# Social inequalities in travel behaviour:
## trip distances in the context of residential self-selection and lifestyles

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**abstract**

In recent years, the framework of 'classical' objective determinants of travel behaviour – such as transport systems, generalised travel costs, life situation and the built environment – has begun to make way for the introduction of subjective elements including attitudes, lifestyles, and location preferences. This paper presents findings from an empirical study of trip distances travelled for three purposes (work, maintenance, leisure). The study was conducted in the region of Cologne, and the analysis is based on structural equation modelling. The results indicate that, in general, neither lifestyles nor location preferences have a strong impact on trip distances, except for leisure activities: here lifestyle has the strongest impact of all variables studied. Maintenance trip distances are significantly affected by the spatial setting in which people live, indicating the relevance of the built environment for this travel segment.

**keywords**: trip distances, lifestyles, residential self-selection, social inequality, structural equation modelling

# 1   Introduction

There has been much research on the determinants of travel behaviour in general, and trip distances in particular. In recent years two interrelated strands of research have become prominent in this context. Firstly, the 'classical' socio-demographic differentiation of travel has been challenged by lifestyle-oriented approaches that claim to be more appropriate in individualised, affluent societal contexts (Ohnmacht et al., 2009; Scheiner and Kasper, 2003) where a majority of the population can afford to choose from various options in their consumer (and, more specifically, travel) behaviour. Typically, lifestyle approaches to travel include subjective attitudes, values, housing or leisure preferences and wishes, rather than just the mere objective circumstances of daily life, such as employment, age or gender roles.

Secondly, while these studies aim to socially differentiate travel, another line of research is more directed towards spatial differentiation and the built environment. Much recent research in this area focuses on the question of whether, and if so the extent to which spatial differences in travel behaviour may be attributed to the built environment, or whether such differences are rather to be attributed to individuals locating in environments that match their specific accessibility and travel preferences (self-selection hypothesis) (see Cao et al., 2009 for a recent review).

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These two lines of research are closely interrelated, and this paper aims to enhance understanding of both the roles of lifestyles and residential self-selection by studying trip distances for three types of activities in the context of life situation, lifestyle, the built environment, and accessibility preferences. Trip distances are an extremely important measure of travel behaviour as they are closely related to transport externalities such as noise emissions, climate change, traffic accidents, and land consumption caused by transport infrastructure. What is more, trip distances may serve as proxies for activity spaces and thus capture social inequalities in the radius of daily spatial behaviour and participation in societal life.

This paper draws on empirical data collected in the region of Cologne. The data are analysed using structural equation modelling (SEM), a flexible technique which is increasingly being used in transport studies (Golob, 2003). Unlike most standard statistical methods, SEM is not limited to the analysis of explanatory variables on a single dependent variable. It can deal with several endogenous variables with interdependent relations with one other, as well as the inclusion of intervening variables. As such, SEM is an adequate tool for the investigation of complex, multi-stage interrelations between variables.

The next section briefly reviews recent related literature. This review is followed by a description of the data and the methodology. Subsequently, the results are presented. The last section draws some conclusions for policy and research.

# 2 Literature review

## 2.1 Lifestyles and travel

Originating from market research, the theoretical background for research on lifestyles is provided by sociological debates on modernisation (Giddens, 1990) and individualisation (Beck, 1992). Observations of a growing 'dis-embedding' of individual action and social networks from spatio-temporal contexts, the decreasing relevance of traditional structures of social inequality, and the change from materialist to hedonist, 'post-materialist' values lead to the assumption of 'new' horizontal differences 'beyond class and status' (Beck, 1992) that may superimpose on (or complement or substitute) 'old' vertical inequalities. These horizontal inequalities are to be captured by the concept of lifestyle.

In transport studies the notion of lifestyles was introduced by Reichman (1977). However, at this early stage the lifestyle concept was still based to a large extent on socio-demographic differences. Since the 1990s lifestyles have been seen rather as being based on values, attitudes, perceptions, leisure behaviour and consumption, a view introduced by sociologists (e.g. Müller, 1992; Schulze, 1995; see for the transport context Bagley and Mokhtarian, 2002; Kitamura et al., 1997; Scheiner and Kasper, 2003).

Götz et al. (1997) transformed the lifestyle concept into 'mobility styles' that are mainly based on travel mode preferences. Ohnmacht et al. (2009) apply this concept to leisure activities, mode share and leisure travel distance and find that mobility styles have significant, if only moderate, effects. Some attributes of mobility styles are also studied in the context of the residential self-selection debate using the terms attitudes or preferences (e.g. 'pro-drive alone', Bagley and Mokhtarian, 2002).

While mobility styles mainly focus on travel modes, the emergence of modern lifestyles may also have substantial consequences for activity patterns, the size and structure of activity spaces and, thus, for trip distances. The increase in travel distances and accessibility has been recognised as being related to individualisation and modernisation (Kesselring, 2006). Empirically, lifestyles have been found to be closely related to trip distances. In a study conducted in the German city of Freiburg, Götz et al. (1997) found trips of risk-oriented car-lovers ('risikoorientierte Autofans') to be substantially longer than those of other mobility style groups. In a follow-up study, average leisure trip distances of the 'traditional' lifestyle group were found to be considerably lower than average (Götz et al., 2002). However, these findings are based on descriptive comparisons, rather than multivariate analysis, and thus do not control for underlying third variables.

Other studies focus on travel distance within a certain time period, either mode-specific or in total. For instance, Schwanen and Mokhtarian (2005) conduct a related study in the San Francisco Bay Area. They find that the factors 'adventure seeker' and 'workaholic' both have a positive impact on

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total miles travelled. Bagley and Mokhtarian (2002) conclude from their US data that lifestyles and attitudes have the greatest impact among all studied impact factors on mode-specific travel distances. In a Swiss study, Ohnmacht et al. (2009) find that mobility styles have moderate but significant effects on leisure travel distances. Surprisingly, the leisure travel distances of the groups 'fun and distraction seekers' and 'culture-oriented' are found to be shorter than those of 'neighbourly home-lovers'. Lanzendorf (2002) studies four neighbourhoods in Cologne. He finds that weekend leisure travel distances by car are longer than average among 'multis' (a group who undertake multiple activities and favour multiple modes).

In total, evidence on the effects of lifestyles on trip distances is much sparser than related evidence on travel mode choice and mode-specific travel distances. While travel distances and travel mode choice (or a combination of the two) are clearly important indicators in terms of sustainability in travel, travel distances are dependent on both activity (or trip) frequency and trip distances. Studying activity (or trip) frequency and trip distances separately may tell us more about socio-spatial inequalities in activity spaces and participation in societal life. To date, findings on the effect of lifestyles on trip distances are very limited, and they are based on descriptive comparisons between groups rather than including underlying third variables. No purpose-specific studies on trip distances could be found.

