Interrelations between travel mode choice and trip distance: trends in Germany 1976 to 2002

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Abstract

In recent decades, trends in travel behaviour have been characterised by increasing trip distances and a modal shift towards the private car. This paper reports findings from longitudinal analyses of the German nation-wide travel survey KONTIV for the period 1976 to 2002. It focuses on travel mode choice, subdivided by distance categories, and also takes car availability and city size into account. In addition, trends in car availability itself are examined by city size categories. The results indicate that even within the same distance categories car use has considerably increased. In some cases bicycle use has increased as well. Gains in the use of the private car are mainly at the expense of trips on foot and by public transport. Accordingly the shift in modal split towards the car is not (only) caused by increasing trip distances but took place even within distance classes. Once car availability is taken into account, the modal shifts appear to be considerably weaker. This suggests that once car availability is held constant the decision rationales of mode choice for a certain trip distance have remained relatively stable. The increase in motorisation over the study period was considerably weaker in large cities than in small towns, although the cities started from a lower level in the 1970s. Thus, the motorisation divide between cities on the one hand, and suburban and rural areas on the other hand has become ever wider. For travel mode choice, the picture is similar. What is more, the results suggest that even car owners are more inclined to walk a given distance in the cities than in small towns, even more so if they live in a central urban area. The built environment, thus, appears to have a strong impact on whether an available car is used or not.

keywords: trip distance, travel mode choice, motorisation, longitudinal analysis

1 Introduction

Time and again, transport researchers have highlighted a number of key attributes of the built environment likely to affect travel behaviour: density, land-use, and distance to the nearest centre (see overviews in Stead and Marshall, 2001; Cervero, 2006). What is more, the connectivity of street networks has frequently been seen as important, particularly in North America and Australia due to the widespread cul-de-sac structures in the suburbs (e.g. Crane, 2000; Badland and Schofield, 2005). The overall spatial determinants of travel have been summarised using keywords such as density, diversity, design (Cervero, 2002).

The built environment has a particularly strong impact on two elements of travel demand: trip distances and travel mode choice. A dense, mixed-use urban structure allows the population to make short trips due to the proximity of housing to other activities. As a consequence of the short distances, a comparatively large proportion of the trips may be undertaken by non-motorised transport modes (NMT, i.e. by bicycle or on foot). The impact of the built environment on travel mode choice is thus in this case indirect: travel mode choice depends on trip distance, and trip distance depends on access to facilities within a certain distance radius (i.e. on the least required distance to a certain activity). These interrelations have been found in numerous empirical studies (see for overviews and empirical studies Cervero, 2002; Schwanen et al., 2004; Guo and Chen, 2007 and other papers in the same issue).

However, there is also a direct interrelation between the built environment and travel mode choice. As well as NMT, public transport (PT) also accounts for a relatively high share of trips in dense, mixed-use structures for two reasons. Firstly, high population and/or activity density often goes along with restrictions for car use, such as lack of parking space, high traffic density, and low travel speed, and therefore reduces the comparative disadvantage of PT against the private vehicle (in some cases even producing the opposite effect). Secondly, the high demand density encourages an attractive PT system. Nonetheless density *as such* has little influence on travel mode choice, particularly on NMT (Filion et al., 2006; Forsyth et al., 2007), when not combined with mixed land-use.

The interrelations between the built environment and trip distances as well as between the built environment and travel mode choice have been investigated in detail in numerous studies. However, this is not true for the interrelations between trip distances and mode choice. The lack of research is particularly striking with respect to long-term analysis that could allow conclusions on the stability or instability of travel behaviour to be drawn. This is the focus of this paper. The following section provides a brief literature overview, followed by some hypotheses. These hypotheses are examined for the period 1976 to 2002 on the basis of descriptive analyses of the German national travel survey KONTIV. Section 3 introduces the data and methodology, and section 4 presents the results. The paper concludes with an outlook.

2 Trip distances, travel mode choice and the built environment: the state of the research

2.1 General trends in travel behaviour

General trends in travel behaviour in recent decades may be roughly summarised in terms of five key characteristics.

First, per capita trip frequencies have remained more or less constant over time. Although in Germany the survey 'Mobility in Germany' 2002 showed considerably higher trip figures than the previous KONTIV surveys (Kunert and Follmer, 2005; Holz-Rau and Scheiner, 2006), this is a consequence of changes in the survey methodology.

Second, people's travel time expenditure has generally been recognised to be relatively invariant over time and space, even if this is likely to be true only on an aggregate level (Mokhtarian and Chen, 2004; in the Dutch context a long-term increase has been detected by Van Wee et al., 2006).

Third, the second half of the 20th century was characterised by the triumphing of the private car (Figure 1). Mass motorisation led to a considerable shift in travel mode choice towards the car at the expense of NMT and, to a certain extent, also of PT. Today about 75 percent of all travel distances in Germany are covered by car (BMVBS, 2007), not unlike the situation in many other European countries. What is more, travel by aeroplane has increased markedly, albeit from a low level.

Fourth, as a consequence of the shift from slow to faster modes (particularly the car) achieved travel speeds have considerably increased.

Fifth, in conjunction with faster modes and constant travel time expenditures people have enormously expanded their activity spaces. Accordingly, per capita travel distances have increased. Due to the more or less constant trip frequencies this is also true for the distances per trip. The daily life-worlds of many individuals have shifted from the local to the regional level.

