approach is that relationships people have with different retail stores determine, or at least influence, destination choice options. In this perspective, the decision about where to shop is not only affected by spatial settings, mobility options, or financial considerations, it is also triggered by more or less changeable assumptions about what is necessary and desirable for living a “normal” life (Urry, 2003, 2007). Considering relationships provides a *meso* level in between individual traits and structural characteristics. We argue that such a meso level appears to be a promising approach for modeling and analyzing the stability of destination choices, in particular in the light of sociotechnical changes.

Evidence for the existence of relationships between customers and retailers is drawn from an interview study conducted in autumn/winter 2018. As qualitative research is not common in combination with simulation studies, we think it is appropriate to say a few words about the character of qualitative research. Qualitative research is not set out to be representative, but is particularly suited to analyze the meanings people attribute to their actions and to understand contextual factors that accompany distinct situations. Through discussions with participants, the researcher is able to understand what facilitates and what constrains behavior change (Clifton and Handy, 2003). A prominent example of how qualitative research can enrich transport studies is the HATS technique, widely acknowledged as a milestone in the field of activity-based travel analysis (Jones et al., 1985). In their paper on qualitative methods in travel behavior research, Clifton and Handy (2003) describe how the research group of the Transport Studies Unit in Oxford began their examination with a qualitative interview study with a small sample of participants in order to test different theoretical assumptions. Results were used to develop a quantitative study, which finally resulted in the development of the first Household Activity-Travel Simulator (HATS).

3.1. Study design and data collection

Main purpose of the study was to examine the web of social relationships people sustain in daily life and how that relates to their transport choices. The data was gathered through a qualitative social network analysis approach in 27 cases in Karlsruhe, Germany (for insights into qualitative social network analysis, see Hollstein, 2011). In order to be able to focus on social aspects of mobility choices, spatial factors of the respondents' living environments were kept similar. All respondents live in the same inner-urban district, characterized by social diversity and manifold opportunities for grocery shopping. Each case consisted of two in-depth face-to-face interviews and the completion of a one-week travel diary. The first interview addressed the social network of the respondent (including individuals, objects, and places). The second interview addressed the different practices for keeping relationships alive. The interviewees were selected purposefully, so that they represent different gender, educational levels, and working status (see Table 1). Main selection criterium though was whether

Table 1
Socio-demographic characteristics of interviewees.

ID	Sex	Age	Household structure	Number of children	Occupation
1	Male	33	Couple	0	Researcher
2	Female	31	Family	2	Midwife
3	Female	35	Single Mother	2	Cleaning lady
4	Female	51	Single Mother	1	Nursery school teacher
5	Male	26	Shared flat	0	Student
6	Male	18	Parental Home	0	Pupil
7	Female	47	Family	3	Full professor
8	Male	20	Shared flat	0	Student
9	Male	37	Family	1	Researcher
10	Male	42	Family	1	Consultant
11	Female	35	Shared flat	0	Laboratory Assistant
12	Female	30	Shared flat	0	Student
13	Male	45	Family	3	Geriatric nurse
14	Female	33	Family	2	Housewife/student
15	Female	40	Family	4	Housewife
16	Female	28	Family	2	Cleaning lady
17	Male	27	Family	2	Conceptor
18	Female	24	Shared flat	0	Nursery school teacher
19	Female	33	Shared flat	0	School teacher
20	Male	31	Couple	0	Private music teacher
21	Male	34	Single Household	0	School teacher
22	Female	30	Family	1	Researcher
23	Male	31	Single Household	0	Dentist
24	Female	24	Couple	0	Nursery school teacher
25	Male	33	Family	2	Chimney sweep
26	Female	29	Single Household	0	Nursery school teacher
27	Female	-	Shared flat	0	Pupil

interviewees lived in a household with or without young children. This criterion is based on the assumption that both groups differ in their freedom of choice and in respect to the social obligations imposed upon them by others and the society as a whole. Interviewees were encouraged to talk about different sorts of relationships, for example, relationships they have with other individuals such as family members or friends, but also about their reasons for choosing specific supermarkets or joining particular sports clubs. As we refer to grocery shopping in this paper, we center our analysis on this purpose in the following.

3.2. Different types of relationships between customers and stores

The vast majority of interview participants report on a relatively stable portfolio of stores to shop for their everyday needs. For some, this portfolio includes only two stores of the same type, while others report of sophisticated and dispersed compositions of several different stores.

“Usually we go to either Kaufland or Real [both large hypermarkets]. Depending on who has the better offers. But we always go by car and when we have time, we go together.”

[[ID_16]]

“We always go to Edeka [supermarket]. I haven't seen another supermarket in a long time. What we do less often, for special things, we go to Füllhorn [organic store] here, if we need some special groceries.”