## 2.2 Residential self-selection, the built environment and travel

While lifestyle studies in the transport arena aim to socially differentiate travel, another line of research is more directed towards spatial differentiation. Transport researchers have highlighted the importance of a number of key attributes of the built environment in this respect: density, land-use, distance to the nearest centre, and connectivity of transport networks (see overviews in Boarnet and Crane, 2001; Stead and Marshall, 2001; Cervero, 2006). The spatial determinants of travel have been summarised using keywords such as the 'three D's' – density, diversity, design (Cervero, 2002).

The built environment has a particularly strong impact on two attributes of travelling: trip distances and travel mode choice (and, consequently, on mode-specific distances), while its effects on trip frequency and travel time budget are considerably weaker[1]. The results of research to date may be summarised in the key statement that the inhabitants of dense, compact cities with mixed land-use undertake comparatively short trips and use public transport or non-motorised travel modes for many of their trips (Boarnet and Crane, 2001; Ewing and Cervero, 2001; Guo and Chen, 2007 and other contributions in the same issue; Chen et al., 2008 with a focus on density; Forsyth et al., 2008 with a focus on walking). This may be explained firstly by the high density and variety of activity opportunities in these urban structures, and secondly by the transport system serving these compact structures, which includes restrictions for car travel, high quality public transport service and near-by destinations which encourage people to walk or use their bicycles.

These observations, however, have been challenged by the debate on residential self-selection effects in travel behaviour. In short, this debate claims that travel behaviour may be an effect of the selective location decisions of individuals or households who locate in neighbourhoods that match their accessibility preferences and travel needs (Kitamura et al., 1997; Scheiner, 2006; van Wee, 2009 and other contributions in the same issue). Consequently, the built environment at the place of residence cannot be regarded as exogenous to travel behaviour (Boarnet and Crane, 2001; Scheiner, 2006).

The evidence on residential self-selection is now substantial (see Cao et al., 2009 for an overview) and cannot be reviewed here in detail. Self-selection has been found to significantly influence travel behaviour, although the built environment remains important. The latter is

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[1] Trip frequency is first of all a function of daily requirements and, accordingly, of the social roles of individuals, to a lesser extent of the built environment. Trip frequencies may be slightly higher in urban settings compared to suburban or rural environments due to people being more inclined to go shopping and do small errands 'on the way' in urban settings with a high density of opportunities (Holz-Rau and Kutter 1995). Longer travel times in suburbia compared to the city might be expected due to longer distances but are compensated by higher mean travel speeds (Schwanen et al. 2002). These are achieved firstly by making more use of the private car, and secondly by the fact that suburban residents' often make their trips on regional traffic networks where higher speeds can be achieved.

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reflected, for instance, in the finding that travel behaviour significantly changes after residential relocations (Bagley and Mokhtarian, 2002; Krizek, 2003), although the self-selection hypothesis may suggest that behaviour is determined by attitudes and preferences and is thus more or less fixed regardless of the spatial context in which an individual lives.

As with the lifestyle issue discussed above, residential self-selection has been studied most with respect to mode choice and mode-specific travel volumes, while the evidence on trip distances and, thus, the size of activity spaces is rather limited. However, one might expect travel and location preferences to affect trip distances in the same way. For instance, individuals with a preference for proximity to the workplace may be expected to live close to their workplace and, accordingly, to undertake short job trips. Associations with activity patterns are also likely. For instance, one could expect individuals who bear domestic responsibilities and undertake much shopping to rate proximity to shopping facilities as being more important than others. What is more, the residential self-selection debate is more focussed on the US than on Europe.

This paper aims to contribute to both the lifestyle and the self-selection debates by studying trip distances for three travel purposes in the Cologne region. It takes into account selected attributes of the built environment as well as related attitudes towards the built environment, and life situation as well as lifestyles, and car availability.

# 3   Methodology

## 3.1   Data and study areas

The data used in this paper were collected in a standardised household survey within the scope of the project StadtLeben while the analysis was undertaken in a follow-up project[2]. The survey was carried out in ten study areas in the region of Cologne in 2002 and 2003. 2691 inhabitants took part in extensive face-to-face interviews about their travel behaviour, housing mobility, life situation, lifestyle, location preferences and residential satisfaction. The response rate was 27 percent of those asked. This appears to be a reasonable rate, given the high respondent burden (the average interview duration was 58 minutes).

As location preferences were not asked for in three of the study areas, the analysis is based on the remaining seven study areas only, all of which were surveyed in 2003. Depending on the model, the resulting net samples have a size of about n=2,000. The working samples have a size of about n=1,000 due to the split of the sample.

The study areas represent five area types, each type is represented by two areas whereby the study areas excluded from analysis are shown in squared brackets (Figure 1): high density inner-city quarters of the 19th century ('Wilhelminian style': Nippes, [Ehrenfeld]); medium density neighbourhoods dating from the 1960s ('modern functionalism') with flats in three- or four-story row houses (Longerich, [Stammheim]); former villages located at the periphery of Cologne which since the 1950s have experienced ongoing expansion with single-family row houses or (semi-) detached single occupancy houses (Zündorf, [Esch]); small town centres in the suburban periphery of Cologne (Kerpen-Stadt, Overath-Stadt); and suburban neighbourhoods with detached single occupancy houses (Kerpen-Sindorf, Overath-Heiligenhaus). The four suburban neighbourhoods are all about 30 km away from Cologne.

As each of the two areas belonging to one type is clearly different, the areas are very varied with regard to location, transport infrastructure, central place facilities and sociodemographic structure. Nonetheless spatially or socially 'extreme' areas were not purposely targeted. There are no

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obvious high income areas, and only one distinct low income area (Stammheim; excluded from the analysis).
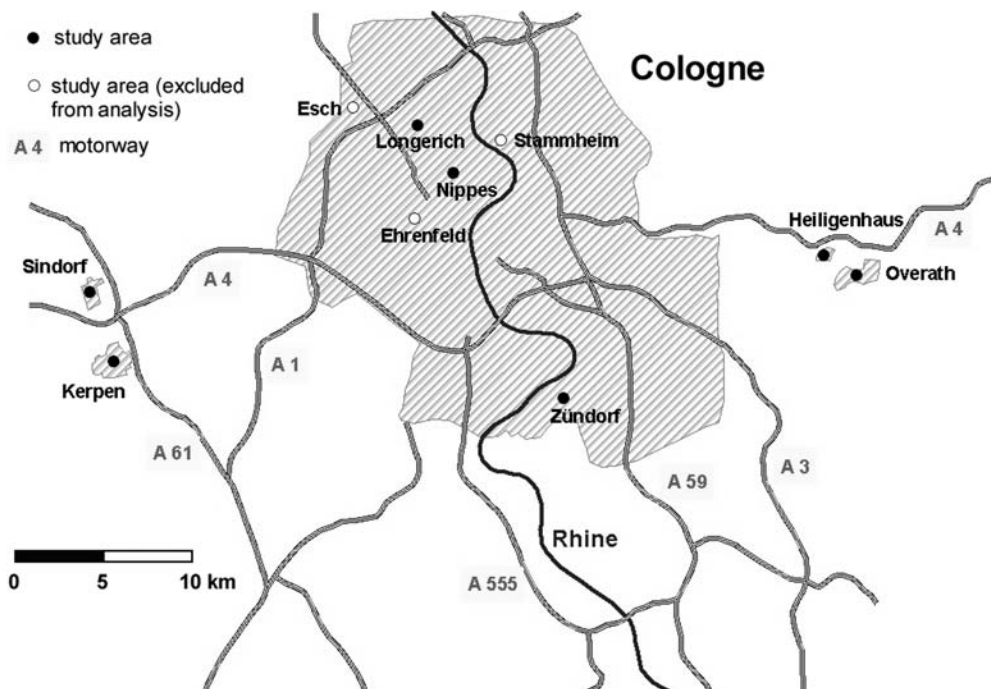


**Figure 1: Location of the study areas in the region of Cologne**

Source: own concept of project group StadtLeben

Heiligenhaus represents the most peripheral neighbourhood. There are no retail facilities or services worth mentioning, and public transport is limited to an irregular bus service. However, one has to keep in mind that even this area is located within the outskirts of the city of Cologne. It is thus not particularly remote when seen in the context of the spatial variety of the whole of Germany.