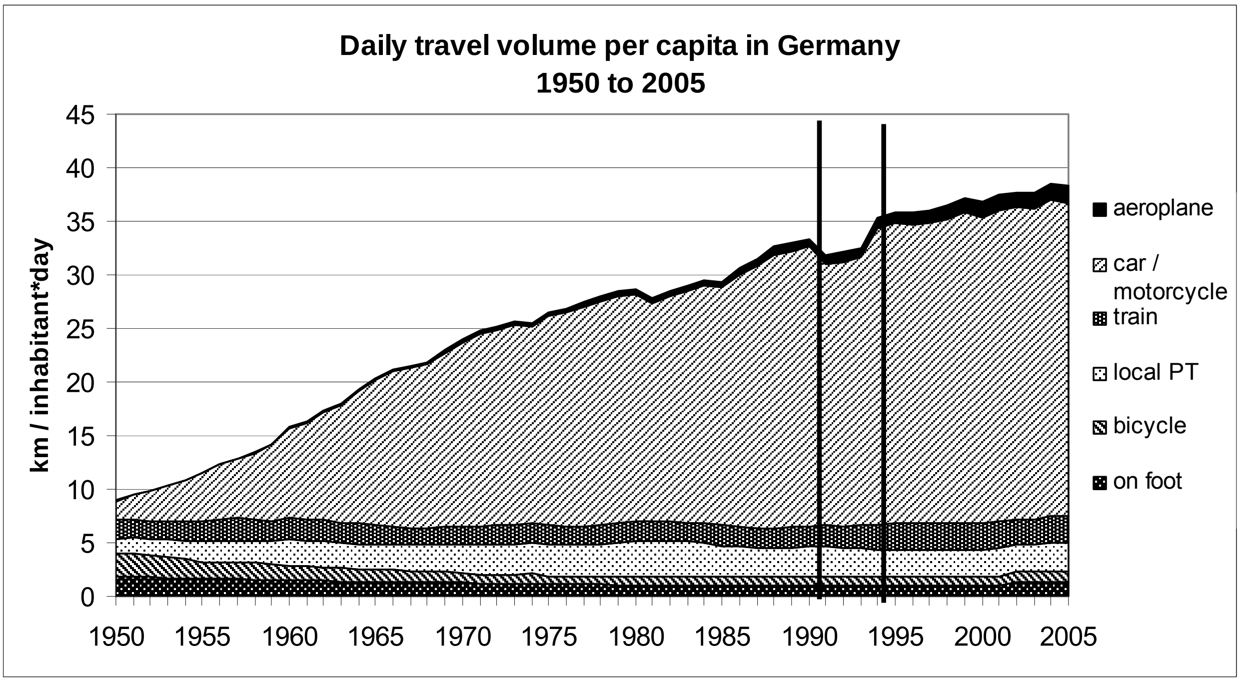

Figure 1: Travel distance per capita and day in Germany by travel mode, 1950 to 2005

The first vertical line indicates German reunification, the second line a change in the model estimation methodology in 1994.
Source: author's analysis based on BMVBS (2007), data before 1976 estimated using Apel (1995) as a basis.

However, such trends leave a number of the interrelationships between various aspects of travel behaviour open. For instance, research has found that long distances in peripheral locations tend to be at least partly compensated by lower trip frequencies (see Holz-Rau et al., 1999 for shopping trips), although some findings seem to contradict this (Naess, 2006). Furthermore, it is as yet unclear whether travel mode changes are actually a *consequence* of increasing distances. Based on a study of commuting in the region of Bremen, Bahrenberg (1997) argues that car use has increased over the period 1970 to 1987 even within distance categories, rather than as a consequence of distance increases. He concludes that the shift towards the car was not caused by spatial changes but is rather an expression of independent individual decisions.

The interrelations between travel mode choice and trip distances form the focus of the following two sections. A distinction is made between least required distance to the nearest facility ('nearest centre') on the one hand, and realised distances on the other hand.

2.2 Travel mode choice and distance to the nearest facility

In contrast to realised trip distances, minimum necessary distances to nearest facilities such as shopping centres, leisure opportunities or schools can be directly affected by spatial planning concepts. There is likely to be a knock-on effect for realised trip distances and travel mode choice. However, there is no common understanding of the details of these interrelations, e.g. of distance thresholds.

One reason for this may be that many studies work with rather generalised distance categories. For instance, the German state North Rhine-Westphalia implemented a programme intended to promote rail-oriented housing schemes. This programme was largely based on the observation that car use among those living in a catchment area of one kilometre around a railway station was slightly lower than outside this radius (ILS, 1999). However, the possible existence of a decline in car use within the 1-km-radius has not been explored.

Holz-Rau (1991) examined shopping trips in a Berlin neighbourhood on a micro-spatial basis. His results show that car use for shopping increases rapidly among motorised households from a distance of 325 m or more to the nearest grocery store. For distances exceeding 670 m motorised households hardly use any transport modes other than the car. Individuals without access to a car tend to switch to the bicycle when the distance exceeds 325 m.

Holz-Rau et al. (1999) found considerably longer, but less frequent shopping trips in poorly served (mono-functional) neighbourhoods, as compared to mixed-use neighbourhoods with good shopping facilities. The proportion of car trips among all shopping trips is markedly higher in mono-functional neighbourhoods, although in absolute terms the differences are less pronounced due to the lower trip frequency. Owing to the longer distances in the mono-functional neighbourhoods, the car is in any case used much more for shopping.

Results from existing studies are not consistent. For the U.S., Handy & Clifton (2001) found that proximity to shopping facilities did not seem to reduce car travel. Yet, in another study distance to the nearest facility turned out to be an important impact factor influencing the frequency of shopping trips on foot (Cao et al., 2006).

Not all trip purposes are equally suited for use in such studies, because of the lack of clarity for some types of activity about the extent of appropriateness of opportunities for certain requirements. It is usual to assume that a shopping centre or a grocery store suits the needs of all. However, the same assumption may not be valid for specialised retail branches, and certainly cannot be made with relation to the appropriateness of the nearest workplace or of a particular location for a stroll.

2.3 Travel mode choice and realised distance

Transport planning commonly assumes that walking is the fastest travel mode for distances under one kilometre, the bicycle for distances between one and six kilometres, and the car for distances over six kilometres; access and egress time are taken into consideration (Zumkeller and Nakott, 1988).

The effect of realised trip distances on mode choice is, if at all, mostly examined in rather coarsely meshed distance categories. The lowest category typically includes trips of up to about one to two kilometres, or one mile (Kloas and Kunert, 1993; Bahrenberg, 1997; Schlossberg et al., 2006; DfT, 2006). Working with these relatively broad categories may mask considerable variation within the categories and (in longitudinal studies) important shifts over time (Scheiner, 2002). An exception is Vågane (2007) who provides differentiated analyses for Norway.

Distance thresholds vary between regions and countries (Badland and Schofield, 2005, p. 186). This may have cultural, economic, topographic or climatic reasons. In many highly motorised countries the car is the preferred mode of transport even for short trips, while in developing countries very long distances are covered on foot. Among the more developed countries there are considerable differences as well. In the UK 76 percent of trips up to one mile (1.6 km) are undertaken on foot (DfT, 2006, p. 15-16). In Germany the equivalent figure is only 60 percent for trips up to one kilometre in length (calculated from DIW/INFAS, 2003), and in Norway it is 53 percent (Vågane, 2007). Besides substantial differences, methodological differences may also play a role here.