[[ID_1]]

For many, the composition of this portfolio is by no means arbitrary. According to Everts and Jackson (2009), different types of stores represent different meanings and in particular different trust relations. The authors distinguish between two sorts of trust relations: a) trust relations fostered by face-to-face interactions, e.g., with the shop owner of a small independent store and b) relations based on trust in specific brands, predominantly fostered by larger supermarkets. In line with this, most participants had a precise idea of which products to buy from which store.

“Well, at Edeka [supermarket] I am definitely once a week. Kaufland, Real [both large hypermarkets] usually changes weekly, because they're further

away and I just look for what I need more urgently. If I need cornflakes, I go to Real, if I fancy muffins, I go to Kaufland.”

[[ID_18]]

“Today we needed very special things, which are available at Edeka [supermarket] and not at Nahkauf [other supermarket], where we usually go more often”

[[ID_13]]

Due to the high market consolidation in Germany, it is possible to maintain relationships based on trust in brands at varying locations (at least when excluding temporal and spatial constraints for now), since it is possible to receive exactly the same products at different branch stores. Most retail companies in Germany provide a substantial range of private labels to increase customer loyalty. In 2018, the market share of private labels in the total turnover was stated to be around 40% (statista, 2019). The following quote exemplifies the loyalty to particular products, for which the respondent interrupted his tram-ride:

“I took the tram that day, got off, and went shopping. We just needed special things that are only available at Alnatura [organic supermarket]. And that's why I got off there”

[[ID_13]]

As indicated by Everts and Jackson (2009), there is another type of trust relations that makes people shop at specific stores: trust in persons. Compared with trust in brands, trust in persons has been losing relevance over the past decades. However, some respondents had a somewhat strong relationship with the shopkeeper of an independent organic store in the district. Interestingly, regular customers refer to the store by the first name of the shop owner, which underlines the relationship they have with this particular person.

“Well, Holger [the shop owner] is like a grandpa to a lot of people around here. And you have to go there regularly. And we often go there, too.”

[[ID_14]]

“Well, I always go to the market on Saturdays. And I get the rest from Holger.”

[[ID_19]]

However, there are also respondents who do not have particular relationships, neither to specific brands or products, nor to persons.

“So I don't have a plan; honestly, I buy when it's necessary or also when I feel like doing something.”

[[ID_4]]

We assume that the different sorts of trust relations determine transport choices, especially regarding the travelers' freedom of destination choice, in distinct ways. In case of trust relations between shopkeeper and customer, the specific location of the store is fixed. For relationships based on trust in brands, the freedom of destination choice is more flexible, since the relationship can be maintained at different branch stores at varying locations. People who do not have relationships, neither with persons nor with products, are more flexible in their destination choice. Fig. 1 illustrates the anticipated freedom of destination choice for distinct trust relations.

Our analysis provides evidence for the validity of trust relations between consumers and stores. Central to transportation research is that social relations are more or less strong connections, which are constituted by periodic encounters. We have argued that conceptualizing choice as a relational rather than an individual phenomenon provides a solid causal explanation for empirically measured stable destination choices. Though the main question in this paper is how the notion of relationships with its strong focus on stability can also be used to analyze changes. Therefore, it seems appropriate to distinguish between the different times at which changes

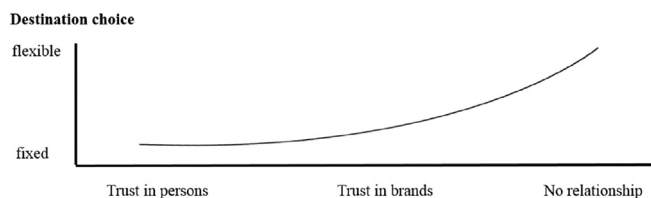


Fig. 1. Anticipated freedom of destination choice for distinct trust relations.

take effect. Taking a medium-to-long-term perspective, Everts and Jackson (2009) outlined in their paper how the introduction of self-service shops and the demise of the corner store replaced the trust in persons with trust in brands. Similarly, structural changes – such as an ageing society, or increased migration, or the growing importance of societal and environmental concerns among certain social groups – could lead today, little by little, to an increase in people who trust in persons rather than in brands.

However, since socio-structural changes are characterized by various interdependent factors, it is beyond the scope of this paper to sketch out complete sociotechnical scenarios. Nevertheless, relationships vary not only over long time periods; they also unfold their impact in a short-term perspective. Based on our results, we assume to find a fruitful approximation for what will happen if infrastructural changes occur in the meaning of the relationship.

3.3. Grocery shopping – for some it is meaningful, for others obligatory

As a result of our analysis, we can distinguish two modi of how relationships to grocery stores come into peoples' life. The majority of respondents maintain an obligatory relationship with certain stores or branches. They head for the same set of stores, almost as being on “autopilot”; mainly because this task has to be done, it has to be squeezed into the day. This kind of relationship comes into peoples life mainly for cost-calculating reasons and is sustained even if new options for grocery shopping appear. This line of reasoning is well-known in psychology-oriented transportation research and subsumed under the term habitual travel choices. By definition, habitual behavior is the repeated performance of behavior (Gärling & Axhausen, 2003; Verplanken & Wood, 2006). The authors outline that choices can still be rational in the first place, but after gaining positive experiences, people continue to make this choice without actively thinking about it anymore. Not surprisingly, the majority of respondents has mentioned the proximity to their place of residence as the main reason for choosing certain stores. The respective relationships have developed almost randomly, in the sense that they were not intentionally established.

