TRAVEL MODE CHOICE OF SHOPPING CENTRE CUSTOMERS IN GERMANY: SPATIAL AND SOCIODEMOGRAPHIC STRUCTURES

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With 3 figures, 3 tables and 1 appendix
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Summary: Shopping trips continue to be an important topic in spatial development and spatial planning. This paper studies the travel mode choice of customers in 17 German shopping centres. Secondary data collected in customer surveys are used to analyse associations between the location and accessibility of shopping centres and customers' travel modes. Associations with customers' sociodemographic attributes are considered simultaneously using a multinomial logit regression model. The results show that shopping centre location, the urban environment at the destination (shopping centre) and the origin of trips (typically the customers' places of residence) have considerable effects on mode use. What is more, the effects of social roles (gender, household size), resources (income), shopping behaviour (frequency of visit), and spatial context suggest that users of public modes and non-motorised modes differ from car users in quite similar ways.

Zusammenfassung: Der mit dem Einkaufen verbundene Verkehr stellt weiterhin ein wichtiges Problem für die Raumentwicklung und Raumplanung dar. Der Beitrag untersucht die Verkehrsmittelwahl der Besucher von 17 deutschen Einkaufszentren (Shopping Center). In einer sekundärstatistischen Analyse von Kundenbefragungen werden Zusammenhänge zwischen der Lage und Verkehrsanbindung der Shopping Center und der Verkehrsmittelwahl ihrer Besucher analysiert. Simultan werden auch die Einflüsse von soziodemografischen Eigenschaften der Besucher ermittelt. Hierzu wird ein multinomiales logistisches Regressionsmodell verwendet. Die Ergebnisse zeigen deutliche Unterschiede je nach Lage des Einkaufszentrums sowie raumstrukturelle Einflüsse am Einkaufszentrum sowie am Startpunkt des Wegs (meist der Wohnort der Befragten). Die Einflüsse der Rahmenbedingungen der Verkehrsmittelentscheidung bezüglich sozialer Rollen (Geschlecht, Haushaltsgröße), Ressourcen (Einkommen), Einkaufsverhalten (Besuchshäufigkeit) und des räumlichen Kontextes zeigen außerdem, dass sich die Nutzer öffentlicher und nicht-motorisierter Verkehrsmittel in ganz ähnlicher Weise von Nutzern des Autos unterscheiden.

Keywords: Travel mode choice, travel behaviour, shopping travel, shopping centre, transport geography, Germany

1 Introduction

The history of shopping centres in Germany spans a period of about 50 years. Starting from the North American model of car-oriented, greenfield shopping centres (known as 'malls' in the US), location choice has shifted towards the inner cities. These locations are often well accessible by public transport, and they permit easy access even for those with no car in their households. However, even shopping centres located in the inner cities typically have dedicated car parks that make access by car attractive.

Car use is known to be linked to numerous problems, including negative environmental effects, the exclusion of non-motorised population groups from socioeconomic activities, and high costs for constructing and operating transport infrastructure. Many of these effects are particularly striking in low-density environments (e.g. when shops and services are located in greenfield areas). Other effects of car use are, however, more problematic in more central areas, including noise and toxic immissions, road capacity overload, and the negative effects for urban life that result from customers parking cars in shopping centre car parks, so there is minimal interaction between customers and surrounding neighbourhoods. On the other hand, there are good options for sustainable urban planning concepts with respect to shopping trips, as shopping trips have been found to be more affected by the built environment than job or leisure trips (Holz-Rau et al. 1999; Van and Senior 2000).

While it is well-known that non-integrated, greenfield shopping centres are mostly visited using private cars (INFAS and DLR 2010b, 122), the travel mode choice of customers in shopping centres at integrated locations has rarely been studied. This paper is probably the first to study the travel mode

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choices of customers of shopping centres in various urban locations, including inner cities, urban district subcentres, and greenfield sites (i.e. integrated and non-integrated locations) using a multivariate approach. It seeks to determine which location, urban environment and accessibility measures affect the travel mode choices of shopping centre customers. Secondary data collected in 17 German shopping centres are used. The customers' sociodemographic attributes are studied simultaneously using a multinomial logit regression model.

The next section briefly summarises the state of research about travel mode choice and shopping trips, with a focus on Germany. This is followed by a short historical overview of shopping centre development in Germany. Section 3 introduces the data and methods. Section 4 presents the findings. The paper closes with a summary and conclusions for urban planning and research.

2 State of the research

2.1 Travel mode choice

Travel mode choice has been widely studied using consumer choice theory. This assumes a rational, utility-maximising decision framework that minimises the generalised costs (disutility) of travel in terms of travel time and monetary costs (Domencich and McFadden 1975, 2–14, Cervero 2002, 266). These costs are subject to the accessibility of the sites of activity that serve as destinations, which in turn depends on transport supply (infrastructure and services) and the spatial distribution of destinations. Additionally, mode choice depends on individual (or household) preferences. Mode choice is typically studied as a function of space-time context, and individual and household attributes. The latter serve to represent social roles, socioeconomic constraints and resources, and preferences. They are reflected in attributes such as gender, occupation, age, income, education, or car ownership, and these attributes have been consistently found to affect mode choice (Handy and Clifton 2001; Best and Lanzendorf 2005; Cervero and Duncan 2006; Van Acker et al. 2014; Konrad 2016). They may not be independent of built environment factors, but interact with the latter. For instance, gender equity in shopping has been seen to vary with the environment. In large cities men and women show a similar frequency of shopping trips, while in smaller municipalities women make more shopping trips than men (Bauer et al. 2011, 11).

Sociodemographics can be seen as reflecting subjective preferences to some extent. However, over the past 10 to 15 years considerable research has been developed that directly investigates the relevance of subjective attitudes, preferences and lifestyles for travel mode choice (Bohte et al. 2009; Cao et al. 2009; Van Acker et al. 2014). This research is particularly important for studying the residential self-selection hypothesis in travel. This hypothesis claims that spatial differences in travel behaviour are (partly) due to households' geographical sorting based on their travel and accessibility preferences. The results of this research show more or less consistently that preferences have significant effects on mode choice, but that built environment effects remain significant nonetheless (see overview in Cao et al. 2009; Cao 2014 and other papers in the same issue).