There are also marked international differences in bicycle use. While the proportion of short trips undertaken on foot is lower in Germany than in the UK, this is largely compensated by the bicycle. Generally, the bicycle is widely used in the Netherlands and in Denmark, in Germany less so, in the UK, France and the US even less so (EU, 2000; Giuliano and Dargay, 2006; Gatersleben and Appleton, 2007). Among other factors this has to do with the bicycle being seen as a serious transport mode. There are also clear inter-urban differences within individual countries which seem to suggest the existence of 'bicycle cultures', but may also indicate different socio-demographic compositions. For instance, in the German university towns of Freiburg, Munster and Erlangen the bicycle plays a much more significant role in daily travel than in most other German cities (BMVBW, 2002). However, I am not aware of any comparisons that take trip length categories into consideration.

Mackett (2003) examines reasons for using the private car for short trips up to one mile in length and finds the most frequently cited reasons to be: goods transport (22 percent), escort (17 percent), too far (11 percent), and convenience (10 percent). The latter reason was given more often than average in rural areas and small towns. From this the hypothesis may be derived that short to medium distances are more frequently covered on foot in cities than in towns or in the countryside. This may be due to the lower motorisation level, the higher generalised costs of car use (lack of parking space at the origin and/or destination, lower travel speed), or the more exciting environment in cities.

To the best of my knowledge, there are hardly any spatially differentiated studies on this topic concerning trends over time. The results found by Scheiner (2006b) point towards an increasing divide in travel mode choice between cities and smaller communities: in cities, car use increases more slowly and from a lower level than in smaller communities.

Recent debate about residential self-selection suggests that the conditions of the built environment, which are reflected in distances to certain destinations should not be regarded as a fixed pre-condition of life. Cao et al. (2006) show that short distances to the next shop markedly increase the frequency of walking for shopping purposes. At the same time, however, the subjective importance individuals assign to the accessibility of shopping facilities increases the likelihood of walking as well, suggesting that people sort themselves into the environments they prefer. For shopping trips the effect of self-selection is stronger than for strolling. Scheiner and Holz-Rau (2007) carried out a similar study on the basis of structural equation modelling. The results confirm the important effect of residential self-selection on travel mode choice, even when objective attributes of the neighbourhood are being controlled for.

The decision in favour of a certain travel mode obviously does not only depend on trip distance. Important factors affecting the propensity to walk are individual motivation, available resources (transport means, financial resources, health), the attractiveness of the route, and social roles and needs, which are reflected in employment, gender and age, among other variables. For instance, adolescents cover considerable distances to school on foot (Schlossberg et al., 2006).

The socio-demographic factors may be summarised under the term life situation (Scheiner and Holz-Rau, 2007)[1]. The availability of a car plays a central role in this respect, because the speed that can be achieved by car is a precondition for long trips under a restricted time budget. Car availability consequently turns out to be an important pre-decision for an individual's travel behaviour, which has a notable impact on his or her activity spaces, trip distances and travel mode choice (Simma and Axhausen, 2001; Scheiner and Holz-Rau, 2007).

In addition, trip purpose has an important influence on the propensity to walk. This is self-evident with respect to trips with an intrinsic motivation to walk, such as strolling or hiking. The requirement of carrying (shopping) goods impacts or even determines the chance of walking. In addition, the high economic cost of travel time (job trips, business trips) may limit the acceptability of slow travel.

It is important to note that there is no clear causal relationship between trip length and travel mode choice from a theoretical point of view. It seems plausible that increasing trip lengths may cause a shift towards the car. However, the causality might also be the other way round. Given a travel time budget which is by and large stable over time, the increase in car use may allow for longer trips. The study by Ye et al. (2007) may serve to support the former direction of causality. They model the interrelation between trip chain complexity and transport mode, and conclude that models in which chain complexity affects mode choice perform better than models which assume reverse causality. This is true both for work trips and non-work trips. Although trip chain complexity and trip length are certainly two different things, this result suggests that mode choice might be an outcome of what somebody has to do and where he or she has to do it.

This interpretation is further supported by the findings of Lanzendorf (2001, p. 205ff) on the sequence of decisions about activities, activity places and travel modes in leisure travel. His findings indicate that in the overwhelming majority of cases people first decide on the destination, before they decide on the travel mode. Taken together, these findings might be interpreted as an indication that people decide on a certain destination (and thus, implicitly, on a certain trip length) and the mode choice decision tends to be 'at the end of the pipeline', even if there are certainly trips for which it is the other way round, e.g. trips to the countryside without a predetermined destination.

2.4 Hypotheses

To sum up, the interrelation between realised or necessary trip lengths on the one hand and travel mode choice on the other hand has not yet been conclusively determined. In addition, there is a considerable lack of research concerning trends over time in this area. The following hypotheses may be derived from the literature review:

- Travel mode choice corresponds closely to travel distances. In this paper, it is treated as dependent on travel distance. This hypothesis may sound not very spectacular, but serves to introduce the following hypotheses.
- Even for a given distance, travel mode choice depends on the transport means available to an individual (besides other resources and social roles). As a consequence, we may expect an increase in car use over time even for short trips due to the increasing motorisation. Within

[1] In transport studies these factors are usually denominated as socio-demographics, though this is just a formal term that does not say anything about the reasons why the underlying variables should influence travel behaviour, whereas life situation explicitly points to an individual's personal circumstances (e.g. social roles, social contact) relevant for his or her travel.

groups defined by a certain level of car availability, however, travel mode use for a given trip distance should by and large remain constant over time. Should this be proved empirically, it would indicate a stable rationale underlying mode choice.

- In urban contexts the costs of car use relative to non-motorised modes are higher (or, to put it the other way round, the benefit of the car is lower) than in suburban and rural areas. As a consequence, short trips are more often made using non-motorised modes in urban contexts than elsewhere, even within groups defined by a certain level of car availability.

3 Methodology

3.1 Data used

Long-term trends in travel behaviour of the German population on an individual basis can best be analysed by using KONTIV data ('continued survey of travel behaviour'). KONTIV is a repeated semi-official nationwide survey undertaken on behalf of the Federal Transport Ministry. It is based on the random day principle. The analyses in this paper use the four KONTIV surveys available to date. They were carried out in the years 1976, 1982, 1989 and 2002. The last survey was renamed as 'Mobility in Germany' (MID) after a comprehensive methodological revision. The data are provided by the Clearingstelle Verkehr in Berlin. They include the respective basic samples without regional supplements (www.clearingstelle-verkehr.de).