“You know, I often go to Nahkauf [supermarket]. Sometimes, when I need something special, I go to Edeka [another supermarket] because it is bigger, but normally I just don't go there, because we always walk in the other direction in the morning.”

[[ID_15]]

Common means to model choice by taking into account the generalized costs to the destination zone come close to this sort of relationship. The other mode for establishing a relationship is different though and can be defined as meaningful. Some of the respondents literally cultivate their relationship with certain stores or branches, meaning they prefer one store over the other. In which supermarket to shop affects their social belonging and identity. This line of reasoning is well-known in social science-based research. Speaking of routines, research in this realm outlines that repeated behaviors are often shared patterns of behavior within a social context: emanating from social norms or emotional attachment (Tomlinson & McMeekin, 2018). For maintaining meaningful relationships, people are willing (and able) to undertake longer journeys and accept higher costs and effort. Shopping patterns in this mode are only partly influenced by external stimuli upon which travelers react, but by more or less conscious

deliberation about what is the expected behavior for themselves and people like them.

“I buy groceries at Holger's and at the market. When I'm in the city center, my favorite is Füllhorn [organic supermarket]. It used to be Alnatura [other organic supermarket], but somehow I learned that Füllhorn is even more ecological and somehow cooler.”

[[ID_10]]

3.4. Implications for behavior change

The principle that recurrent behaviors have been established holds true for both types of relationships. The reasons, though, and thus their implication for fostering behavior change, is different. Psychology-oriented transport research has shown that transport habits are a type of tacit knowledge that has been proved appropriate in certain situations. Thus, habits are relatively easy to maintain, they have proved to be efficient and are often backed by an additional normative support (that, e.g., shopping in a nearby supermarket allows for other activities considered more relevant). Verplanken and Wood (2006) have shown that people who are in the habit of, e.g., shopping in a certain grocery store, experience a biased perception of information on alternatives and do not actively search for new options. Therefore, successful habit change interventions involve disrupting the cues that lead to automatic behaviors, e.g., by substantially changing circumstances to reach a certain destination. In the case of grocery shopping, we consider it likely that relationships that are perceived obligatory are maintained as long as spatial-infrastructure factors are kept similar. In case of changing context factors though, we assume that shopping destination choice follows a similar justification, namely that the store has to be reached as easy and effective as before. The type of store plays a minor role for the decision-making process.

Relationships that we define as meaningful are based on a different reasoning. Meaningful relationships with certain stores or chains often emanate from strong emotional or normative bonds. Such relationships are of great importance for the people, both for their self-concept and their social status. As indicated above, food, its origin and quality, cooking and eating together, are increasingly important for large parts of the well-educated middle class and are used as a means of social distinction (Reckwitz, 2018). Eating as a meaningful performed practice transforms grocery shopping into an equally meaningful activity. For certain lifestyle groups, it becomes more important to obtain beef from a certain butcher or to be able to offer the olives from a certain market stall, since “they lack in taste elsewhere” [ID_22]. Where to receive groceries from becomes an essential aspect of daily life. Therefore, we assume that in the case of changing spatial-infrastructure conditions, people who maintain a meaningful relationship will more actively hold on to this relationship, even if this implies higher costs and effort, or replace it by a relationship which expresses a similar meaning (see Table 2).

4. Simulation study

In the following, we present an approach to model the behavioral implications outlined above. To assess the impact of the distinctions made, a hypothetical scenario of a car ban is used. We are aware that such a scenario is only capable of taking into account short-term changes of the spatial-infrastructure environment, but does not synthesize the combined occurrence of sociotechnical dynamics inherent in medium- to long-term changes. For such, assumptions about societal dynamics and their influence on choice making would be needed, which is beyond the scope of this paper. However, implementing an infrastructural intervention and leaving societal developments aside, still allows us to consider situative stability of shopping destination choices.

To assess the effects resulting from the distinctions made above, an existing model is used. For the study, the destination choice model of mobiTopp, an agent-based travel demand model for the region of Stuttgart, is modified. The effects of the infrastructural intervention are analyzed in

Table 2
Choice options in the light of spatial-infrastructure changes for different sorts of relationships.