These built environment effects may be summarised briefly as follows (see Holz-Rau 1997; Crane 2000; Ewing and Cervero 2010; Boarnet 2011). Dense and compact urban development with mixed land-use is associated with short trips and high shares of public transport and non-motorised modes in trips. What is more, regional and local location relative to centres is an important factor in travel distances and mode choice. Proximity to the nearest (sub-)centre is associated with short travel distances and the overproportionate use of non-motorised modes. A reasonable scale of land-use mix varies by the degree of specialisation of activities (e.g. basic needs provision versus specialised supply) (Handy 1996; Naess 2011).

These results may be explained by the idea that the large potential of activity opportunities (workplaces, shopping and leisure facilities, etc.) offered in dense and mixed land-use environments is a necessary condition for the short trips of those living in such environments. At the same time, the same attributes enable the operation of a well-developed public transport system that permits households to organise daily life without owning a car.

These basic associations vary considerably in detail. Additionally, cause and impact of the associations are ambiguous and, hence, great care needs to be taken when interpreting findings and drawing policy conclusions. For instance, there is considerable debate concerning the relevance of specific attributes of the built environment, how various factors interact with each other, possible rebound effects (e.g. 'escape trips' from urban areas at the weekends), and the causality of associations (e.g. with respect to residential self-selection). Still one may well sum up that the basic findings outlined above tend to be robust.

2.2 Shopping travel

Shopping trips account for the second largest share of trips in Germany (21 %); only the share of leisure is larger (INFAS and DLR 2010b, 117). However, shopping trips are considerably shorter than trips made for most other purposes (mean distance: 5.0 km) (INFAS and DLR 2010a, 41).

In order to better understand shopping trips, they need to be subcategorised according to different types of goods. This is important for this paper, as shopping centres typically tend to favour medium-term demand goods, while two-thirds of all shopping trips serve daily needs (groceries). Grocery shopping may well be done in shopping centres, as these often include supermarkets, discounters, drugstores and bakeries. However, this is not why customers typically visit shopping centres in Germany. Visiting a shopping centre therefore accounts for a small proportion of shopping trips but a larger share of shopping travel distances, because shopping centres have large catchment areas and, thus, attract long trips. A shopping trip to a greenfield shopping centre has been found to produce three to four times as much car traffic (in terms of distances covered) as a shopping trip within a residential neighbourhood, and 1.6 times as much as a shopping trip to an integrated shopping centre in a city (SCHEINER 2011, 6).

Mode choice for shopping trips has changed considerably over time, similar to other trip purposes. In 1976, i.e. in the early days of shopping centres in Germany, about half of shopping trips were made on foot, and one-third by car. This proportion was turned around in 2012. Now half of shopping trips are made by car, and one-third on foot. Public transport and the bicycle account for just under 10 %, without much change over time (BMVI 2014, 226).

The relative shortness of shopping trips corresponds with the more or less comprehensive geographical coverage of local supply facilities in large cities as well as in small towns. The potential short trips that these facilities make possible may however be counterbalanced by regional accessibility (HANDY 1996; LIMANOND and NIEMEIER 2003), and this results in large proportions of the population making longer trips than 'necessary' (from a functional point of view) for shopping (ACHEN 2005; HANDY and CLIFTON 2001).

Travel mode choice differs considerably with urban context. In Germany's largest cities, the share of shopping trips made on foot is twice as large as in smaller municipalities (41 versus 20 %) (BAUER et al. 2011, 12–13). The share of cycling differs less pronouncedly between city size categories. Public transport accounts for a noteworthy share of 8 to 10 % only in cities larger than 100,000 inhabitants. This stronger use of public transport in large cities is mainly due to leisure shopping tours (*'Einkaufsbummel'*) and shopping of medium-term to longer-term goods, while daily grocery shopping is typically done on foot. Conversely, the proportion of trips made as a car driver is twice as high in smaller municipalities than in large cities (57 versus 29 %). Within a city there are considerable differences in mode choice according to micro-scale location, which determines walking access to shops. Isolated shops (such as a single supermarket) contribute less to short trips than a broad, differentiated supply with multiple shops in a neighbourhood (ibid., 13).

Over and above such differences according to place of residence, the destination of a shopping trip plays a role in mode choice. The location of shopping was recorded for the first time on the national level in Germany in the survey Mobility in Germany (MiD) 2008. The results indicate that shopping centres have become established places of shopping. More than one in five shopping trips (22 %) ends in a shopping centre located on the urban fringe, while for longer-term demand (without *'Einkaufsbummel'*) this figure is 30 % (INFAS and DLR 2010b, 122). Car use is particularly dominant in shopping centres on the urban fringe (83 % of trips), while public transport plays virtually no role here (3 %) (ibid.). In contrast, shopping in the vicinity of the residence is mainly undertaken using non-motorised modes, even though the private car holds a share of 42 % of trips here as well (similarly for the US: HANDY 1996, 194).

The information on destinations included in MiD 2008 does not permit the identification of shopping centres other than those located on the urban fringe. The urban fringe and 'greenfield sites', however, host only a minority of shopping centres, while the majority are located in urban centres or subcentres (PROSSEK et al. 2009, 152). To the best of our knowledge, there are no studies that consider travel behaviour when visiting shopping centres in various types of location.

The above results suggest that the urban periphery is an unfavourable location for shopping centres for ecological and transport reasons. Other studies, however, suggest that suburban shopping centres may relieve the inner cities from the pressure of incoming shopping traffic. BORSDORF and SCHÖFFTHALER (2000, 155) find for Innsbruck, Austria, that the inner city would not be able to absorb the traffic of additional incoming customers that would be diverted to the city if two shopping centres on the urban fringe were closed. This is even true assuming a modal shift from the car towards public modes. Pätzold (2009, 118–119) argues that shopping centres on the urban fringe of Berlin result in decreased shopping trip distances for the suburban population and may, hence, contribute to sustainable transport.

Similar to other trip purposes, shopping travel displays pronounced sociodemographic impacts. For instance, men and high-status individuals have been found to make fewer but longer shopping trips, and produce more car-based shopping travel than women and low-status individuals (Bauer et al. 2011). Despite considerable gender convergence in travel behaviour over the past decades (Konrad 2016), pronounced gender role behaviour still exists in couple households (Gershuny und Kan 2012). This is reflected in women undertaking more complex trip chaining (Paleti et al. 2011) and more frequent shopping and child-serving trips (Srinivasan and Bhat 2005, Manz et al. 2015, Konrad 2016) than men. Gendered differences in mode choice are more limited when employed women and men are compared. Findings on the effects of having children on mode choice are inconsistent. While Best and Lanzendorf (2005) find that parenthood reduces car use by women, but increases men's car use, Vance and Iovanna (2007) find that the number of children increases women's car use considerably more than men's, leading to higher probabilities of car use for women than men in families with two or more children.