	KONTIV 1976	KONTIV 1982	KONTIV 1989	KONTIV/MID 2002
survey institute	Socialdata (Sozialforschung Brög)	Socialdata (Sozialforschung Brög)	Emnid	DIW, infas-Institut für angewandte Sozialwissenschaft
sampling procedure	address books	1/3 address books, 2/3 random route	random route	community register
population	German speaking residential population aged…			total residential population
	10 yrs and older	10 yrs and older	6 yrs and older	
survey methodology	self-administered postal survey	self-administered postal survey	self-administered, by messenger with completion support	CATI + postal survey
no. of random days	2-3	1	1	1
return rate	72%	66%	64%	42%
sample of analysis (individuals)*	41,318	38,411	40,194	25,730
sample of analysis (trips)**	74,010	72,056	81,763	53,392

Table 1: Methodological comparison of the four KONTIV surveys

* after filtering individuals under 10 years of age, foreigners, East Germans
** after filtering complex trip chains with more than two trips
author's composition based on Kloas and Kunert (1994), Kunert et al. (2002), Kunert and Follmer (2005)

The continual improvement of the KONTIV design since 1976 causes problems when comparing the four surveys (Table 1). For instance, in 1976 the respondents had to complete trip diaries for more than one day. This led to a lower number of trips being recorded on the second and third days due to the respondents' increasing 'fatigue'. From this survey, only the first random day is available for analysis. In the following surveys, only one random day was recorded for each respondent. In the 1989 survey, the collection of the completed questionnaires by messengers led to the under-representation of highly mobile individuals/households. This effect was further intensified due to the substitution of these households with others. In addition, it seems likely that in many cases the trip diaries were completed by a representative of the household when the messenger arrived. This led to even more unrecorded trips (Kloas and Kunert, 1994). In the 2002 survey, the telephone method was used for the first time and led to distinctly higher trip counts, compared to the former KONTIV surveys, due to the direct enquiry approach. Households whose telephone number could not be traced were contacted by post and asked either to supply their telephone number or to complete a self-administered questionnaire. More than 80 percent of those in this group who participated in the survey supplied their telephone number (Kunert and Follmer, 2005)[2]. A special questionnaire module for business trips increased the trips counts even further.

Furthermore, the samples of the surveys are not immediately comparable (see Kunert et al., 2002; Scheiner, 2006a). In the 1976, 1982 and 1989 surveys the basic population was the 'German-speaking' residential population (the criterion 'German-speaking' was handled rather arbitrarily), and the lower age limit was set at six years in 1989, but at ten in 1976 and 1982. In 2002 the whole residential population including foreigners was considered for the first time, and the survey was extended to East Germany. Moreover, in 1989, and partially in 1982, a random route method was used which took non-registered residents into account, in contrast to the other surveys.

Due to these problems analyses here are limited to consideration of German individuals (1976 to 1989: total sample, 2002: persons with German nationality) aged 10 and older. Business trips are excluded. The analysis of the 2002 survey is limited to the old *Länder* (former West Germany). The resulting net samples (counted in persons as well as trips) are given in Table 1. All distance estimates are self-reported by the respondents.

3.2 Analysis

The findings reported in this paper are based on descriptive analyses of the four KONTIV surveys, complemented by cross-sectional spatial comparisons. Travel behaviour indicators studied include modal split subdivided by distance categories, city size categories and car availability. In addition, car availability itself is examined by city size categories. An initial spatial classification distinguished three region types developed by the Bundesamt für Bauwesen und Raumordnung (agglomerations, urbanised regions, rural regions) over and above city size categories. This was based on the assumption that the increase in car travel may have been particularly steep in suburban communities, compared to rural communities. As the results did not show any systematic variation between the region types, the spatial differentiation here is limited to city size categories.

Examination of modal split by distance categories faces the problem that travel mode choice does not necessarily depend on the length of a simple trip, but rather on the length of the whole trip chain. For instance, the car may be used for a short trip when the destination is only an intermediate stop in a chain. In order to account for the effects of complex trip chains on travel mode choice, the analyses were limited to 'simple' home-based trip chains with two trips (outward and return trip). This means that 68 percent of all reported trips are considered, taking all surveys together.

What is more, it should be noted that car availability was recorded in the first three surveys in terms of individual car ownership; in 2002 respondents were asked about individual car

[2] Although this still does not solve the problem that households with 'secret' telephone numbers are likely to be a selective sample and may be characterised by active lifestyles and thus high mobility, the survey results do not suggest that this leads to underestimation of trips.

availability with four possible answer categories (at any time, occasionally, by way of exception, never). In this paper respondents who claimed to have a car available at any time are treated as car owners. This conforms to the previous surveys.

Because of the limited comparability of the surveys, the time series should not be over-interpreted as overall trends. Thus, the interpretation mainly refers to comparisons of trends, e.g. between different city size categories, rather than marginal trends in total. Such relative interpretations only become problematic when changes in the survey methodology affect the units to be compared in different ways. To give an example: A comparison of trends for cities and small towns is problematic only if the change from the written to the telephone-based survey design affected reported trip frequencies in cities and small towns differently. There is, however, no reason for such an assumption. Comparisons of trends thus seem reasonable regardless of methodological differences between the surveys, and may lead to instructive results.

4 Results

4.1 Travel mode choice in distance categories 1976 to 2002

In the KONTIV data there are some irregularities over time in modal split within the distance categories. These are at least partly due to methodological changes between the surveys. For instance, in the 1989 survey the proportions of trips undertaken on foot are higher in some distance categories than one would expect, while the corresponding car shares are lower (Table 2). The bicycle shares show irregularities as well. This is probably due to low-mobility and neighbourhood-oriented individuals being overrepresented in the 1989 survey (see section 3.1).

	1976				**1982**				**1989**				**2002**			
	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**
≤ 0.2 km	96	3	0	1	92	5	0	3	95	3	0	2	94	5	0	1
0.2-0.4 km	90	7	0	3	84	10	0	5	89	7	0	3	81	11	0	7
0.4-0.6 km	81	12	0	7	76	15	1	8	76	12	0	11	64	19	0	17
0.6-0.8 km	73	14	1	13	66	19	0	14	74	14	2	10	56	21	1	21
0.8-1.0 km	64	15	2	19	53	23	1	22	58	20	1	20	38	19	1	40
1.0-1.5 km	51	19	3	26	44	24	2	29	48	24	3	24	25	19	3	53
1.5-2.0 km	39	17	8	36	30	23	6	41	32	22	5	41	18	17	5	60
2-3 km	24	15	14	46	20	20	13	46	19	20	10	50	10	14	7	68
3-5 km	10	11	26	53	10	12	21	57	8	14	17	61	4	9	10	77
5-7 km	3	7	30	59	3	7	25	64	2	7	21	69	1	6	11	81
7-10 km	1	4	28	66	2	5	26	67	1	5	19	74	1	4	12	82
10-20 km	1	2	29	68	0	3	23	73	1	3	16	80	0	2	10	87
> 20 km	0	0	25	74	0	1	23	75	0	1	12	86	1	1	13	85
total	37	10	14	39	29	13	13	44	29	13	10	48	21	10	7	62

Table 2: Modal split by trip distance, 1976 to 2002

* PT: public transport (including long-distance train and coach); ** car including motorcycle
Complex trip chains with more than two trips excluded
The values do not always sum up to 100 due to the exclusion of other transport modes (mostly 0 to 1 percent)
Source: author's analysis. Data: KONTIV 1976, 1982, 1989, 2002

Focussing on the main tendencies makes clear, however, that the tendency to walk short distances has declined markedly over time. To a limited degree this is compensated for by the bicycle, which in Germany has gained in importance over recent decades: in the 1970s it was generally regarded as a travel mode for children, adolescents and the poor. Nonetheless the bicycle did not gain in total (over all distance categories), because its gains on short trips were countered by the shift in distance distribution towards longer trips.