NATURE OF RELATIONSHIP	MEANING OF RELATIONSHIP	
	Meaningful <i>Relationship follows social norms</i>	Obligatory <i>Relationship follows cost-calculating considerations</i>
“Trust in persons” <i>(destination choice is fixed to determined destinations)</i> or “Trust in brands” <i>(destination choice is limited to certain types of destinations)</i>	Stick to a relationship (up to a time or financial threshold) or search for alternative relationship expressing a similar meaning	A relationship is substituted by an alternative that is as comfortable and effective as the former one
“No trust relation” <i>(destination choice is flexible)</i>	x	x

three steps: Step one uses the existing destination choice model of *mobiTopp* in order to circumvent missing quantitative data, which would be needed to model relationships. Since the existing destination choice model in *mobiTopp* is calibrated on representative empirical data, we assume to have relationships of distinct kind to grocery stores already included in the sample. However, there is yet no mechanism available to distinguish the different dimensions of relationships as introduced in Section 3. We will therefore model the limited freedom of choice resulting from different trust relations as outlined in Section 3.2. in a second step. Here, we define choice sets for destinations fixed to determined destinations (*trust in persons*) and choice sets that are limited to certain types of stores (*trust in brands*). In a third step we aim to approach the likeliness of a relationship to be replaced by another by including the distinction of meaningful and obligatory relationships as outlined in Section 3.3. All steps are applied for the activity type “grocery shopping” only.

4.1. The *mobiTopp* model

mobiTopp is an agent-based travel demand model that models every person, household, and car of the study area. Agents make their decisions autonomously, individually, and situation-dependent, based on the current situation or the interaction with other agents. In *mobiTopp*, every agent has an assigned activity program for a whole week, which is gathered from representative empirical data. While agents carry out their activity programs, they decide where an activity will take place and which mode to use. Destination choice and mode choice are both based on discrete choice models (Mallig et al., 2013; Mallig & Vortisch, 2017b).

mobiTopp consists of two stages: initialization (long-term module) and simulation (short-term module). For initialization, the long-term decisions of agents and households are defined. This includes population synthesis, generating all agents and households based on structural and empirical data. Also, locations for fixed activities (home, work, and education), the ownership of private cars and transit passes, and the activity programs for each agent are modeled. The simulation of travel demand for the short-term module is based on these long-term decisions. In this stage, travel behavior of all agents is simulated simultaneously. All agents are simulated over one week, applying the destination and mode choice models sequentially for each trip of an agent. The destination choice model is based on traffic analysis zones. The default mode choice model supports five modes: walking, cycling, public transport, car as driver, and car as passenger. Agents make their decisions in the context of their household, in particular if a car is available to the household. For this case, the car is only available for an agent if it is not used by another household member.

For modeling destination choice, two types of activities are distinguished: activities at fixed locations (work, education, and home) and flexible locations (e.g., leisure and shopping). Fixed locations are modeled in the initialization stage and are therefore excluded from destination choice modeling. For activities with flexible locations, a discrete choice model selects a zone in which the respective activity can be performed. The default model takes into account the attractiveness of the destination, travel time and travel cost from the current location to the next potential destination, together with travel time and travel cost from the potential destination to

the next fixed location (e.g., to the workplace or back home) (Mallig & Vortisch 2017b). So far, the sales area is used as a proxy for attractiveness, defining how likely an agent will move to this location. A repeatability mechanism in form of a bonus system is applied to model simple stability aspects. On this basis, agents decide whether to select one of the already used destinations or to try out a new one. By doing so, relationships and thus stability is rather random and will probably change if input data changes.

4.2. Study area

We apply our research on an existing *mobiTopp* model of the region of Stuttgart, consisting of the city centre and the surrounding districts with more than 2.7 million inhabitants. People aged six and over are included in the modeling, resulting in about 2.5 million agents. Travel demand for all agents is modeled for a whole week. The study area consists of 1012 traffic analysis zones. Zones, travel times as well as cost matrices are taken from an existing macroscopic model. The models for activity generation, destination and mode choice have been estimated and calibrated with a household travel survey, which is not related to the sample mentioned in Section 3. However, the aim of this paper is not to model representative travel behavior, but to approach social aspects of travel decisions, which we assume to be comparable in Stuttgart and Karlsruhe. So far though, there is no representative dataset on these aspects available. We therefore use the existing representative dataset of the region of Stuttgart and apply the observed phenomena to it. A detailed description of the models, the estimation process and the parameters can be found in Mallig & Vortisch 2017b and in Mallig, 2019.

4.3. Simulation setup

mobiTopp is designed in a modular way allowing to replace or extend existing models with other approaches. For the purpose of this paper, a reasonable way to integrate stable grocery shopping behavior as introduced in Section 3 is to extend or replace the destination choice model (see Fig. 3). Therefore, the long-term module is modified. Besides fixed destinations for work, education and home, a fixed choice set for grocery shopping is allocated to each agent of the study area. This choice set is drawn from the existing model. Based on findings presented in Section 3, we generate choice sets based on trust in persons and based on trust in brands. For the short-term module, this predefined choice set is then used for modeling grocery shopping. For further analysis, attributes of certain destinations can be modified, e.g. by synthetically increasing costs.