Taken overall, long-term trends in shopping travel are unsustainable for several reasons. From an ecological perspective, the negative environmental effects of shopping trips are increasing. From a social viewpoint, non-car owning population groups experience increasing social inclusion. From an economic perspective, increasing trip distances result in high costs for motorised transport services and infrastructure that are allocated inefficiently particularly with respect to low-density developments (greenfield shopping facilities).

However, it seems more possible to use urban planning to support sustainable travel for shopping trips than other types of trip. This is because the associations between the built environment and travel are stronger for shopping travel than for other trip purposes, and this is true with respect to mode choice as well as trip distances (Holz-Rau et al. 1999; Van and Senior 2000; Scheiner 2010). There are, however, studies that come to different conclusions. For instance, Cervero and Duncan (2006) find in California that a balanced land-use mix of housing and jobs reduces car commuting more than a balanced land-use mix of housing and shopping facilities reduces shopping travel by car.

2.3 Shopping centres

Shopping centres were first introduced in the US in the 1950s. Architect Victor Gruen, who planned the first enclosed shopping centre in a Minneapolis suburb in 1956, is considered as their 'inventor'.

In Germany, the Main-Taunus-Zentrum in the urban fringe of Frankfurt am Main was the first shopping centre and opened in 1964 (see in the following Gerhard and Popp 2009, 43ff). The first generation of shopping centres (1964 to ca. 1973) were constructed as large low density developments with simple, unadorned architecture on suburban greenfield sites. Despite the extremely low levels of car ownership of the time they were designed exclusively for car access. Soon, however, the drain of purchasing power from the inner cities as well as the negative environmental effects of car traffic became apparent.

A special feature of second generation shopping centres (1973–1982) was their location in inner cities. Also, these centres were more ambitious architecturally. They still aimed to attract customers by car. All these shopping centres have their own car park which is directly connected with the mall.

The third generation (1982-1990) is again primarily located in inner cities. This generation's architecture is characterised by subtle signs of corporate identity and image. The fourth generation (from 1990) is very diverse, because German reunification induced different developments in West and East Germany. In West Germany ('old *Länder*') shopping arcades and shopping galleries continued to spread, while in East Germany ('new *Länder*') a very dynamic development of greenfield, suburban shopping centres started but continued for just a few years. From the turn of the millennium the inner cities and urban district centres became the most popular locations for new shopping centres in East Germany (Groner and Pittroff 2009, 8, Kulke 2014, 96). At the same time, the revitalisation of the early West German shopping centres began.

With respect to new developments in Germany, car-oriented shopping centres on greenfield sites are therefore a thing of the past. Modern, integrated shopping centres are connected to public transport, and they may easily be accessed by individuals without use of a car. In inner-city, high-density locations they are accessible on foot as well. The reurbanisation of housing seems to go hand in hand with the reurbanisation of large-scale retail facilities. A large proportion of German mid-sized and large cities now have one or more shopping centres. The boom days of shopping centre development are over in Germany.

Both transport connections and visitors' travel mode choice are important elements in the integration of a shopping centre into the urban neighbourhood. This is because the 'introverted' design of shopping centres as autonomous units with a comprehensive scope of supply causes problems for the surrounding neighbourhood. An attractive shopping centre may impact on pedestrian frequencies in the surrounding area, and cause decreasing sales for shops in the neighbourhood (Junker 2006, 111). Mode choice plays an important role in this respect. While shopping centres may be approached directly by car without any contact being made to the surrounding area, trips made by public transport or non-motorised modes permit interaction with the environment around the centre. This increases the economic feasibility of shops, services, restaurants and pubs in the area, hence improving the social and economic liveliness of the neighbourhood.

For these and other reasons stated above visitors' mode choice plays an important role in the successful integration of shopping centres into the urban realm. Mode choice is studied in the following empirical analysis.

3 Data and methods

3.1 Data

Several national travel surveys are available in Germany that permit to analyse shopping trips. However, none of them include the geocodes of households' residences, trip origins or destinations. Spatial information is therefore limited to rough categories (e.g. municipality size classes). Shopping centres in different types of locations cannot be compared using these data because it is not possible to consistently identify whether or not a destination is a shopping centre.

The *mfi shopping center management AG (mfi AG)* undertakes annual customer surveys in the shopping centres they operate. These market research data include some travel behaviour information, and they have a large potential for research, although they do not include all desirable information. These data were collected by the market research agency *Innofact AG* in November 2012 and November 2013 using the CAPI method (computer assisted personal interview) in 17 German shopping centres. The surveys were conducted within the early Christmas business periods. The sample sizes are ca. 1,000 (2012) and ca. 500 (2013) completed interviews per shopping centre. The total sample includes 15,518 individuals aged 16 and older, with 8,455 of them having been interviewed in 2012. In terms of weekday distribution, about 15-16 % of the respondents were interviewed between Monday and Thursday, respectively, and 18-19 % on Friday or Saturday. Hence, the sample sizes do not fully reflect the weekday distribution of visitor frequencies (which are higher on Fridays and Saturdays). Weighting the frequencies is not feasible due to the lack of visitor counts.

An important methodological constraint is that the selection of respondents was not subject to any traceable control. For instance, one may suspect that adolescents tended to be asked in cases where they visited the centre without their parents, while otherwise the mother or father would normally have been interviewed. The exact staff survey sites can also not be determined, although they are likely to strongly affect the results in terms of mode choice. The focus of this research is, however, on the analysis of associations between mode choice on the one hand, and sociodemographic and spatial context attributes on the other, rather than on descriptive figures of travel behaviour. A perfect representation of quantities is therefore unnecessary (Babbie 1998).

The main focus of the survey is on shopping behaviour and the preferences of customers. For the present research, other information is more important, i.e. mode choice for the trip to the centre, and the origin of the trip (recorded as the customers' residence, workplace or place of education, or elsewhere). Additionally, some sociodemographic information is recorded. The possibility to match the data with spatial information regarding the origin and destination of the trips is an important and, in Germany, very rare quality of the data that makes them interesting for research purposes.