The region of Cologne is a polycentric agglomeration with the clearly dominating centre of Cologne. The population trend is slightly positive, and the housing market is largely supply dominated. This limits the opportunities for different population groups as defined by lifestyle or life situation to realise a specific location choice that meets their needs and wishes: an important condition for the interpretation of the results.

The data used are unique in Germany in so far that they allow connections to be drawn within a large variety of information on the individual level. To the best of my knowledge, the only similar data set in existence was collected in Northern California (Cao et al., 2007). However, the data shows some deficiencies:

1. The data are based on a cross-sectional survey with only a few retrospective elements. Cross-sectional data do not allow for the investigation of processes, such as the adjustment of lifestyles and location preferences to the chosen location.

2. All data were collected with reference to the date of the survey. But the last relocation took place in the past. The location decision was made in a certain life situation that might well have differed from the life situation that represents the basis for the surveyed travel behaviour. Lifestyles and location preferences may have changed as well.

3. The basis of the models is both individual behaviour (travel) as well as collective behaviour (household location). Possible interdependencies cannot be integrated into the models. For instance, location preferences might in some cases not have had any impact on the actual location decisions, because the decisions were based on the partner's location needs. The calculated path coefficients should, therefore, be conservative estimates.

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## 3.2 Variables

The basic concepts used in this research, such as lifestyle or life situation, can be specified with a low or high degree of complexity. Here, an attempt is made to keep the degree of complexity in the model components as low as possible. This is achieved by using dimensions of lifestyle, preferences and the built environment that seem relevant for the activity studied from a theoretical point of view, rather than including all available dimensions. However, in order to avoid ignoring significant, if unanticipated, effects of other dimensions of attitude and lifestyle, extensive regression analysis including multiple dimensions were undertaken before the models were constructed. Finally, the following components are used.

*Life situation* was measured by a set of seven observed variables, namely gender, age, number of children in the household, total household size, education level, per capita household income (with children counting as 0.8 persons) and employment. Some transformations of the ordinal-level variables education level and employment were undertaken in order to achieve metric variables. Education level was transformed into an estimated number of years in school. Employment (full-time, part-time, marginal, none) was similarly transformed into an estimated number of working hours per week.

After extensive attempts, a measurement model of life situation was developed[3] in which household size, number of children, age and income were allowed to load on one latent variable, which was called 'family'. It should be noted that this variable, despite its name, refers to individuals living in a certain household type (family) rather than to households as units, as all analyses are based on individuals. Education level, employment, income and age are allowed to load on a second latent variable called 'social status'. With a certain blurredness (as is usually the case in factor analysis) we thus have a more demographically oriented latent variable (family) and a latent variable which is more characterised by social stratification. Gender, last but not least, does not load on either of the latent variables thus allowing it to operate as an exogenous variable and rendering its binary scale unproblematic.

*Lifestyles* are presented in the data using four domains: leisure preferences, values and life aims, aesthetic taste (measured using preferences in reading and television viewing), and frequency of social contacts. These were represented by a total of 34 items measured by five-point Likert-type answer scales. In order to keep the models as simple as possible, only a few items are selected for each model to represent lifestyle. Scheiner (2008) gives an extensive methodological description. As some questionees are more inclined than others to generally agree with items, the answers were normed by subtracting a respondent's mean answer to all the items from the respective value. This results in normalised variables that take any individual tendency to generally agree or disagree into account.

In the work trip model, lifestyle is measured by a latent variable called 'self-realisation'. It is based on the items 'importance of societal engagement' and 'importance of achieving a leading job position'. This latent variable is primarily job-oriented and is assumed to be associated with long job trips. The exclusion of other lifestyle dimensions is based firstly on the notion that preferences in leisure, reading and TV watching do not have a great deal to do with job trip distance, and secondly on preceding regression analyses (see above). In the maintenance trip model, 'familial leisure preferences' are used to capture lifestyle. This latent variable is based on the two items 'play with children' and 'engage with my family'. Although this orientation does not have an obvious link to trip distance, it is hypothesised to be associated with feelings of responsibility for the immediate social environment and, thus, the neighbourhood. It should thus be linked to relatively short maintenance trips. For the leisure model, it seems obvious to choose leisure

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[3] In earlier analyses of the same data set (Scheiner and Holz-Rau 2007), latent variables were excluded from the model estimations by using scores derived from preceding factor analyses. The models with latent variables had very poor fit values (likewise: Simma 2000). However, using factor scores for life situation or lifestyle as 'observed variables' assumes that there are no measurement errors in such highly theoretical constructs – an assumption which appears unsatisfactory. Measurement models for life situation, lifestyle and accessibility preferences were therefore re-introduced into the analyses. The results were validated as far as possible using the rigorous approach described below. One should also note that far more models than those presented here were estimated. As the measurement model for life situation should be consistent for all models, some interrelations between manifest variables and latent variables were maintained even if the loadings do not reach acceptable standards (e.g. the loadings of age on family in Figure 2).

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preferences. Lifestyle is represented here by the strength of out-of-home leisure preferences, a latent variable based on the items 'going to the movies/theatre/concerts' and 'attending training/education courses'. This latent variable is assumed to be related to a large variety of out-of-home leisure needs, including relatively specialised needs that may be linked to long trips. It should be noted that the two leisure preference indicators (out-of-home and familial) are not two ends of the same scale, but two different dimensions. Hence, a respondent may have high scores on both variables. In a control analysis for leisure trips, lifestyle was measured using the two leisure indicators simultaneously. The result showed that out-of-home leisure preference was clearly superior to familial leisure in explaining leisure activities. For the sake of parsimony, familial leisure was excluded from the leisure model.