4.3.1. Defining grocery store types

Basic premise of choice models is that choices are assumed to be largely free, mainly governed by the intention to minimize travel time and cost. We have outlined in the previous chapters that this holds true for some relationships, while other relationships are build upon social norms or emotional bonds. Furthermore, the availability of specific brands or trust in a specific person makes people prefer one store over the other. However, *mobiTopp* neither includes information on brands or shop owners, nor on the meaning

of different stores to people, but it reliably estimates results based on representative empirical and structural data. So far though, the attractiveness of a specific shopping destination depends on the size of the sales area and certain traits of the individual (e.g. income). In order to model shopping destination choice as a relational rather than an individual phenomenon, we had to assign further characteristics of the respective grocery stores to the

destination zones. We therefore distinguished different types of stores into seven categories: discount store, supermarket, organic store, drug store, open market, hypermarket, and other grocery stores. Given the fact that most retail companies provide a substantial range of private and store specific labels (statista, 2019), we assume this classification as a suitable characteristic to model distinct sorts and meanings of relationships.

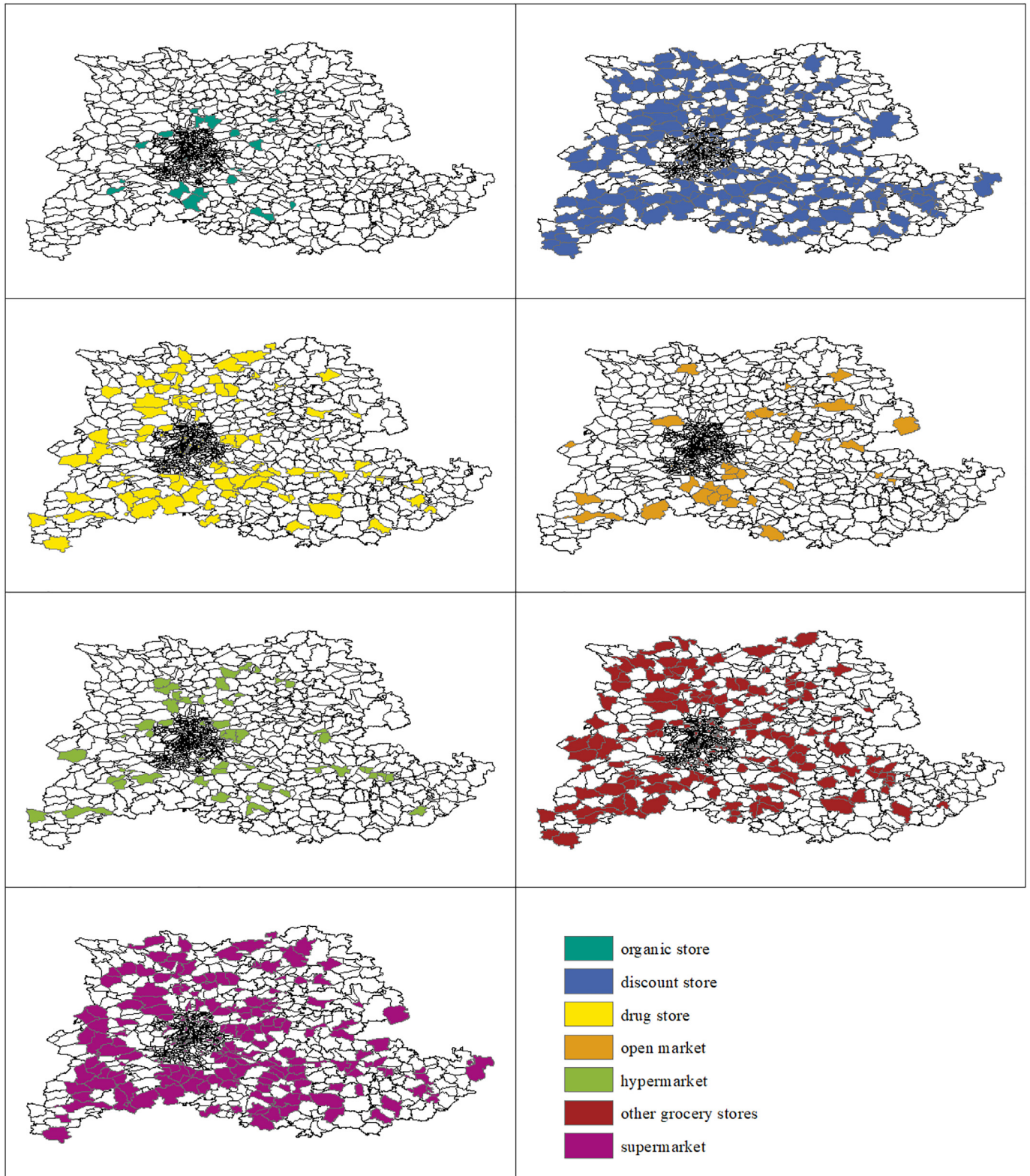


Fig. 2. Classification of the study area by store type.