3.2 The shopping centres

The 17 shopping centres of the *mfi ag* are located in six different federal states (*Bundesländer)* (Fig. 1). All shopping centres are located in cities with more than 100,000 inhabitants, the only ex-

Fig. 1: Location of the shopping centres

ception being Gera (95,000 inhabitants). Except for Gera, Erlangen, Regensburg and Bochum, all the cities have more than 500,000 inhabitants. Six of 17 shopping centres are in Berlin. The shopping centres are not a representative sample, but cover a broad selection of different urban location types (inner city, urban district subcentre, greenfield site) and transport connection qualities. A table showing the characteristics of the shopping centres is shown in the appendix.

3.3 Method of analysis

Factors associated with mode choice are typically studied using discrete choice models (binary or multinomial logit regression). We use the multinomial logit regression model, and we distinguish between three modes: car (including motorcycle), public transport, non-motorised modes (walking, cycling). We do not distinguish between walking and cycling in regression modelling because of the low proportion of cycling trips (surveys were undertaken in November). The car serves as a reference category, and therefore is not shown in the results displayed in table 3. The coefficients show the effects of the independent variables. They need to be interpreted relative to the reference category (car use).

Besides the regression model, we also present some basic descriptive findings on mode choice and trip distances, categorised by the shopping centre location type.

3.4 Variables

The data required some preparation to be consistent, as different questionnaires were used. Some variables were not recorded in all shopping centres, e.g. the number of children in the respondent's household. Key variables such as mode use, trip origin (on the postcode *[Postleitzahl]* level), the respondent's age, and household income are available for all respondents.

3.4.1 Mode choice

It needs to be highlighted that mode choice was not recorded consistently in the different variants of the questionnaire (Tab. 1). We use the cat-

Tab. 1: Questionnaire variants to record mode choice

2012	2013	
Which mode do you typically use to get to this shopping centre?	**How did you get to this shopping centre today?**	
Automobile/car	By automobile	Automobile/car
Motorcycle/motor scooter	By motorcycle/motor scooter	Motorcycle/motor scooter
On foot	On foot	On foot
Bicycle	By bicycle	Bicycle/E-bike
Bus	By bus	Bus
S-Bahn/underground/tram	-	-
-	By underground	Underground
-	-	S-Bahn (regional train)
-	By tram	Tram
Long-distance train/*Bundesbahn* (train)	-	Regional train/ long-distance train
Other mode	Other mode	Other mode

Source: Questionnaires of the mfi AG 2012/2013.

egories recorded in 2012. The more detailed categories used in 2013 could easily be recoded. The missing rail categories in some of the 2013 surveys (S-Bahn, regional train/long-distance train) can be implemented by assuming the mode that is available in the proximity of the centre in question. For instance, in the Munich Pasing Arcades a high proportion (14.5 %) of other modes was recorded in 2013. As the centre is immediately adjacent to a S-Bahn station we assume that other modes refer to the S-Bahn. This simple assumption is supported by the fact that in 2012, when the rail category was included, the category 'other modes' was not chosen by any of the respondents.

What is more, respondents had the option to choose multiple modes in 2013, but not in 2012. We reduced multiple modes to the mode that was typically used for the longest part of a trip. Finally, in 2012 respondents were asked which mode they typically used to approach the centre, while in 2013 they were asked which mode they used on the survey day. This suggests differences may arise due to temporary circumstances. Separate models estimated for the two years result in a somewhat lower model fit for the 2013 model (McFadden's Pseudo R^2 for 2012=0.289, 2013=0.214). This confirms expectations, as mode choice on a single day is more due to the specific circumstances pertaining on this day, which results in random variation.

3.4.2 The built environment and trip distances

The trip distances between the trip origin and the shopping centre are calculated as straight-line distances between the centre of the postcode area of origin (residence or workplace) and the main entrance of the shopping centre. Respondents could indicate whether their trip had started elsewhere (neither at the place of residence nor the workplace) but in these cases the origin postcode was not recorded and, hence, these cases were excluded from regression analysis. The origin categories are distributed as follows: at home (71.9 %), workplace (15.0 %), school, university (4.4 %), other (8.7 %). The large majority of visitors apparently start their trip at their place of residence. For 2012, we therefore assume place of residence to be the trip origin, as in this year the residence postcode was recorded but the trip origin was not.

Another bias is due to variations in the size of postcode areas. These are considerably smaller in high-density (inner city) areas than in more remote areas. This means that, on the one hand, remote shopping centres may erroneously be associated with high shares of short trips (when origin and destination are in the same postcode area). On the other hand, the trip distances of those who start their trips in another postcode area may be overestimated to a larger extent than in inner city areas due to the larger area units. Biased distances are a common problem in transport studies, as distances are often based on respondents' own estimations. We summarise our calculated distances in rough categories to avoid spurious accuracy (see Table 2 for descriptive statistics of the variables used in regression). Judged against the results the estimations appear plausible. We exclude distances of 100 km or more as we assume that the main reason for a customer to take the trip in these cases was not to visit the shopping centre, but rather for other (tourist) reasons.

We match the survey data with spatial information for the trip origin and the shopping centre. First we divide the shopping centres into three categories: greenfield, urban district subcentre, and inner city. The categories are chosen according to location in the city, central-place function in the urban retail concept, and population density and settlement density.

In the regression model we use the same two density indicators to describe the urban structure around the centre. Settlement density was calculated as the share of the built-up area in the total area in a radius of 1 km around the main entrance to the shopping centre. This information was based on OpenStreeMap data. It could be postulated that the inclusion of the centres in the calculation of density may cause a bias due to the variation in shopping centre size. This would, however, suggest that large-scale centres (that typically have large catchment areas) and the associated higher densities result in less non-motorised travel. The results show that the opposite is true: density is positively correlated with non-motorised travel, in line with the literature (Section 2.1). We conclude that such a bias is not a major problem. Population density was calculated on the postcode level for the trip origin and the shopping centre; the population data refer to 2014, and they were provided by GfK GeoMarketing GmbH. The population density at the shopping centre was excluded from the final regression model because of its strong correlation with settlement density (multicollinearity).