The main winner of the decline in walking, however, is the private car. The car shares increase in all distance categories, most pronouncedly among short trips below 2 km, albeit from a low level. This increase is mainly at the expense of walking, while for longer trips it is at the expense of PT. PT declines sharply in the medium distance categories between 3 km and 20 km, i.e. in urban and regional transport (its decline on long-distance trips is smaller; this is not explicitly shown in Table 2).

The picture changes as soon as car availability is taken into account (Table 4). Due to methodological differences between the surveys in recording car availability, only two 'extreme groups' are considered here: individuals without a car in their households (termed: car-less) and individuals having access to a car at any time (termed: car owners).

Turning our attention to car owners, there are some shifts in modal split among short trips below 2 km, namely from walking (and, to a lesser extent, from driving) towards the bicycle. This might well be understood as a mixture of increasing time rationality on the one hand, and 'cultural' value change (increasing environmental awareness, health awareness, appreciation of the bicycle) on the other hand. For instance, the increasing appreciation of the bicycle in Germany since the 1970s is supported by Pucher and Buehler (2008), and the Eurostat survey provides evidence for the long-term increase in environmental awareness over the past decades (Aidt, 2005, see also Kuckartz et al., 2007 for more recent trends in Germany).

However, taking into account that the modal changes found here are mainly at the expense of trips on foot, time rationality seems to be dominant. This is generally supported by the observation of an increasing acceleration of society (Virilio, 2005), and more specifically by recent evidence on the ‘densification’ of time use by means of simultaneous activities or multitasking, particularly by making use of information and communication technologies during travel (Lyons and Urry, 2005, Kenyon and Lyons, 2007), although there is still a substantial lack of long-term studies.

	gender			age group			
	men	women	all	18-24	25-64	65+	all
car fully available*							
1976	65,8	14,2	37,8	34,1	45,2	13,3	37,8
1982	79,8	32,2	56,9	40,3	66,0	30,4	56,9
1989	76,3	30,6	52,9	48,0	61,2	25,1	52,9
2002	80,1	60,3	69,6	57,1	76,4	50,7	69,6
share of the group among those with full car availability							
1976	79,5	20,5	100,0	9,8	83,4	6,8	100,0
1982	72,9	27,1	100,0	8,3	82,6	9,1	100,0
1989	70,3	29,7	100,0	9,7	81,2	9,1	100,0
2002	54,1	45,9	100,0	6,4	78,5	15,1	100,0

Table 3: Car availability by gender and age group, 1976 to 2002

* car fully available: 1976 to 1989: individual car owner; 2002: car available for driving at any time
Source: author's analysis. Data: KONTIV 1976, 1982, 1989, 2002

	1976				**1982**				**1989**				**2002**			
	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**
	car fully available* **															
≤ 0.2 km	94	2	0	4	91	4	0	6	92	2	1	6	95	3	0	1
0.2-0.4 km	84	5	0	11	80	8	0	11	84	7	1	9	78	12	0	10
0.4-0.6 km	70	5	0	25	70	9	0	20	68	9	0	23	62	16	0	22
0.6-0.8 km	54	7	0	38	59	12	0	27	64	14	1	22	50	20	0	30
0.8-1.0 km	42	6	0	52	41	14	0	43	46	12	1	41	33	15	0	51
1.0-1.5 km	31	6	1	62	34	13	1	52	39	15	1	44	20	16	0	64
1.5-2.0 km	23	5	1	72	21	9	2	67	22	11	1	66	14	13	2	70
2-3 km	15	4	2	79	16	7	3	73	14	11	3	71	8	10	3	79
3-5 km	7	3	3	87	8	5	4	82	7	6	4	84	3	7	3	87
5-7 km	2	3	5	89	3	5	3	89	2	3	6	88	1	4	4	90
7-10 km	1	1	4	94	1	3	5	90	1	4	4	91	1	3	5	90
10-20 km	0	1	6	93	0	2	6	91	0	2	4	94	0	1	4	94
> 20 km	0	0	11	89	0	0	13	86	0	0	7	92	1	1	8	90
total	19	3	4	74	19	6	4	70	18	6	3	72	17	7	3	73
	no car in household															
≤ 0.2 km	97	2	0	1	96	3	1	1	99	1	0	0	96	3	1	0
0.2-0.4 km	93	6	0	1	92	6	1	2	97	3	0	0	92	6	0	2
0.4-0.6 km	87	11	0	1	88	9	2	1	92	6	0	2	76	19	1	4
0.6-0.8 km	85	11	3	1	80	15	0	4	86	11	1	1	73	16	3	2
0.8-1.0 km	81	13	5	1	80	11	6	3	78	16	2	4	58	24	8	9
1.0-1.5 km	71	18	6	5	69	14	9	8	71	16	6	7	45	23	11	21
1.5-2.0 km	60	15	17	8	51	23	21	5	48	26	13	12	38	24	23	15
2-3 km	40	17	30	14	36	21	32	10	32	27	27	13	22	31	31	14
3-5 km	18	13	55	14	18	15	57	10	16	21	46	17	11	16	48	23
5-7 km	5	12	66	17	5	10	69	17	5	11	59	24	3	15	59	21
7-10 km	4	6	69	20	4	5	65	24	2	8	65	24	2	6	63	29
10-20 km	0	3	70	26	1	3	72	24	1	7	57	30	0	13	45	40
> 20 km	0	1	67	32	0	1	62	36	0	4	42	54	1	0	54	46
total	57	11	23	9	51	12	28	9	55	14	19	11	44	16	24	15

Table 4: Modal split by trip distance and car availability, 1976 to 2002

*** car fully available: 1976 to 1989: individual car owner; 2002: car available for driving at any time
Further remarks see Table 2
Source: author's analysis. Data: KONTIV 1976, 1982, 1989, 2002

However, the cultural value change that might hide behind the figures should not be underestimated. While in 1976 only one mode of travel other than the car was common among car owners – i.e. their own feet – some of them at least occasionally use the bicycle for short trips in 2002. This may well be interpreted as an expression of a certain flexibilisation of travel mode choice.