Different data sets were used to fill the missing information on store types. For the city of Stuttgart, a list of stores is used, which is built upon different statistical data sources, containing the name, classification, sales area, and address of the respective stores. However, for the surrounding communities, the list is not as complete as for the city centre. Different store types tend to be underrepresented. To compensate this, we used open street map for filling the gap of lacking information. Thereafter, zones were labeled according to the store types residing in this zone. Each zone could contain multiple labels (see Fig. 2).

4.3.2. Calculating different choice sets

As indicated in Section 3.2, we distinguish two types of trust relations for grocery shopping: trust in persons and trust in brands. While trust in person relationships are fixed to a small number of determined locations, trust in brands relationships are limited to certain types of stores and thus a variety of destinations (see Fig. 1).

To generate respective choice sets, the results of a default mobiTopp destination choice simulation is used (see Fig. 3). The results of this first model run serve as a proxy for trust in persons choice sets. For doing so, an agents' choice set is limited to the particular destinations s/he has chosen for grocery shopping in the first model run. For example, an agent has chosen two distinct zones for grocery shopping in the existing model, the trust in persons choice set is limited to exactly these two destination zones for the trust in persons scenario.

Modeling trust in brands is much more difficult, since the existing model treats all stores equal. The sales area which serves as a proxy in the existing model does not allow distinguishing different brands or store types. Therefore, modeling trust in brands relationships requires defining store types first and to assign them to destination zones (as introduced in Section 4.3.1). For generating trust in brands choice sets, all zones that contain the particular store type chosen in the existing model are suited to fit that agents' choice set. For example, if an agents' choice set consists of a discounter and a hypermarket in the existing model, all zones containing discounters and hypermarkets are part of this agents' individual choice set.

Our interview data suggests that trust in persons and trust in brands relationships coexist and are not equally distributed among the different store types (i.e., it seems much more likely that trust relations to persons exist more often for independent stores and open markets, while discounters and supermarkets are much more likely to attract trust in brands relationships). We are aware that for analyzing scenarios that are more dependent

on developments in society (e.g. increasing ageing of society, migration, awareness for sustainability issues), a more sophisticated differentiation would be needed. However, for testing the phenomena as such, we consider a scenario in which all agents either trust in persons (choice sets consist of determined destinations) or in brands (choice set consists of all destinations that host a specific store type). This approach allows us to separately understand the effects of both relationships on the model, before defining more differentiated scenarios in future work.

4.3.3. Modeling distinct meanings

As introduced in Section 3.3, the meaning of a relationship is essential for analyzing the persistence of a relationship. Some relationships are meaningful to the people and they imply a strong normative background. We expect those relationships to be relatively persistent, despite difficulties to keep the relationship alive. Obligatory relationships on the other hand follow cost-calculating considerations and we expect them to be more variable in the process of change (see Table 2).

Since we assume obligatory relationships to be mainly build upon cost-calculations, there is no need to change the existing destination choice model (because that is what it is already based on). To model meaningful relationships, destination choice is limited to specific destinations. Instead of having the choice from all destinations, only zones with store types as used in the existing model will be available for the agent (similar to the trust in brands choice set). For example, agents that chose an organic store in the existing model will only have destinations in their new choice set that host an organic store. The choice model can thus only select from these destinations.

However, there is indication that only a minority maintains a meaningful relationship to their preferred grocery store. Therefore, this particular restriction is only activated for 30% of all agents. At this point, it is again important to emphasize that our data does not stem from a representative survey, but from qualitative research that aims to shed light on the phenomenon in general. The amount of 30% is thus only an assumption to test the reasoning. We are fully aware that for giving more reliable statements and to specify how many and which consumers sustain a meaningful relationship, a quantitative survey is needed.

4.3.4. Scenarios

In the following, we will test the modifications on the model. Changes of destination choice can only be analyzed if choice decisions are made