3.4.3 Transport connections

Transport connections to the shopping centre are determined separately for public transport and the car. As road provision is rather ubiquitous, car access was defined by the number of parking lots at the centre. The availability of parking space was assumed to encourage car use. Additionally, the straight-line distance from the main entrance of the centre to the nearest federal highway exit was measured, but did not exhibit any significant effect on mode choice, and was thus excluded from further analysis.

In order to determine public transport connections, all bus, tram, underground, and railway (S-Bahn, regional train) stops located within a radius of 200 m around all shopping centre entrances were identified. Beyond this short distance the modal shares of walking notably decrease in several spatial contexts (Scheiner 2010, 80–82). OpenStreetMap data was used but as these data are collected by private individuals on a honorary basis, the data were cross-checked against GoogleMaps and information taken from public transport agencies. There were no cases of notable false information. The data were then used to calculate an indicator of public transport system quality inspired by Scheiner (2008, 20–21). This indicator is based on the hierarchical function of different public transport modes. The bus predominantly serves micro-scale access (neighbourhood level), the S-Bahn and regional train serve regional connections (regional level), and the underground and/or tram cover the area between the two extremes (local level). The systems available within a 200 m radius around any shopping centre entrance are used to construct an ordinal scaled variable:

1 No public transport service (does not apply here)
2 Served by one public transport mode (i.e. either bus, or S-Bahn/regional train, or underground/tram)
3 Neighbourhood and local level service (i.e. served by bus and underground or tram), but no regional service
4 Neighbourhood and regional level service (i.e. served by bus and S-Bahn or regional train), but no local service
5 Neighbourhood, local and regional level service available.

3.4.4 Sociodemographic variables

The questionnaire included the following sociodemographic variables of use for the modelling: age and gender of the respondent, household size, net monthly household income in seven categories (mostly in 500 euro brackets). The mean values of income brackets are used to calculate per capita income (not equivalent income). The respondents' age is used to construct age brackets as a linear effect of age on mode choice cannot be assumed (Tab. 2). Respondents living in one

Tab. 2: Descriptives of the variables used in regression

	Min	Max	Mean	SD
Per capita income (in €1,000 per month, net)	0.1	6.0	1.1	0.67
Number of parking lots at the shopping centre (in 1,000)	0.3	7.3	1.8	2.04
Population density at the residence (in 1,000 inhabitants / sq-km)	0.0	29.3	6.2	6.35
Share of built-up area in shopping centre surroundings (in % of total area)	9.2	34.8	22.7	7.70
Frequency of visit (per month)	0.1	40.0	6.5	6.49
Gender female	65.0 %			
Quality of public transport supply at shopping centre				
2 (one mode) (reference)	22.1 %			
3 (small-scale and local)	40.7 %			
4 (small-scale and regional)	6.8 %			
5 (comprehensive – small-scale, local and regional)	30.4 %			
Age				
16-17 years	4.2 %			
18-29 years	20.9 %			
30-39 years (reference)	14.8 %			
40-49 years	16.2 %			
50-64 years	23.2 %			
65-74 years	14.5 %			
75 and older	6.1 %			
Trip distance				
0-1 km	21.6 %			
1-2 km	21.5 %			
2-4 km	22.3 %			
4-6 km	8.7 %			
6-8 km	6.6 %			
8-10 km	4.6 %			
10+ km	14.7 %			
Household size				
1 person	26.5 %			
2 persons	43.1 %			
3 persons	16.3 %			
4 persons	9.5 %			
5+ persons	4.6 %			
Car, motorcycle	35.5 %			
Public transport	40.1 %			
Non-motorised modes	24.4 %			
n	7,303			

Source: authors' calculation. Data: mfi AG 2012/2013.

or two person households are overrepresented (70 %) against the German population (49 %, Destatis 2011). The reasons include less frequent shopping trips among those living in families (including children), and the larger shares of singles and couples without children in urban settings.

For market research purposes, the group size (respondent plus number of accompanying individuals), the weekday and the monthly frequency of visit are included in the questionnaire. Group size records include many missing values, and are thus excluded from the analysis presented here. An additional regression model suggests that the propensity to use public transport or non-motorised modes is inversely related to group size. The weekday of survey is also excluded from analysis as it did not show any significant relationship with mode choice. We expect frequency of visit to be negatively related to car use, as the car permits the transport of large amounts of goods. The maximum value observed is 40 visits per month. This may appear implausible, but excluding outliers does not materially affect the results and, hence, all values are included in the analysis as reported.

Taken overall, the sociodemographic variables collected appear limited. Nonetheless, they allow interesting conclusions to be drawn. The most desirable attribute among those that are missing is possibly car ownership. On the other hand, car ownership is endogenous to household and individual sociodemographics (Van Acker et al. 2014). Hence, controlling for car ownership as an additional, additive variable in regression may result in underestimating the effects of sociodemographic attributes. However, as car ownership cannot be controlled here its impact needs to be considered when interpreting results.

4 Results

4.1 Travel mode choice and trip distances by shopping centre location

As expected, greenfield shopping centres (Ruhrpark Bochum, Paunsdorf Center Leipzig) are associated with a high proportion of car trips (almost 80 %) (Fig. 2). 16 % of visitors use public transport. Among those, the share of the tram is 11 % (only available in the Paunsdorf Center), the share of the bus is 5 % (predominantly used in Bochum). Non-motorised modes account for just under 6 %. Both shopping centres have large, ground-level car parks (Ruhrpark: 4,800 lots, Paunsdorf Center 7,300 lots). These car parks are themselves barriers to non-motorised modes, as they appear confusing and – because of car traffic – unsafe to pedestrians and cyclists. The car modal share is in line with the abovementioned values taken from MiD for shopping centres at the urban fringe. The higher proportions of public transport that we found (compared to MiD) make us suspect that the survey staff were overproportionately located close to pedestrian flows between the centre and public transport stops. What is more, Berlin is somewhat overrepresented in the sample of centres, and it has an excellent public transport system. The unusual tram connection of the greenfield Paunsdorf Center may also explain the high share of public transport to some extent.

Shopping centres in urban district subcentres are visited on foot considerably more frequently (25 %). The share of cycling is only slightly higher than for greenfield centres (4 %). The good public transport connections are reflected in a high share of this mode (44 %). Only 26 % of trips to an urban district shopping centre are made by car. It needs to be highlighted that five of six Berlin shopping centres are in this category. All of them have excellent public transport access and high population densities in the immediate surroundings. Hence, they are accessible on foot by many people, which may explain the high proportion of walking.