Besides time rationality and value change, a change in the social structure of car owners may be reflected here, e.g. the increasing shares of women and retirees owning a car. The share of women among all car owners more than doubled from 20 percent to 46 percent over the study period, and the share of those aged 65+ increased from 7 to 15 percent (Table 3). As a consequence, the activity spectra of car owners may have changed over the study period (increase in shopping and leisure trips). This again may have an impact on mode decisions. What is more, the improvements in bicycle infrastructure (mainly in the 1990s) may be reflected in the increase in bicycle use in some distance categories.

However, it is striking that in many of the distance categories the car proportions in 2002 are very similar to those in 1976. This suggests that for a given distance and a given availability of transport means the decision rationale of mode choice has hardly changed over time. Given certain conditions, the behavioural outcome appears to be fairly stable. It has to be noted, however, that private vehicles may only be characterised as pre-conditions of behaviour from a short-term perspective. In the long run the possession of a car is in itself subject to certain decision rationales.

Among the car-less, car use increased considerably from extremely low values in 1976. Taking the lack of direct access to a car in the household into account, this might be due to a change in external circumstances. With increasing motorisation, even individuals in car-less households increasingly have a chance to participate in motorisation and use a car from outside their own households, e.g. cars owned by their adult children, parents, organised car-sharing, etc. At the same time, a shift in mode choice in favour of the bicycle and at the expense of walking can be observed for this group in many distance categories. Nevertheless, the shifts within the categories are considerably smaller for the car-less than for the total population. Again this suggests a certain stability in the decision rationales of mode choice.

Of relevance to the issue of using spatial planning concepts to affect travel mode choice is the question of the distance thresholds at which mode choice changes notably (Table 2, Table 4).

The analyses confirm the importance of a highly differentiated subdivision of distances (Table 2, Table 4). The share of walking decreases at a trip distance of not more than 400 m (in small towns even at 200 m, see below). A further decrease is at a distance of 800 m. For car owners the thresholds are lower than for those without a car in the household. However, the distance thresholds are less obvious than expected.

The share of the bicycle notably increases at distances of no more than 200 to 400 m. It reaches its maximum at 600 to 800 m and decreases slightly in the longer distance categories. Only for trips longer than about two to three kilometres does bicycle use decrease markedly. In this distance category, PT use increases considerably and quickly reaches its maximum, which is held even for long-distance trips. Individuals without a car use the bicycle much more often than car owners even for relatively long distances.

4.2 Comparing city size categories

It was hypothesised above that short to medium distances are more likely to be seen as acceptable walking distances in urban contexts than in other spatial settings. The KONTIV data allow for a comparison between city size categories. When making this comparison car availability has to be controlled due to the lower motorisation level in large cities compared to small towns. The comparison is therefore limited to individuals with access to a car at any time (car owners, Table 5). This includes 69 percent of the adult population who are of particular interest, as it may be more reasonable to assume a free mode choice decision for these individuals than for others.

The results confirm the hypothesis. Short trips are much more often covered by NMT in large cities than in smaller towns. Up to a distance of 1.5 km the NMT figures are no less than about 20 percentage points higher in the largest cities than in towns with less than 50,000 inhabitants. Only for the shortest trips (< 200 m) do small town residents use NMT almost as often as city dwellers, although they show a stronger tendency towards the bicycle than towards walking. For trips between 200 and 400 m in length the difference is 11 percentage points, and it increases to 20 percentage points from 400 m. Distances over two kilometres are seldom walked, regardless of the spatial setting. However, medium distance trips between one and seven kilometres are undertaken more often by bicycle in urban environments than in small towns. At the same time, the share of PT is markedly higher in cities than in small towns.

The spatial environment thus indeed appears to have a certain influence on the use of the car: city dwellers tend to leave their car at home for short trips more often than small town residents, even if they have it readily available. There is no conclusive answer as to the driving forces behind this. One might assume higher generalised costs of car use in urban environments due to traffic density and lack of parking space. Urban environments might be more exciting or otherwise attractive for walking[3]. In either case, both interpretations suggest that within cities the NMT shares should be higher in inner city neighbourhoods than in the outskirts. Evidence for this can be found by a, albeit rough, spatial subdivision of the KONTIV data within cities (Table 6). The analysis distinguishes between areas where detached and semi-detached houses dominate and those where larger buildings dominate. The latter type essentially represents centrally located, dense, mixed-use neighbourhoods, while the former by and large represents less dense, less mixed-use peripheral areas. The results show that in the peripheral areas of the large cities the car and the bicycle are used more often for short trips, whereas in central areas people are more inclined to walk. The spatial differences are substantial. For longer trips, PT is used more often in central areas. In total, car use among car owners is markedly lower in the central areas of the cities than in peripheral neighbourhoods.

	< 50.000 inh.				**50-100.000 inh.**				**100-500.000 inh.**				**> 500.000 inh.**			
	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**
≤ 0.2 km	94	5	0	1	97	3	0	0	96	2	0	2	100	0	0	0
0.2-0.4 km	71	16	0	12	82	8	0	10	85	5	0	10	93	5	0	1
0.4-0.6 km	57	17	0	27	68	9	0	22	61	21	1	17	81	13	0	6
0.6-0.8 km	43	20	0	37	42	20	0	39	62	20	1	17	70	15	0	14
0.8-1.0 km	30	13	0	56	29	18	0	53	42	17	1	40	47	14	0	37
1.0-1.5 km	18	15	0	67	11	16	0	72	25	18	2	55	37	20	1	42
1.5-2.0 km	11	11	1	76	19	12	0	69	15	19	4	62	22	17	8	52
2-3 km	9	8	1	82	5	11	2	82	9	14	7	70	9	12	7	71
3-5 km	3	5	0	91	2	7	2	89	3	9	8	80	4	8	12	76
5-7 km	1	4	0	95	1	1	4	94	1	7	7	86	4	6	15	74
7-10 km	1	2	2	95	0	6	2	92	1	3	7	88	2	3	23	71
10-20 km	0	1	2	96	0	3	1	96	0	3	5	92	0	1	15	84
> 20 km	1	1	9	89	0	0	5	95	0	0	7	92	0	2	12	86
total	15	7	2	76	14	8	2	76	18	10	5	67	24	8	10	58