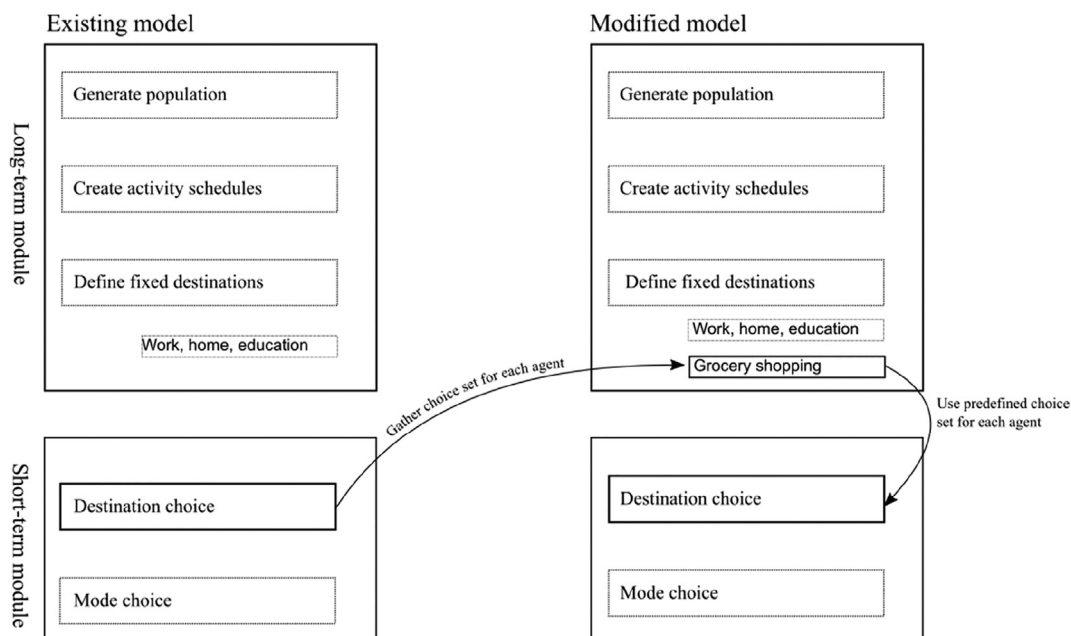


Fig. 3. Modification of the mobiTopp framework.

frequently, or if any form of intervention is implemented. Since grocery shopping is performed from rarely to frequently, depending on the individual agent, we aim to test the modifications by implementing an infrastructure intervention. In order to achieve a significant effect, we take up the discussion about reducing particulate matter and close the city center of Stuttgart to motorized means of private transport. Stuttgart is one of several German cities where the concentration of fine particulate matter has reached harmful levels. In order to reduce emissions, a partial ban for diesel cars in different parts of the city has been discussed at the political, legal, and public level. The discussion does not seem arbitrary, since other European cities, such as Oslo, Madrid, or Barcelona have already done so and partially banned cars from their city centers. We take this discussion as a basis for our hypothetical scenario of banning all cars from the inner city of Stuttgart. In order to do so, we increase the costs for OD relations using private motorized modes that either start or end in the city or both.

The effects of the distinctions are examined in a total of six scenarios (see Fig. 4). First, the existing model is used, both with and without a car ban (scenario 1 & 2). This serves as a base scenario. Second, choice sets are generated for all agents, once determined to specified destinations (scenario 3) and once limited to certain store types (scenario 4). For both, 30% of the agents are assigned a meaningful relationship and 70% are assigned an obligatory relationship. Third, a car ban is simulated and the destination choice model is carried out again for both, the trust in brands and trust in person model (scenario 5 & 6).

4.4. Discussion

The modification of the mobiTopp system provides a very first approximation to model stable destination choices based on qualitative interview data. It needs to be noted that both, the modifications of the destination choice model as well as the car ban are only hypothetical changes to measure the sensitivity of the model. The sensitivity is measured by comparing the destination choice sets of all agents (Hanson, 1980). As intended, altering the existing destination choice model to a trust in persons model shows only minor effects. Compared to the original model, very few agents change their set of destinations. Changing the spatial-infrastructure setting by introducing a car ban has a huge effect on the existing model in the base scenario. About 26% of the agents change their set of destinations compared to the existing model without car ban. Using the trust in persons model for simulating the car ban reduces the effect to 18%. This correlates to the number of agents configured to have a meaningful relationship with a particular grocery store (30%).

However, not all modifications worked well. Implementing the trust in brands model appeared to be much more challenging. Compared to the original model, too many agents change their set of destinations. One explanation could be that the choice sets of about 50% of the agents in the trust in persons model contain only one destination. Limiting their freedom of destination choice reduces their movement substantially. Additionally, the choice sets consist of destinations based on probabilities that have been generated from the existing model. In contrast, for the trust in brands model, the number of possible destinations includes all zones containing the same store types as used in the original model. The set of destinations is thus not only based on the probability to choose a zone but also on

attributes not considered to calculate the probability before. The resulting choice set might contain the likeliest zone and many other zones, but not the likeliest zones in terms of the original model. This has a much greater effect on the probabilities used to select a destination since further destinations become available. Applying the car ban to the trust in brands model results in an increased number of agents changing their set of destinations compared to the scenario without car ban. As this is a counter-intuitive – introducing stability induces instability – we assume this as a result of the input data. The classification of stores in the inner city is based on a broader data set, resulting in a comprehensive and more diverse classification of zones according to store types compared to the surrounding area. Agents sticking to a specific store type are therefore more affected by a car ban, if the store type is significantly present in the city center. The stability aspects of trust in brands are apparently much more challenging and need further approaches to estimate reasonable results.

In general, the results show that using a rule-based approach allows integrating stability aspects of the trust in persons model quite easily. The number of agents choosing a destination out of their choice set can be configured using a single parameter. While the trust in persons approach worked well, the trust in brands model changes destination choices in a disproportionate way, indicating that the trust in brands model needs more information and parameters to be calibrated correctly.