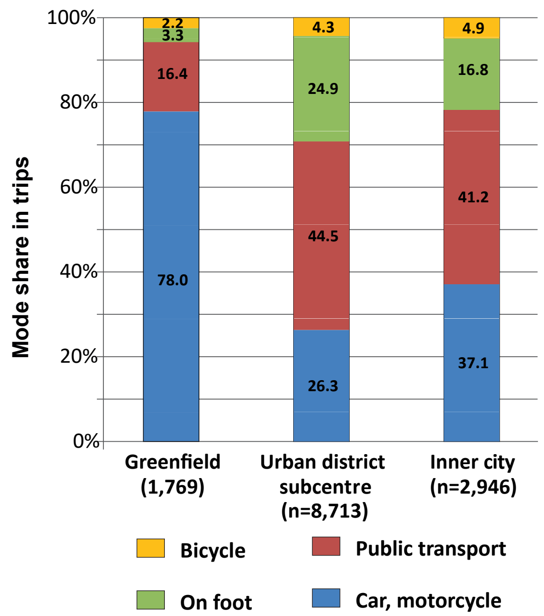

Fig. 2: Travel mode choice categorised by shopping centre location type. Difference between centre types significant (Chi-Square=1,780.9, p<0.01). Source: authors' calculation. Data: mfi AG 2012/2013.

The share of the car is higher for inner city shopping centres than for those located in district centres. 37 % of customers use the car. Public transport use is similar to district centres (41 %). The share of walking is lower (17 %) than in district centres, while the share of cycling is on a similar level.

The variations in modal shares correspond with the centres' catchment areas, and these are also reflected in trip distances. The mean distance between customers' place of residence and a greenfield shopping centre is 9.3 km, while the corresponding values for district centres and the inner city are 5.5 km and 11.1 km, respectively. The inner city centres thus have larger catchment areas than centres located on greenfield sites, despite the biased distance estimations based on large postcode areas in remote areas. On the other hand, despite the large catchment areas the share of non-motorised modes is considerably larger in inner city centres than in greenfield centres. Furthermore, the sample includes inner city centres in cities with a low density on the urban and regional level (including their hinterland, e.g. Regensburg), and these are associated with high shares of car use. Despite the mean distance value of 9.3 km a majority of customers (65 %) live less than 4 km from the centre they visit (Tab. 2). This implies that a small number of customers covering very long distances are included in the mean distances. The use of straight-line distances for the distance calculation, the more frequent visits of those living in the vicinity of the centres, and the location of centres in urban areas contribute to the large share of short trips. These are particularly dominant in urban district subcentres (Fig. 3), where a large proportion of the data was collected. The inner city and greenfield centres both have larger proportions of customers living further away.

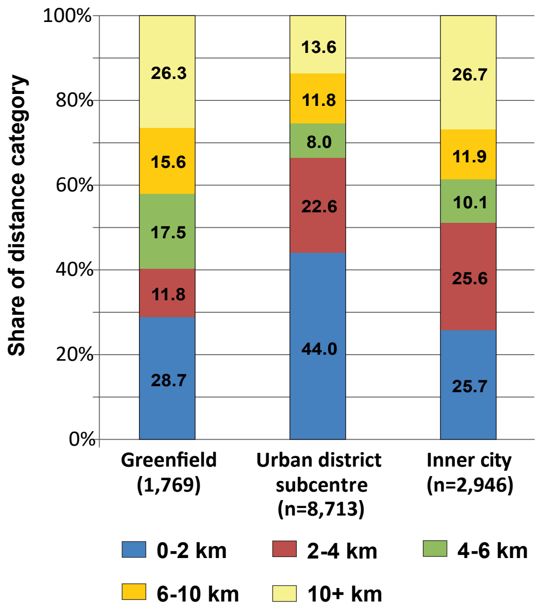

Fig. 3: Travel distances categorised by shopping centre location type. Difference between centre types significant (Chi-Square=1,275.3, p<0.01). Source: authors' calculation. Data: mfi AG 2012/2013.

4.2 Correlates of travel mode choice

The following regression analysis simultaneously studies a range of geographical and sociodemographic correlates of mode choice. The model fit can be judged as more than satisfactory, given the generally low fit values in mode choice models on the individual level (McFadden's Pseudo-R^2=0.25; Nagelkerke's Pseudo-R^2=0.47) (Tab. 3).

4.2.1 Public transport versus the car

The odds of using public transport rather than the car is more than 50 % higher for women than for men (Exp(B)=1.52). For adolescents, the overproportionate use of public transport – compared to the reference group of 30-39 year olds – is particularly striking, which confirms expectations (Exp(B)=11.55). For other age groups, except for those aged 40-49 years, the odds of public transport use are also significantly higher than for those aged 30-39 years. This is particularly evident for young adults (18-29 years) and the elderly (75+ years).

Living in a small household increases the likelihood of using public transport rather than the car. This is most striking for single households, which have a lower household car ownership level than those livinig in larger households (INFAS and DLR 2010b, 62). What is more, singles are more flexible in scheduling their travel in line with public transport requirements than couples or families, as the latter may well need to coordinate travel within the household and (in some cases) transport children and belongings (MANZ et al. 2015, 6ff).

Income is negatively related to the propensity to use public transport. The strength of this association is likely to be due to some extent to the higher levels of car ownership among those with higher incomes (INFAS and DLR 2010b, 52) and, perhaps, subjective needs for social distinction and individualism.

Geographical variables show significant associations as well. Public transport quality is positively associated with the propensity to use public transport.