Individual *location preferences* were operationalised using subjective importance ratings of neighbourhood and location attributes, again measured by five-point Likert-type answer scales. Information was gathered as part of the survey by asking 'How important are the following features of the neighbourhood for your personal decision in favour of a certain place of residence?' The attributes were then listed, for instance 'accessibility of the city centre' or 'access to public transport'. Again, the scales are normalised in order to take any individual inclination to generally agree or disagree into account. This makes sure that the preference ratings are treated as relative to other preferences and, thus, preference trade offs are accounted for. E.g., assume that two respondents both give access to their workplaces a score of 4 (out of 5). However, respondent one rates proximity to other activities as being more important than access to the workplace (scoring other activities on average with, say, 4.3), while respondent two rates proximity to other activities as being less important than access to the workplace (average score 3.5). For respondent one this would result in a negative value for access to the workplace (access to workplace is less important than access to the average of all activities), while respondent two would obtain a positive value.

Specifically, when examining job trips, the importance of access to the workplace is used as an indicator of location preferences, while in the maintenance activity model, the importance of proximity to shopping for a location decision is used. This was measured by a latent variable based on two observed variables: 'proximity to shops' and 'proximity to services'. In the leisure model, the importance of proximity to leisure facilities for adults is used.

The *built environment* at the place of residence is studied with regard to specific attributes of the neighbourhood that are selected in accordance with the location preferences. It should be noted that attributes of the built environment at the destinations are not available for analysis. This does not mean it is assumed that such attributes have no role to play (see Cervero, 2002; Shearmur, 2006). In the maintenance activities model, the supply of retail and services is used to describe the neighbourhood. Similarly, the supply of leisure opportunities is used in the leisure trip model. Both indicators are measured as the number of opportunities within a straight-line distance of 650 m around the place of residence. The indicators are calculated separately for all individuals[4].

In the work trip model, access to workplaces ('job supply quality') is used to describe the built environment. This was far more difficult than for shopping and leisure trips, as the number of workplaces can hardly be estimated by field work, and official data on the number of workplaces is only available in Germany on the community level, a spatial scale lacking the necessary precision for a micro-scale study. The spatial disaggregation was undertaken for Cologne with data provided by PTV, a firm using an estimated number of workplaces in the 721 Cologne transport zones for transport modelling. For the towns of Kerpen and Overath the breakdown made use of the private database 'Markus' (Bureau van Dijk, 2004), which allows for a small-scale decomposition of workplaces on the neighbourhood level. Unfortunately this database counts all workplaces as being situated at the location of firms' headquarters; however, the results could be validated by discussions with two local experts. These micro-spatial data for the three communities studied were complemented by official employee data for North-Rhine Westphalia on the community level. All estimations are based exclusively on the number of

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[4] The mapping of opportunities was undertaken by the RWTH Aachen and the Ruhr Universität Bochum. Leisure opportunities include sites of informal activity, such as chance meeting points in public space. I extended this survey beyond the borders of the study areas to meet the full radius of 650 m even for respondents living close to the border of an area.

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employees liable for social insurance contributions. From the resulting spatial distribution a gravity model was estimated with a distance coefficient of $\alpha=1$ [5].

*Car availability* is measured in the data as an ordinal variable which can take on four values: no car in the household, car in the household not available to the respondent, car in the household partly available, and car in the household available at any time. This ordinal variable may be interpreted as metric when the distances between the four values are equal. Actual car use in the four groups suggests that this is approximately true (Table 1). None of the groups are extremely close together or extremely far apart from one another.

| | car use per week | | |
|---|---|---|---|
| Car availability | distance | frequency | n |
| no car in household | 12.2 | 0.8 | 305 |
| car in household, but not available | 34.9 | 2.2 | 88 |
| car in household, partly available | 67.0 | 4.8 | 273 |
| car in household, available at any time | 104.3 | 6.7 | 1,454 |
| All | 83.2 | 5.4 | 2,120 |

**Table 1: Car use by car availability (means)**

Source: author's analysis. Data: StadtLeben.

Travel behaviour was recorded by applying the frequent activities method. Activity frequency, usual travel mode, destination and travel distance were surveyed for selected activities including work, education, daily grocery shopping, weekly shopping, event shopping, administrative transactions at public authorities, private visits, sports, visits to restaurants or pubs, cultural events and sport events, disco and concert, walks, and excursions. As the frequent activities method does not take trip chaining into account, the recorded trip distances reflect distance from home rather than the actual distance of a single trip which may be part of a trip chain. This means that the results do not accurately reflect transport volumes, but rather the extension of activity spaces. While retrospectively collected information on activities and their attributes (such as frequencies, distances, and mode choice) may not be as accurate as trip diary data, they capture regular individual patterns of mobility better than trip diaries, which do not account for longer-term habits and structures of daily life (Schlich and Schönfelder, 2001; Madre, 2003).

*Trip distances* were examined on the basis of mean values for selected activities an individual reported having made. These were weighted by activity frequency. Work obviously includes only trips to the workplace(s). Maintenance activities include daily grocery shopping, weekly shopping, event shopping and administrative transactions at public authorities. Leisure trips included all other activities listed above except for education. Due to skewed distributions, all values were transformed into their natural logarithm.

## 3.3 Methodology of structural equation modelling

Structural equation modelling (SEM) provides a flexible tool to study the interrelations between a large number of variables, and it is being increasingly used in transport studies (Golob, 2003). SEM can be described as a combination of factor analysis and a generalised form of regression analysis. Compared to other multivariate techniques, SEM allows the investigation of multi-stage interrelations between variables. Unlike regression analysis or discriminant analysis, SEM is not limited to the analysis of explanatory (exogenous) variables on a single dependent (endogenous) variable. It can deal with several endogenous variables with interdependent relations with one other, as well as the inclusion of intervening variables.

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[5] This rather small coefficient results from the small-scale decomposition. Most commuter studies that rely on gravity models use more coarsely-grained zones (e.g. communities or counties). Consequently even the nearest spatial units represent relatively long distances. Thus, the likelihood of an area to be chosen declines steeply even for 'short' distances (i.e. in the adjacent spatial units). This is reflected in relatively large distance coefficients.

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As one usually has to handle non-normal and often skewed distributions in travel data (and in trip distance data, in particular) one has to consider which estimation method to use. Browne (1984) developed an asymptotically distribution-free (ADF) estimation procedure that can be applied to binary or ordinal-level variables. However, the sensitivity analyses undertaken by Bagley and Mokhtarian (2002) suggest that 'the findings from the model that met the assumption of multivariate normality were very similar to the results of the earlier model, on the larger sample, that did not meet the assumption' (ibid., p. 287). Simulation studies also show that for large samples the maximum likelihood (ML) approach is robust against violations of distribution assumptions (Golob, 2003, p. 8). For non-normal continuous variables it is regarded as superior to the ADF procedure (Schermelleh-Engel et al., 2003, p. 27).

According to Hoogland and Boomsma (1998) the ADF procedure performs better in the estimation of standard errors as long as the average kurtosis of the observed variables exceeds 3, and n>400. Concerning necessary sample sizes, Hoogland and Boomsma suggest n>5*df, as otherwise the ML chi square statistics tends to reject the model too often. For an average kurtosis >5.0 and ML estimation, the sample size should be n>10*df, for the ADF procedure even n>20*df.