Table 5: Modal split by trip distance and city size category, 2002 (car owners)

inh.: inhabitants. For further remarks see Table 2. Source: author's analysis. Data: KONTIV 2002

[3] At least it is more appropriate for trip chaining and therefore for walking, due to the high density and variety of land-use. For instance, among car owners the share of trips that are part of complex trip chains is 41 percent in cities with more than 500,000 inhabitants, while in communities with less than 100,000 inhabitants it is only 37 percent (all surveys taken together).

	central areas				peripheral areas			
	on foot	bicycle	PT*	car**	on foot	bicycle	PT*	car**
≤ 0.2 km	100	0	0	0	96	0	0	4
0.2-0.4 km	96	3	0	1	85	11	0	4
0.4-0.6 km	85	9	0	6	73	20	0	6
0.6-0.8 km	77	11	0	11	52	24	0	24
0.8-1.0 km	61	10	0	29	31	18	1	47
1.0-1.5 km	39	16	2	43	35	25	0	40
1.5-2.0 km	22	15	12	51	23	20	2	55
2-3 km	12	9	9	69	5	16	5	74
3-5 km	5	8	17	71	2	9	4	85
5-7 km	2	7	16	75	8	5	13	73
7-10 km	4	2	28	67	0	6	15	79
10-20 km	0	1	16	83	0	1	12	87
> 20 km	0	1	13	86	0	3	11	86
total	28	6	12	55	18	11	6	64

Table 6: Modal split by trip distance and location within the city, 2002 (car owners, cities > 500,000 inhabitants)

Due to a lack of data on small-scale location within individual cities, the neighbourhoods are classified according to dominant house types. Neighbourhoods where detached and/or semi-detached houses dominate are classified as 'peripheral'. Neighbourhoods where larger buildings dominate are classified as 'central'.
For further remarks see Table 2
Source: author's analysis. Data: KONTIV 2002

The following section addresses the question as to whether there are trends over time in the spatial differentiation of motorisation and travel mode choice.

4.3 Comparing city size categories: trends over time

In this section the focus is on spatial comparisons of trends in travel mode choice and car availability. Car availability refers to car ownership of individuals as well as population shares according to the motorisation of the households they live in.

It should be noted that the analyses may again include methodological flaws. In the 1989 data the NMT shares are higher than expected, while the motorisation level is lower (Table 7, Table 8). Again this is likely to be caused by the under-representation of highly mobile individuals/households in this survey. In the 1982 data the population share living in households without a car is unexpectedly low (Table 8).

However, the spatial comparison is instructive in any case. As expected, the PT share has declined remarkably over the study period (Table 7). The same is true for NMT. Both these trends are confirmed for all city size categories except for the largest cities with more than 500,000 inhabitants. In these cities the PT share remains on a constant level, while the NMT share only marginally declines. In medium size cities of between 100,000 and 500,000 inhabitants NMT faces only minor losses as well.

Motorisation shows a corresponding spatial picture (Table 8). Car availability clearly increased in all city size categories over the study period. However, the increase was least distinct in large cities. Roughly speaking, the population share with individual car ownership doubled from 1976 to 2002 in all city size categories up to 100,000 inhabitants. E.g., in small communities with less than 2,000 inhabitants it rose from 38 to 81 percent; in cities from 100,000 to 500,000 inhabitants the increase is slightly lower; in cities with more than 500,000 inhabitants even lower ('only' from 33 to 58 percent).

The widening spatial gap in motorisation is particularly striking with respect to households with more than one car. In communities with less than 2,000 inhabitants, 21 percent of the population older than 10 years of age lived in households with more than one car in 1976. By the year 2002 this proportion had increased by a factor of 2.5 to 52 percent. In cities with more than 500,000 inhabitants the corresponding share increased from 11 to 19 percent in the same period. This corresponds to a factor of 1.7. This is clearly a marked increase. However, given that the population in the large cities started this period from a markedly lower motorisation level than the small town and rural population, one may well speak of a widening gap. E.g., the proportion of people living in non-motorised households was 39.8 percent in the largest cities in 1976, while in the smallest communities it was only 20.6 percent.

This raises the question as to whether travelling by automobile would have increased (to the extent it has) if urban structure had developed in favour of the large cities instead of the small (suburban) communities. Basically: can suburbanisation be blamed for the increase in car travel? This interpretation is possible, and, considering the effects of the built environment on motorisation and travel mode choice found in numerous studies (e.g. a recent study by Scheiner

city size (1,000 inh.)		NMT	PT*	car**
< 2	1976	33,8	9,2	56,9
	1982	30,2	8,6	61,2
	1989	37,4	4,8	57,8
	2002	25,2	3,2	71,7
2-5	1976	38,8	8,3	52,8
	1982	35,1	9,1	55,8
	1989	37,2	5,5	57,3
	2002	23,5	3,9	72,5
5-20	1976	42,9	6,9	50,2
	1982	36,7	7,6	55,8
	1989	37,0	5,3	57,6
	2002	27,4	3,8	68,8
20-100	1976	41,8	8,8	49,4
	1982	37,4	8,5	54,1
	1989	41,8	6,4	51,8
	2002	30,1	4,8	65,1
100-500	1976	38,0	13,7	48,3
	1982	38,5	13,0	48,5
	1989	41,4	12,0	46,7
	2002	34,2	9,5	56,3
500+	1976	38,9	19,8	41,3
	1982	35,5	20,5	44,0
	1989	36,9	19,0	44,1
	2002	36,1	19,1	44,8
total	1976	40,1	11,2	48,7
	1982	36,5	11,1	52,4
	1989	39,0	8,9	52,1
	2002	30,2	7,2	62,5