5. Conclusion

We have argued in this paper that social processes of travel decisions are only insufficiently represented in transport demand models. Most modeling frameworks are based on revealed or stated preferences. This works well for modeling known cause-effect relations, such as estimating the consequences of building a new tramway line. However, using today's statements and preferences for estimating future states of the transport system holds some uncertainties, particularly with respect to potential societal processes. From a sociological point of view, there is little reason to assume that current preferences will still be valid in the future. In addition, modeling frameworks are often designed in a way that keeps certain factors stable (e.g. consumer preferences), while others are considered variable (e.g. technology). Sociotechnical transitions, with its interplay of various societal and technical factors, cannot be represented that way. By taking a closer look at grocery shopping, we have outlined how decisions in one sub-domain of daily life are triggered by (changing) assumptions about what is necessary to live a “normal” life and how these assumptions determine travel decisions.

Instead of asking for individual preferences and attitudes, we have focused on relational aspects between individuals and grocery stores. The qualitative interview study reveals that people tend to maintain a relationship with grocery stores or chains, triggering stable destination choices. It became clear that stability cannot be explained by frequency only. Pointing at relationships reveals that stability is multi-faceted. First, the nature of a relationship was interpreted in terms of different spatial flexibilities. People having a relationship with a specific shop owner (trust in person) tend to shop at exactly the same destination, while people having a relationship with specific brands (trust in brands) have a higher flexibility, since they are able to receive their favorite products from various stores. Furthermore,

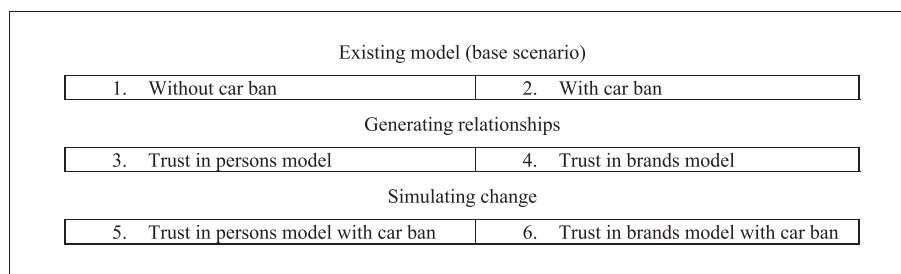


Fig. 4. Diagram of the six scenarios.

we have used the meaning of a relationship as an indicator to determine the persistence of a relationship. Some people maintain a meaningful relationship, often expressing someone's social norms or social belonging. Others have an obligatory relationship towards certain grocery stores or chains, usually for cost-calculating reasons. It is argued that meaningful relationships are more likely to sustain, while obligatory relationships are more likely to be replaced by another relationship.

On the basis of these distinctions, we presented a very first approach to modify an existing agent-based travel demand model. Each of the different steps and considerations were more or less isolated to remain controllable. It has become clear that the numerical implementation of relationships and their complex interplay still needs further research and that future improvements are needed. The implementation of the trust in persons model worked well, while modeling the more complex trust in brands relationships lead to counter-intuitive results. Furthermore, the interviews reveal that most people sustain a portfolio of different relationships, of which some are meaningful and others that have a more cost-calculating character.

Nevertheless, by focusing on relationships, an analytical approach has been developed that aims to take a closer look at the elements that lead to behavior stability. We are aware that it remains a difficult task to assess the extent to which travel behavior may change in the light of sociotechnical transitions and to translate this into a numerical model. However, the approach presented in this paper aims to overcome the lack of social context inherent to most modeling frameworks. Focusing on relationships seems a promising approach to design scenarios that map how new lifestyles may diffuse into society. In view of the expected major changes in technology and society, there is a need for transport models to better reflect the interplay between various determinants. By respecting the interplay between structural changes and individual behaviors, models could assist in managing dynamics and help to avoid undesired outcomes. Models assessing technological innovations in a technology biased way are running the risk of misinterpreting the impact and consequences of potential measures. For city and transport planners, a better anticipation of behavior persistence, but also on societal acceptance is important.

Yet, there remain several tasks for future work: first, this paper focuses on grocery shopping only. Other activities, such as family life, social engagement, or new work environments are accompanied by rather different decision processes. Spatio-temporal flexibility as well as the motivation to engage in the various relationships can have various facets, which we aim to bring to light. Thus, the conceptualization of relationships presented in this paper can only be a first glimpse. Furthermore, for developing a robust modeling framework, results need to be quantified. So far, the qualitative design of the study does not enable us to make reliable assumptions on the extent to which socio-demographic characteristics have an effect on the individuals' propensity to engage in certain relationships.

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CRediT authorship contribution statement

Maike Puhe: Conceptualization, Methodology, Investigation, Formal analysis, Validation, Writing - original draft, Writing - review & editing.

Lars Briem: Data curation, Software, Formal analysis, Visualization, Validation. **Peter Vortisch:** Supervision.

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