The available sample of about n=2,000 seems appropriate for a robust application of the ML procedure, even if the sample is split into two halves (see below). The ADF procedure then reaches the limit of reliability, but seems still to be acceptable.

Due to poor model fit values in early attempts (confirming overall experience with structural equation modelling), the violation of distributional assumptions and the sensitivity of the models against minor variations, a rather rigorous approach was applied. First, the sample was split into two halves by a random procedure. Then each model was estimated in four versions:

1. ML estimation of a theoretical model (no error covariances allowed) with the main sample

2. Empirical fitting of the model to the data by setting error covariances free step by step and checking the results for stability after each step

3. ADF estimation of the theoretical model

4. ML estimation of the theoretical model with the second sample for validation.

Version 2 only serves to verify the coefficients in the theoretical model version when fitted to the data, while my substantial interest lies in the theoretical models. Note also that due to cases of empirical underidentification, some covariances between life situation variables had to be set free in some models. Thus, the theoretical models are not fully theoretical, but contain some 'empiristic' elements.

Each of the four model versions was compared to the others with respect to the strength and sign of the effects. As many of the interrelations between two variables were examined identically in a large number of models (e.g. the effect of the life situation variables on location preferences and lifestyles), the overall picture of effects was also used to get a general impression of the stability of the models. The results show considerable variations between each of the four versions in the direct effects of one variable on another. However, once the total effects are investigated, the results turn out to be fairly stable and may clearly be interpreted in terms of the sign and strength of the effects. An example for the calculation of total effects can be found in the next section (Figure 2). For this paper an effort was made to select for each activity the model version that best represents the essential findings of all four versions. Differences between the versions are considered for interpretation, as appropriate. More details can be found in Scheiner (2009a).

The analyses were undertaken with the programme AMOS 5.0-7.0 (Analysis of Moment Structures) that is available for SPSS with a user-friendly graphic surface.

# 4 Results

## 4.1 Model fit

There are a number of heuristic indicators to assess the goodness-of-fit of structural equation models. For most of these indicators there are decision rules available and they have been tested in methodological studies. Two of these indicators, along with the corresponding decision rule,

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are given in Table 2 for the models shown in the figures below and for the respective best model version (i.e. the ones that have been empirically fitted to the data, version 2). The fit values of the theoretical models fail to meet a satisfactory level, but the values of the fitted models are satisfactory to close.

Figures 2-4 show shares of explained variances of endogenous variable and standardised direct effects (path coefficients) of a variable on another variable, as the main focus is on the strength of the examined interrelations. The variance explanation rates are in a reasonable range for individual data of travel behaviour.

| | indicator of goodness-of-fit | | | | df | |
| | RMSEA | | Hoelter (p=0,05) | | | |
| | decision rule | | | | | |
| Modell | <0,05 good | | ≥ 200 | | | |
| | >0,1 n.a. | | good | | | |
| | figure | best version 2 | figure | best version 2 | figure | best version 2 |
| Job trip distance | 0.091 | 0.043 | 136 | 388 | 45 | 40 |
| Maintenance trip distance | 0.098 | 0.034 | 126 | 659 | 58 | 43 |
| Leisure trip distance | 0.103 | 0.042 | 119 | 534 | 44 | 32 |

**Table 2: Goodness-of-fit and degrees of freedom for the models**

n.a.: not acceptable
The table gives values for two goodness-of-fit indicators as well as the degrees of freedom (df) for the model shown in the following figures and for the empirically fitted 'best' model version.
RMSEA (Root Mean Square Error of Approximation) measures discrepancy between the model implied and the true population covariance matrix, in relation to degrees of freedom. This ratio is related to sample size. In cases of close fit, RMSEA approaches zero. Values smaller than 0.05 indicate a close fit.  The Hoelter statistics specifies the required sample size (critical n) to reject the model at a given significance level. The larger the value, the better the fit. Values larger than 200 can be regarded as good. The table gives decision rules for the two indices.
Source: Author's analysis. Data: Project StadtLeben.

## 4.2  Some notes on car availability

Before highlighting the determinants of trip distances, the role of car availability shall be outlined briefly. Other interrelations examined in the model framework, such as effects of life situation on lifestyle, are excluded from interpretation due to lack of space (see Scheiner, 2009a).

Car availability shows powerful associations with the built environment: car owners tend to live in areas with low levels of access to jobs, shopping and leisure facilities, i.e. in suburban rather than in urban locations (see Figures 2-4, total effects are shown in Tables 3-5). However, as noted above, there is no unidirectional relationship between location choice and car availability. The same is true for location attitudes and car availability. Therefore, further models were estimated in which the direction of causality between the said constructs went the other way. The results were almost identical to the models presented here. From these results, it is not possible to conclude whether there is a causal direction between location attitudes/choice and car availability that fits the data better than the other direction[6].

Car availability is above all determined by social status. Individuals with high social status have increased access to a car. The same is true for people living in family households, while in all models presented here gender effects are negligible[7]. What is more, familial leisure preferences are positively associated with access to a car, and the same is true (albeit not significantly) for out-of-home leisure preferences. Further analyses show that lifestyle effects on car availability

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[6] To shed more light on the question of causality, models were tested that allowed for bi-directional causality between (1) location preferences and car availability, and (2) location choice and car availability. Unfortunately, these models turned out to be unidentifiable.

[7] The effect of the latent variable 'family' is negative in the maintenance trip model, but its total effect is positive. Gender shows negative effects in many other model variants, suggesting higher car availability for men (Scheiner, 2009b).

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are generally relatively weak (Scheiner, 2009a). For instance, one might expect self-realisation to have a distinct positive effect on car availability. This is not confirmed by the results. Furthermore, one would expect the effect of out-of-home leisure on car availability to be stronger than the effect of familial leisure. Again, the evidence does not confirm this. These findings cast some doubt on the relevance of lifestyle for motorisation, despite the effects found.