Tab. 3: Multinomial logit regression of travel mode choice on trips to shopping centres (reference category: private car)

	Public transport			Non-motorised modes		
	B	Exp (B)	Sign.	B	Exp (B)	Sign.
Constant	-2.42		0.00	-5.09		0.00
Gender female	0.42	1.52	0.00	0.23	1.25	0.01
Age (Ref. 30-39 years)						
16-17 years	2.45	11.55	0.00	1.84	6.32	0.00
18-29 years	0.89	2.44	0.00	0.51	1.67	0.00
40-49 years	0.17	1.19	0.12	0.13	1.14	0.32
50-64 years	0.28	1.33	0.01	0.21	1.23	0.10
65-74 years	0.32	1.38	0.01	0.24	1.27	0.10
75 and older	0.74	2.10	0.00	0.48	1.62	0.01
Household size (Ref. 5+ persons)						
1 person	1.86	6.40	0.00	1.79	6.01	0.00
2 persons	0.63	1.87	0.00	0.73	2.07	0.00
3 persons	0.38	1.46	0.02	0.51	1.67	0.01
4 persons	0.13	1.13	0.46	0.18	1.20	0.40
Per capita income (in 1,000€ per month, net)	-0.67	0.51	0.00	-0.63	0.53	0.00
Number of parking lots at the shopping centre (in 1,000s)	-0.24	0.78	0.00	-0.14	0.87	0.00
Share of built-up area in shopping centre surroundings (in % of total area)	0.04	1.04	0.00	0.07	1.07	0.00
Quality of public transport supply at shopping centre						
2 (one mode) (Reference)						
3 (small-scale and local)	0.36	1.43	0.00	0.05	1.06	0.69
4 (small-scale and regional)	0.58	1.79	0.00	0.73	2.08	0.00
5 (comprehensive – small-scale, local and regional)	0.92	2.51	0.00	0.74	2.10	0.00
Population density at the residence (in 1,000 inhabitants/km²)	0.03	1.04	0.00	0.03	1.03	0.01
Trip distance to shopping centre (Ref. 10+ km)						
0-1 km	-0.09	0.91	0.56	3.31	27.52	0.00
1-2 km	0.26	1.29	0.03	2.36	10.54	0.00
2-4 km	0.17	1.18	0.09	1.25	3.48	0.00
4-6 km	0.16	1.18	0.20	0.62	1.86	0.01
6-8 km	0.07	1.08	0.58	0.23	1.25	0.38
8-10 km	0.08	1.08	0.62	0.12	1.13	0.69
Frequency of visit (per month)	0.06	1.06	0.00	0.09	1.09	0.00
Pseudo-R² (Nagelkerke)	0.47					
Pseudo-R² (McFadden)	0.25					

$p<0.01$; Filter: Trip distance <= 100 km. n=7,323.

Source: authors' own calculations. Data: mfi AG 2012/2013, GfK GeoMarketing GmbH 2014, Openstreetmap 2015.

The highest odds (Exp(B)=2.51) are found in the presence of comprehensive systems that include bus, underground (or tram) and S-Bahn (or regional train) connections. This includes some shopping centres in Berlin and Munich. Settlement density (share of built-up area) is positively associated with public transport use as well. In contrast, the number of parking spaces is negatively related with public transport use. An increase of 1,000 parking lots reduces the odds of using public transport rather than the car by 22 % (Exp(B)=0.78). Urban context at the trip origin also affects mode choice. According to the model, a population density increase of 1,000 inhabitants per square km increases the odds of using public transport by 4 % (Exp(B)=1.04).

Trip distance hardly shows any significant associations with the use of public transport versus the car. Only for trips of between one and two kilometres does the model suggest significantly positive odds for using public transport. This may be an effect of urban structure, as trips in this distance range are overproportionately represented in the data for dense, inner-city areas which are most prone to small postcode areas.

Finally, public transport use is positively associated with frequency of visit. This is likely to be due to the possibility of transporting larger amounts of goods by car, resulting in a lower frequency of shopping. However, despite this lower frequency the monthly volume of sales is almost twice as high for customers using the car than for those using public transport.

4.2.2 Non-motorised transport versus the car

The effects of age and gender on the odds of using non-motorised modes versus the car are similar to those discussed for public transport. The same is true for the effects of household size and per capita income.

Public transport quality is strongly and positively associated with the odds of using non-motorised modes. This is likely to be an effect of urban context in a wider sense, as a well-established public transport system is typically found in more walkable inner-city areas.

An increase of 1 % in the share of built-up area results in a 7 % increase in the likelihood of using non-motorised modes rather than the car (Exp(B)=1.07). Furthermore, an increase in the number of parking lots available at the shopping centre decreases the odds of choosing a non-motorised mode. This may, firstly, be a direct effect of parking lots encouraging car use. Secondly, shopping centres with large car parks are less accessible on foot and by bicycle, because the – often giant – car parks appear inconvenient and unsafe to cross.

The built environment at the trip origin also plays a significant role for mode choice. Population density at the trip origin is positively associated with the odds of using a non-motorised mode instead of the car. This confirms numerous studies finding that mode choice is associated with built environment measures at the respondents' places of residence. In this case it may be due to lower car ownership as well as the lower car use of those who have a car available.

In contrast to the odds of using public transport, the use of non-motorised modes is strongly associated with trip distance. In the distance bracket 0-1 km the odds of using a non-motorised mode is 27.5 times higher than in the reference category (> 10 km). In the second lowest distance band (1-2 km) the odds are still 10.5 times higher. This is a plausible reflection of a strongly negative exponential function of the use of non-motorised modes even for short distances.

Similar to public transport, the frequency of visit is positively associated with the use of non-motorised modes. Besides the limited options of transporting goods (and, accordingly, smaller amounts of shopping) this may to some extent reflect that visitors from the immediate surroundings tend to visit the shopping centre more often, even though trip distance has roughly been controlled.

5 Discussion and conclusions

This paper studied customers' travel mode choice on their trips to shopping centres. We used large-scale customer surveys provided by *mfi shopping center management AG* for the empirical study. Although these data have some methodological problems in terms of the questionnaire content and survey methods, the results of a multinomial logit model are conclusively in line with previous transport studies. All associations found are in the expected direction, and the model fit is clearly satisfactory, given the typical low fit values in mode choice models (see the excellent series of regressions in Konrad, 2016, Table 7.5.6–7.5.15).

The novelty of the study is threefold. Firstly, this is probably the first study of mode choices for trips to shopping centres in a variety of urban locations, rather than studying shopping travel in general. This makes direct comparisons with other studies somewhat difficult. Secondly, while the results are generally consistent with previous studies, some findings shed new light on the travel behaviour debate. Thirdly, the study extends the methods typically used in German transport studies. The second and third points are now discussed in more detail.