Table 7: Travel mode choice by city size category, 1976 to 2002

For further remarks see Table 2
Source: author's analysis. Data: KONTIV 1976, 1982, 1989, 2002

city size (1,000 inh.)		individual car ownership*	no car in household	one car in household	2+ cars in household
			(population shares)		
< 2	1976	38,4	20,6	58,4	21,0
	1982	58,0	7,1	54,8	38,2
	1989	60,2	10,7	48,4	40,9
	2002	81,0	5,4	42,7	51,9
2-5	1976	37,9	23,8	54,6	21,5
	1982	54,7	7,6	56,5	35,9
	1989	54,8	16,0	46,1	37,9
	2002	78,9	5,4	43,9	50,7
5-20	1976	36,9	26,6	56,2	17,2
	1982	56,8	9,6	55,8	34,6
	1989	54,2	18,4	49,8	31,8
	2002	76,6	8,7	45,7	45,6
20-100	1976	37,3	28,8	55,6	15,6
	1982	56,3	12,1	58,3	29,6
	1989	52,8	19,9	54,3	25,8
	2002	72,9	12,0	51,7	36,3
100-500	1976	35,7	33,7	52,4	13,9
	1982	54,5	17,9	57,8	24,2
	1989	48,3	28,0	50,9	21,1
	2002	65,1	18,7	52,7	28,6
500+	1976	33,1	39,8	49,0	11,2
	1982	49,9	23,7	57,5	18,8
	1989	46,4	31,5	50,1	18,5
	2002	57,7	28,8	52,4	18,8
total	1976	36,3	30,1	54,0	15,9
	1982	55,0	13,5	57,1	29,4
	1989	51,7	22,2	50,8	27,0
	2002	71,3	13,8	49,2	36,9

Table 8: Individual car ownership and population shares by number of cars in the household, by city size category, 1976 to 2002

* The column shows individual car ownership, but for 2002 individual car availability at any time due to a different survey methodology
Source: author's analysis. Data: KONTIV 1976, 1982, 1989, 2002

and Holz-Rau, 2007), it is plausible and likely to have a kernel of truth. However, the debate on residential self-selection noted in section 2 has to be accounted for as well. There is clear evidence that car availability is not only an outcome of households' residential location decisions, but also a pre-condition for these decisions. Highly motorised households tend to move to peripheral locations (and on the regional level this means, by and large, to small suburban communities), while households with no or only one vehicle tend to move to the cities (Scheiner, 2005, 2006a).

Thus, the trends found here may reflect several mechanisms, namely the effect of urban structure (large cities tend to curb motorisation), the self-selective in-migration of households without a car or with only one car, and the self-selective stay of the same type of households in the cities. This type of residential location behaviour may reflect preferences as well as (non) available resources. The different effects that may be hidden here cannot be separated using the data analysed. However, one point may be noted:

As car travelling increasingly becomes a societal norm and also a necessity (because of the spatial and individual separation of urban functions such as housing, working, shopping and so on), the big cities become (with some slight exaggeration) the last areas where one can still live without a car and where car-less households are gathering, regardless of whether their car-less life is voluntarily chosen or caused by a lack of resources.

5 Outlook

This paper reports findings from longitudinal analyses of the German nation-wide travel survey KONTIV for the period 1976 to 2002. It focuses on travel mode choice, subdivided by distance categories, car availability, and city size categories. In addition, trends in car availability itself are examined by city size categories for the said study period.

The results indicate that even within distance categories car use has considerably increased. The proportion of bicycle use has partially increased as well. The gains of the private car are mainly at the expense of trips on foot for shorter trips, and at the expense of PT for longer trips. According to this, the shift in modal split towards the car is not (only) caused by increasing trip distances and, thus, expanding activity spaces, but took place even within distance classes. Once car availability is taken into account, these modal shifts appear to be considerably weaker. This suggests that once car availability is held constant the decision rationales of mode choice for a certain trip distance have remained relatively stable, while the change in decision rationales mainly resulted in increasing car ownership.

Spatial comparisons show that the increase in motorisation over the study period was considerably weaker in large cities than in small towns and the countryside, although the cities started from a lower level in the 1970s. Thus, the motorisation divide between cities on the one hand, and suburban and rural areas on the other hand has become ever wider. For travel mode choice, the picture is similar. While car use in small towns steeply increased at the expense of PT and NMT, modal split remained rather stable in the cities. This may be traced back to the built environment, or to the residential self-selection of households without a car or with only one car who move to (or stay in) the cities.

What is more, the results suggest that even car owners are more inclined to walk a given distance in the cities than in small towns, even more so if they live in a central urban area. For trips over two kilometres the use of PT or the bicycle is more prevalent in the cities than in smaller towns.

The built environment thus indeed appears to have an impact on whether an available automobile is used or not. Without being able to factor out the key determinants for this, the reasons may be found in the transport system as well as in urban structure. Firstly, lack of parking space and high car traffic density may be decisive, i.e. higher generalised costs of car travelling. Secondly, urban environments may be more attractive or exciting for walking, or more appropriate for coupling activities on foot.

Given the lower motorisation combined with the lower car use of motorised individuals in the cities, one may conclude in any case that the dense, mixed land-use structure of the cities – particularly in the centrally located neighbourhoods – appears to be a key factor for a relatively low level of car use. This is even more so the case, as the well-known shorter travel distances of city dwellers have not been considered here.

This has important, albeit not new, consequences for policy. Despite urban sprawl and increasing spatial dispersion, most cities in a European context still have a lively centre, accommodating an urban population who lead their daily lives with relatively short trips, low motorisation levels and high levels of walking. Although travel behaviour has been shown to be at least partly an effect of residential self-selection, most related studies find that the built environment has significant effects as well (Cao et al., 2006; Scheiner and Holz-Rau, 2007). This study confirms that spatial planning may indeed affect travel. But even if the specific travel behaviour of urban – as compared to suburban or rural – populations is mainly an effect of residential self-selection, there is still a 'built environment effect' in terms of the provision of options for residential choice. There is no residential self-selection as long as there are no options to be selected. Thus, even in this case it is still worthwhile making cities more healthy, attractive and liveable for those who prefer to live there, thereby providing options for living without a car or at least for using it less. This is particularly true as suburbia might face increasing problems in the future due to demographic ageing and rising transport prices (Hesse and Scheiner, 2007).

Finally, the limitations of the dataset and the methodology of analysis should be kept in mind. The four surveys differ in sampling procedure, survey methodology and content of the questionnaires. Because of these limitations, the time series should not be over-interpreted as overall trends. Thus, the interpretation mainly referred to comparisons of trends, e.g. between different city size categories, rather than marginal trends in total. Improved long-term monitoring of travel behaviour in terms of adequate, stable survey methodologies is clearly desirable for Germany.

With respect to the methods of analysis applied, the findings reported in this paper are based on descriptive statistics. Clearly, a multivariate analysis could lead to a more thorough understanding of the relationship between trip distance and mode choice as well as possible changes over time in this relationship. Such an analysis should account for a range of other variables beside the ones considered here, such as socio-demographics, transport prices (public transport fares, fuel), or congestion levels. The changes in all of these in recent decades may have affected trends in travel distances and mode choice. However, this would significantly extend the scope of the research project this paper is based on. A multivariate longitudinal analysis would, however, be a worthy subject of further research and a future paper.

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