## 4.3 Trip distances

In the following, the determinants of trip distances are discussed. Findings concerning activity frequency are included as appropriate. They are discussed in detail in a related paper (Scheiner, 2009b). The job trip model is largely dominated by social status (Figure 2), which is primarily determined by income. What is more, commuting distances are longer for individuals living in families: this may be due to the spatial ties of families to their place of residence persisting even after workplace relocations. The significantly shorter commuting distances found among women are a standard observation in research on transport and regional economics. This gender gap in commuting has been recognised to be mainly linked to the matter of families, while gender differences in couple households without children are smaller. It is worth mentioning that the effect the private car has on commuting distances is insignificant. Lifestyle has a minor and insignificant impact in terms of shorter job trips for individuals with a distinct orientation towards self-realisation. As self-realisation mainly refers to vocational/career aims here ('achieve a leading job position'), the explanation for the negative sign of the lifestyle effect is not obvious. One might expect longer job trips for individuals with ambitious career aims. However, once the analysis is limited to full-time employees, the negative effect of self-realisation turns into positive. It therefore seems to be caused by students with career goals who are in part-time employment.
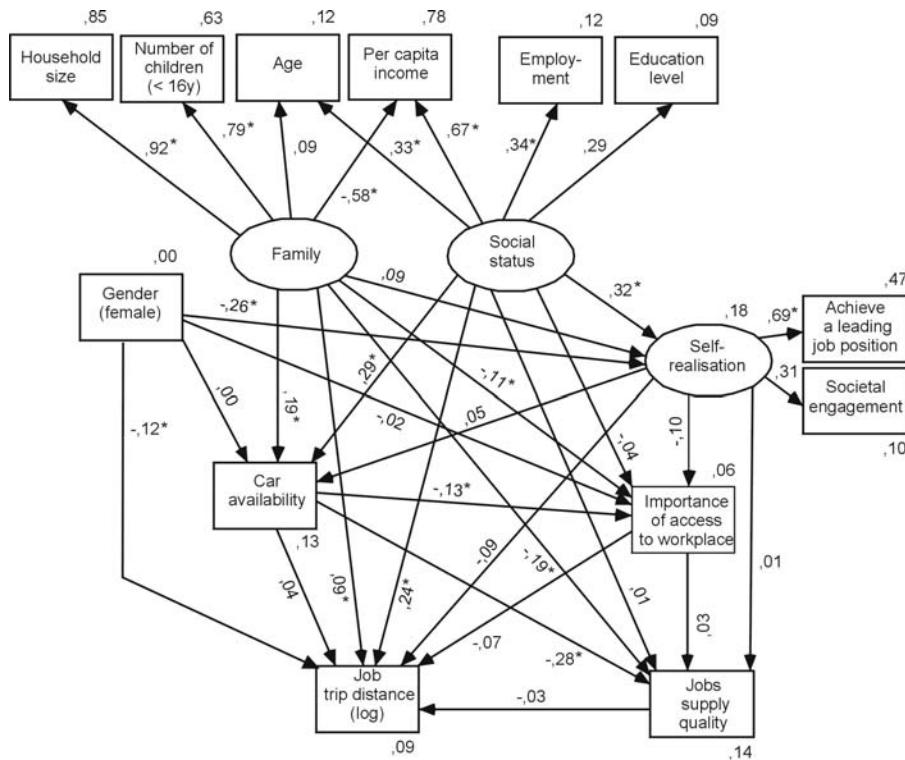


**Figure 2: Model of work trip distances**

Theoretical model (version 1, ML estimation).
This and the following figures show the estimated standardised path coefficients and the proportion of explained variance of the endogenous variables, the latter being indicated next to the variable boxes. Significant coefficients (p=0.05) are marked with an asterisk.
The total effect a variable has on another variable is calculated as the sum of direct and indirect effects. For instance, the total effect of 'importance of access to the workplace' on 'job trip distance' equals -0.07 + 0.03*-0.03 = -0.071.
The rectangles are observed variables, the ovals are latent constructs.
Source: Author's analysis. Data: StadtLeben.

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| effect of... | | | | | | | |
|---|---|---|---|---|---|---|---|
| …on: | Social status | Family | Gender | Self-realis-ation | Car avail-ability | Importance of access to workplace | Jobs supply quality |
| Self-realisation | 0.324 | 0.093 | -0.257 | | | | |
| Car availability | 0.303 | 0.191 | -0.015 | 0.046 | | | |
| Importance of access to workplace | -0.107 | -0.145 | 0.009 | -0.105 | -0.127 | | |
| Jobs supply quality | -0.081 | -0.247 | 0.003 | -0.010 | -0.287 | 0.027 | |
| Job trip distance (log) | 0.233 | 0.108 | -0.103 | -0.077 | 0.058 | -0.071 | -0.026 |

**Table 3: Model of work trip distances – total standardised effects**

Source: author's analysis. Data: StadtLeben.

High subjective importance ratings of access to the workplace are negatively associated with commuting distance, although again the effect is not significant. The spatial distribution of jobs does not seem to play a role, as actual employment opportunities (job supply side) are scarcely associated with commuting distance at all.

Generally, the job trip model is largely dominated by life situation in general, and social status in particular. Lifestyle, accessibility preferences and job supply do not appear to play a significant role.

Maintenance trips are largely determined by shopping in the data used. 68 percent of reported maintenance activities and 37 percent of reported maintenance distances are due to daily grocery shopping. When weekly shopping and event shopping are included, shopping activities make up 84 percent of all maintenance travel distances.

Maintenance trip distances appear to be easier to explain than job and leisure distances, as reflected in the high variance explanation rate of 26 percent in the maintenance model (Figure 3).

In terms of social structures, individuals with high social status tend to travel long distances for shopping. The same is true, albeit to a lesser extent, for individuals living in families (note that the weak direct effect is fuelled by indirect effects mediated by residential location and lifestyle). Women cover significantly shorter distances for shopping than men, although the gender effect is only moderate.
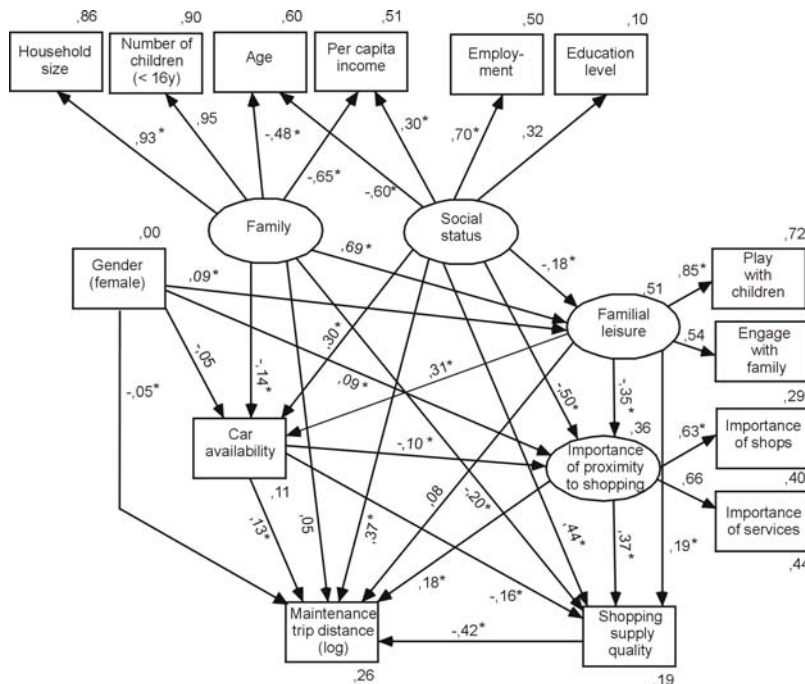


**Figure 3: Model of maintenance trip distances**

Theoretical model (version 3, WLS estimation).
Source: Author's analysis. Data: StadtLeben.