As regards results, the study is one of only a few to study mode choice for shopping trips using multivariate methods. The results are largely in line with earlier research in that women, adolescents, young adults and the elderly, singles, and those with lower social status (measured by income or education) are less likely to drive (Best and Lanzendorf, 2005), and more likely to do their shopping in the neighbourhood (Bauer et al., 2011). A perhaps more remarkable result of the regression model is that the use of public transport and the use of non-motorised modes differ in similar ways from using the car (with the exception of trip distance effects, which are obviously shorter for non-motorised modes than for public transport and the car). This means that car users differ distinctly and consistently from both public transport users and non-motorised mode users with respect to the conditions that affect mode choice in terms of social roles (gender, household size), resources (income), shopping behaviour (frequency of visit), and geographical context. This social gap between those who have a car and those who have not is remarkable as earlier studies found sociodemographic effects to be similar for public transport use and car use, but in the opposite direction for non-motorised modes (Scheiner and Holz-Rau, 2007), which suggests that differences in mode use are linked to social inequalities in activity spaces.

The effects of the geographical variables studied suggest – in line with previous research – that high densities at the origin and the destination of a trip are associated with lower levels of car use. At the same time, a well-developed, multiple level (neighbourhood, local, regional) public transport system is associated with less car use, while the contrary is true for the provision of large numbers of parking lots. A descriptive comparison between shopping centres in different location types additionally indicates that centres located on greenfield sites are predominantly visited by car. Shopping centres located in urban district subcentres are associated with large shares of public transport (45 %) and non-motorised modes (30 %), while the car plays a minor role here. Inner city shopping centres are predominantly visited by public transport and the car. But even here, more than 20 % of visitors make their trips on foot or by bicycle. Strong urban form effects are in line with previous studies on mode choice, auto kilometres travelled and trip distances covered for shopping (Holz-Rau et al., 1999; Best and Lanzendorf, 2005; Cervero and Duncan, 2006; Scheiner, 2010), but counter findings that call into question a significant link between urban form and shopping travel, or find that it is moderate at best (Van and Senior, 2000; Handy and Clifton, 2001).

As regards methods, this study has extended the options provided by nationwide household travel survey data, such as MiD or the German Mobility Panel, by matching geographical context data. In contrast to most other German studies this included origin and destination information, and the results show that mode choice is affected by both ends of a trip. The paper thus suggests a way to catch up with travel research in other countries that have less restrictive data protection laws. However, spatial categorisation was only possible on the rough level of postcodes. Future research could elaborate upon this study by matching geographical information on transport networks, including travel times and distances, land-use, and other information on more precise levels than has been possible here. Furthermore, the study of inter-individual variation, e.g. with respect to gender roles, occupation, car access, consumption preferences or lifestyles, was only possible to a very limited extent.

The consequences of this study for urban planning are less novel, yet still urgent. The 'golden era' of car-oriented shopping centres on greenfield sites is history in Germany, and more recent shopping centre developments suggest similar trends of reurbanisation as seen in the development of residential populations. Nevertheless, the transport problems associated with peripheral, non-integrated shopping centres remain on the policy agenda. They include environmental problems (immissions, land consumption, climate change), issues of urban design, the necessity of securing public services for households without access to a car, and the socioeconomic robustness of urban neighbourhoods. Many existing shopping centres are expanding, thereby strengthening their market position. A decrease in customers' car travel is not to be expected for greenfield shopping centres. Improving public transport and cycling access to these shopping centres – which are often huge – is urgently warranted, but the same is true for reducing parking space ('carrot and stick' policy, Petrunoff et al., 2015). There is a negative relationship between the number of parking spaces and public transport quality, and this may reflect the different strategies of centres in terms of focusing on accessibility by car or public transport. Other retail properties such as discounters or specialist retailers continue to be developed on non-integrated, greenfield sites, and they generate transport similar to greenfield shopping centres.

In urban district subcentres and inner city centres in large cities with high population densities customers' trips are to a large extent conducted using environmentally friendly public and non-motorised modes, and visiting urban district subcentres is typically associated with short trips. This is good news from an urban development perspective, as strong pedestrian and/or bicycle flows and high levels of public transport use have positive effects on the immediate neighbourhoods of shopping centres. They mitigate the isolation of a shopping centre from the neighbourhood. This is, however, not true for those with an internal connection to a main public transport station (e.g., the Berlin Gropius Passagen where the underground station is located in the basement). Such integrated entrances prevent interaction between customers and the neighbourhood, just as shopping centre car parks do. These considerations suggest that much remains to be done on the way to more sustainable shopping transport.

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Appendix

Characteristics of the shopping centres

Name	Population density (inh/km²)	Share of built-up area around centre (%)	Location type	Parking lots	Public transport systems available	Public transport quality
Berlin						
Forum Steglitz	12,522	31.6	Urban district	605	S-Bahn, U-Bahn, bus	5
Gropius Passagen	5,537	16.9	Urban district	2,014	U-Bahn, bus	3
Neukoelln Arcaden	23,194	32.7	Urban district	650	U-Bahn, bus	3
Schoenhauser Allee Arcaden	16,692	30.7	Urban district	324	S-Bahn, U-Bahn, tram	5
Spandau Arcaden	3,602	19.4	Urban district	1,700	S-Bahn, U-Bahn, bus, regional train	5
Wilmersdorfer Arcaden	18,069	34.8	Inner city	303	U-Bahn	2
Hamburg						
Harburg Arcaden	9,133	25.6	Urban district	320	S-Bahn, bus	4
Rahlstedt Arcaden	3,141	13.6	Urban district	500	Bus	2
Munich						
Pasing Arcaden	5,779	18.5	Urban district	942	S-Bahn, bus, tram, regional train	5
Riem Arcaden	2,090	17.8	Urban district	2,408	U-Bahn, bus	3
Leipzig						
Hoefe am Bruehl	4,774	29.3	Inner city	820	Tram	2
Paunsdorf Center	3,046	10.8	Green-field	7,300	Bus, tram	3
Other cities						
Erlangen Arcaden	4,351	25.4	Inner city	660	Bus	2
Regensburg Arcaden	1,464	25.5	Inner city	1,546	Bus, regional train	4
Gera Arcaden	5,109	18.7	Inner city	1,309	Bus, tram	3
Koeln Arcaden	7,324	26.0	Urban district	1,796	Bus, tram	3
Bochum, Ruhrpark	1,954	9.2	Green-field	4,823	Bus	2

Source: authors' calculations based on GfK GeoMarketing GmbH 2014, Openstreetmap 2015, mfi AG 2015.