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| effect of...<br>…on: | Social status | Family | Gender | Familial leisure | Car avail-ability | Importance of proximity to shopping | Shopping supply quality |
|---|---|---|---|---|---|---|---|
| Familial leisure | -0.177 | 0.687 | 0.086 | | | | |
| Car availability | 0.245 | 0.075 | -0.020 | 0.308 | | | |
| Importance of proximity to shopping | -0.468 | -0.246 | 0.063 | -0.377 | -0.100 | | |
| Shopping supply quality | 0.193 | -0.167 | 0.043 | 0.001 | -0.200 | 0.371 | |
| Maintenance trip distance (log) | 0.230 | 0.144 | -0.058 | 0.054 | 0.201 | 0.017 | -0.425 |

**Table 4: Model of maintenance trip distances – total standardised effects**

Source: author's analysis. Data: StadtLeben.

Social status is more determined by demographic than by socio-economic elements here. It is mainly young and employed individuals who undertake longer maintenance trips. This may be interpreted in terms of efficiency gains, as the same associations, but with different signs, can be found with respect to the *frequency* of maintenance trips (Scheiner, 2009b). Young employees tend to shop less frequently, but to make longer trips, and they tend to make use of large shopping centres rather than go shopping 'round the corner'. Among the elderly and non-employed, a pattern of frequent shopping in the neighbourhood is more common.

Spatial context at the place of residence has the strongest influence on the maintenance trip distances. A good quality and quantity of shopping facilities in the neighbourhood is associated with considerably shorter maintenance trips. Although the reverse is true for maintenance trip frequency (i.e. individuals in urban environments tend to go shopping more often, but make shorter trips, see Scheiner, 2009b), total maintenance travel volumes decrease with increasing supply quality. Mixed land-use is therefore indeed linked to less maintenance travel. These observations reflect differences in ways of organising daily life in cities compared to suburban settings. In urban neighbourhoods well supplied with shopping facilities, there is a tendency to fit shopping in between other activities. In suburban or peripheral locations, weekly shopping is more common. However, it has to be highlighted that a surplus in centrality may *in total* lead to high travel volumes once incoming commuters are accounted for (Holz-Rau and Kutter, 1995), which the data used here do not allow for.

What is more, car availability has a pronounced positive effect on maintenance trip distances. This effect is composed firstly of a direct effect which is due to the faster speed and, thus, shorter travel times a car allows. Secondly, the car has an indirect effect mediated by residential location. Car owners tend to locate in more peripheral locations that are, in turn, associated with longer shopping trips.

The lifestyle effect is positive, but insignificant. A strong familial leisure orientation is associated with somewhat longer (but less frequent) shopping trips. This may be interpreted in terms of the efficient shopping behaviour of individuals with a family-oriented lifestyle. It should be noted that the lifestyle effect is not statistically significant and should therefore not be overemphasised.

Finally, a strong subjective preference for proximity to shopping facilities is associated with longer shopping trips. However, once indirect effects are accounted for, preference does not appear to play a role (Table 4). One may expect a strong preference for proximity to shopping to be associated with shorter rather than longer shopping trips, and indeed this turns out to be true in the validation sample. Taking into account that the causality between preference and behaviour might be the other way round[8], one could also expect preference for proximity to be associated with longer trips: the reality of long, burdensome trips could fuel a high preference for less burdensome and, therefore, shorter trips. Anyway, due to the contradictory results, one should not overemphasise the findings concerning preference here.

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[8] Turning around the causal interrelation between shopping preference and shopping trip distance does not result in significant changes in the estimated coefficients. Allowing for bi-directional causality results in an unidentifiable model.
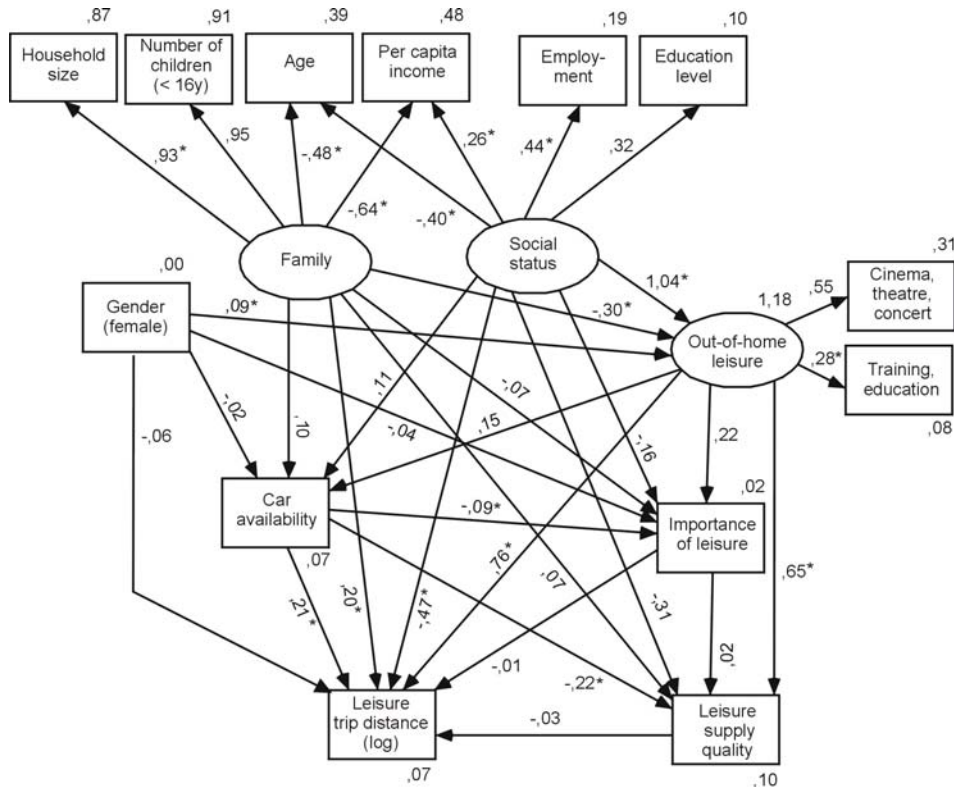
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**Figure 4: Model of leisure trip distances**

Theoretical model (version 3, WLS estimation).
Source: Author's analysis. Data: StadtLeben.

| effect of... | | | | Out-of-home leisure | Car avail-ability | Importance of proximity to leisure | Leisure supply quality |
| ...on: | Social status | Family | Gender | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Out-of-home leisure | 1.040 | -0.298 | 0.090 | | | | |
| Car availability | 0.262 | 0.061 | -0.010 | 0.146 | | | |
| Importance of proximity to leisure | 0.041 | -0.145 | -0.019 | 0.202 | -0.094 | | |
| Leisure supply quality | 0.312 | -0.145 | 0.061 | 0.625 | -0.222 | 0.015 | |
| Leisure trip distance (log) | 0.373 | -0.006 | 0.000 | 0.775 | 0.213 | -0.006 | -0.026 |

**Table 5: Model of leisure trip distances – total standardised effects**

Source: author's analysis. Data: StadtLeben.

Recorded leisure trips again include only selected activities: private visits, sports, visits to restaurants or pubs, cultural events and sport spectating, discos and concerts, walks, and excursions.

As one might expect from the hypothesis of diffuse, highly individualised, and barely explicable leisure travel behaviour (Heinze, 2000), the leisure trip model performs more poorly in terms of variance explanation than the job and shopping models (7 percent, see Figure 4), although some impact factors show strong coefficients. Apparently, leisure trip distances vary strongly between individuals, but these variations are not very closely related to the variables included in the model.

Lifestyle has the strongest impact on leisure trip distances among all variables considered. This means that the factors influencing leisure trip distances strongly differ from those affecting maintenance or job trips. Distinct out-of-home leisure preferences are associated with considerably longer leisure trips (and more leisure activities, see Scheiner, 2009b).

Social status is also positively correlated with leisure trip distances (as well as with activity frequency). The direct status effect is negative, but this is more than outweighed by positive

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indirect effects, leading to the positive correlation mentioned. The indirect effect is primarily mediated by lifestyle, as high status individuals tend towards a strong out-of-home leisure orientation.

As with maintenance trips, car availability has a marked positive effect on leisure trip distances. All other determinants are of minor relevance here. The direct effect of family households is positive, indicating long leisure trips among those living in a family household. However, this effect is outweighed by the weak out-of-home leisure orientation of those living in a family, which in turn leads to shorter leisure trips. The direct effect of gender is negative, but insignificant, possibly suggesting shorter leisure trips among women.

Neither residential preferences nor the residential environment appears to be associated with leisure trip distances.

Over all, lifestyle turns out to be the crucial factor for leisure trip distances. Within the scope of this paper, this is the first strong piece of evidence pointing to the relevance of lifestyle for travel behaviour. This is not surprising as the lifestyle dimension applied in the leisure activities model explicitly refers to leisure activities. By contrast, job and maintenance activities have been studied with reference to lifestyle dimensions, from which a more indirect association with the activities may be expected at best, even though the dimensions have been chosen deliberately.

With respect to leisure activity *frequency*, the substantial proximity between the definition of the explanatory variable (lifestyle as leisure preferences) and the dependent variable (leisure activities) has posed the question as to whether the strong impact of lifestyle might be the result of a tautology. As the same lifestyle dimension turns out to significantly affect leisure trip *distances* as well, I consider a tautology to be unlikely.

# 5 Conclusion

This paper has presented structural equation models of travel behaviour focussing on objective as well as subjective determinants of trip distances for three travel purposes, i.e. for job, maintenance, and leisure trips. The findings show that the main factors relevant for distance behaviour vary greatly between different types of activity.

Overall, trip distances for all travel purposes studied are strongly influenced by social status. Accordingly, the size of activity spaces appears to be significantly affected by vertical social inequalities. Living in a family household also seems to be related to longer trips, although to a much lesser extent.

With respect to gender, the well-known shorter trip distances of women were confirmed here. Shorter trips among women were also found for maintenance trips, although the effect was only moderate.

Having a car readily available is associated with markedly longer maintenance and leisure trips. This is not surprising, as the car tends to reduce travel times and, thus, generalised travel costs. However, the effect the car has on job trips is insignificant.

What is more, car availability plays a powerful role for location choice. Individuals with access to a car tend to locate in peripheral settings with lower levels of access to jobs and fewer shopping and leisure facilities in the neighbourhood. This can be interpreted in at least two ways. Firstly, the car may have a structural impact on location choice, given that car availability itself is clearly unequally distributed among societal groups. Secondly, without neglecting such structural inequalities, the specific location decisions of individuals with access to a car as compared to those who have no access may also be interpreted as an effect of residential self-selection spatially separating the population according to their car availability, as car availability itself may depend on travel mode preferences (Cao et al., 2007).

So far, the findings generally confirm standard knowledge in travel studies. Turning our attention to lifestyles, it was found that lifestyle appears to be the major impact factor for leisure trip distances. While social status shows a strong positive effect as well, the direct status effect is negative, but more than outweighed by indirect effects. Lifestyle is such a powerful impact factor here that it strongly mediates all life situation factors. For other trip purposes, lifestyle was found to be of minor importance.

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With respect to the residential self-selection debate, it is remarkable that location preferences do not show any noteworthy impact on trip distances. The only significant effect is the positive direct effect in the maintenance model, suggesting that individuals with a strong preference for proximity to shopping make *longer* shopping trips than others. However, this relationship is counterbalanced by an indirect effect: those with a strong proximity preference tend to live in areas well-served by shopping facilities and this, in turn, leads to shorter shopping trips. In total, this results in the effect of preference being close to zero. This confirms other studies that found that "the impact of land use preferences is much smaller than that of the physical attributes of the neighborhood" (Schwanen and Mokhtarian, 2005, p. 141). However, it contradicts studies that found self-selection effects to be much stronger than the effects of the built environment (Bagley and Mokhtarian, 2002).

I see at least three reasons for self-selection effects appearing to be limited in the data examined in this paper:

1. Location preferences were recorded using rather generalised items. The respondents were asked about access or proximity to certain opportunities. Yet these concepts may be understood in different ways. Car owners might regard a shopping centre within a 3 km distance as being close by, while for people without a car proximity probably means 'within a range of some 500 m'

2. The housing market in the region of Cologne is supply dominated. Thus, the opportunities of different population groups to realise a specific location choice that meets their needs and wishes are limited. In demand-driven housing markets the effect of location preference on location behaviour and travel behaviour may be much greater.

3. Location preferences might in some cases have had no impact on actual location decisions if the decisions were based on the partner's location needs (which were not recorded in the data).

Consequently, the true effect residential self-selection has on travel behaviour may be larger than the empirical findings presented here suggest. However, the questions of causality between subjective preferences and lifestyles on the one hand, and objective life circumstances such as car availability and the built environment on the other hand, are to date unresolved. Given that actual residential location may well have a strong impact on location preferences, modifying the built environment may be a powerful way of reshaping people's attitudes.

Last, but not least, the built environment appears to have virtually no effect on job and leisure distances. On the other hand it turns out to be the most important factor influencing maintenance activities, suggesting that spatial planning may impact on travel demand for shopping trips more than in other transport sectors.

One may conclude that in terms of social inequalities, the influence of objective life situations, and thus vertical social inequalities, on trip distances by far exceeds the influence of 'subjective' lifestyles, with the notable exception of leisure distances, which are first of all affected by lifestyle. The general finding that life situation is more important than lifestyle confirms related analyses of travel mode choice and activity frequencies (Scheiner and Holz-Rau, 2007; Scheiner, 2009b). However, one has to note that in the data used in this study, lifestyles are conceptualised in purely 'sociological' terms with no presumptive connection to mobility. Lifestyles may have much more impact on travel behaviour once they are measured in a way more closely related to mobility, access, or travel modes. However, the challenge in appropriately defining lifestyle is to find dimensions that are theoretically relevant and focussed on activity/travel behaviour without being tautologically interrelated with the dependent variable.

Finally, one should not forget that lifestyles and preferences or, to put it more generally, the subjective side of travel behaviour, has long been neglected in transport studies (Holz-Rau and Scheiner, 2009). Consequently, more theoretical reasoning on this issue and the development of empirical applications (e.g. Ory, 2007) still seems to be a promising line of research for the future. There will, however, be new theoretical, empirical and conceptual challenges.

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