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Going soft: on how Subjective Variables Explain Modal Choices for Leisure Travel

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Most studies on the link between the built environment and modal choice characterize and model this relationship by objectively measureable characteristics such as density and diversity. Recently, within the debate on residential self-selection, attention has also been paid to the importance of subjective influences such as the individual's perception of the built environment and his/her residential attitudes and preferences, resulting in models that take account of both the objective and subjective characteristics of the built environment. However, self-selection might occur on other points than residential location as well. Expanding the analysis to also include both objective and subjective characteristics at other model levels (i.e., not only stage of life characteristics but also personal lifestyles; not only car availability but also travel attitudes, not only modal choice but also mode specific attitudes) is the purpose of this paper. To this end, a modal choice model for leisure trips is developed using data on personal lifestyles and attitudes, collected via an Internet survey, and estimated using a path model consisting of a set of simultaneously estimated equations between observed variables. While controlling for subjective lifestyles and attitudes, the effects of the built environment and car availability on modal choice can more correctly be determined and thus insights into self-selection mechanisms can be gained. Moreover, we compared the results of a model with and without these subjective influences. The results show that subjective characteristics at various model levels are important decisive factors of modal choices for leisure travel.

Keywords: lifestyles, modal choice, path model, residential attitudes, self-selection, travel attitudes

1. Introduction

The relationship between the built environment and daily travel behaviour has long been of interest to many researchers in the fields of urban planning and transportation. It was first

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articulated by Mitchell and Rapkin (1954) but today is still heavily researched. Literature reviews (e.g., Crane, 2000; Ewing and Cervero, 2001; Handy, 2002, 2005; Stead and Marshall, 2001; Van Acker et al., 2010a) summarize various variables that are commonly used to explain this relationship. These variables are either objectively observed and measured by an outsider or are self-reported but externally-observable characteristics of the traveller, and are sometimes referred to as "hard variables" (Sztompka, 2000). For example, the built environment is characterized by such structural variables as population density, land use mix, jobs-housing balance and accessibility, and the objective socio-economic and socio-demographic (SED) characteristics of the traveller relate to age, gender, household size, educational level and household income. Recently, some researchers have argued in favour of including more cultural or subjective explanations focussing on such "soft" variables as individuals' attitudes and preferences which cannot be easily observed and measured by an outsider (Ross, 1975; Sztompka, 2000). After all, different travel patterns still exist within otherwise socio-economically and socio-demographically homogeneous population groups (van Wee, 2002). This indicates that travel behaviour modelling is not just about measuring objective and structural variables, but that more subjective variables such as personal attitudes, personality traits and lifestyles are involved. Transport behavioural analysts have been aware of this for some time, and many studies discuss the role of attitudes in travel behaviour decisions (e.g., Dobson et al., 1978; Gärling et al., 1998; Gauthier and Shaw, 1986; Golob et al., 1979; Lyon, 1984; Tardiff, 1977; and more recently Parkany et al., 2004, and Thogersen, 2006). However, these studies tend to neglect the link with the built environment. Therefore, the general aim of this paper is to discuss the added value of including subjective variables into the analysis of the relationship between the built environment and modal choice. Moreover, the paper unravels the complex relationships between lifestyles, attitudes, the built environment, car availability and modal choice. Our analysis focuses on the modal choice for several types of leisure trips (active leisure activities such as practicing sports and theatre acting; family visits and fun shopping) because we assume that lifestyles and the built environment have a larger impact on optional or discretionary trips than on routine or recurrent trips (like commuting) (Boarnet and Sarmiento, 1998; Meurs and Haaijer, 2001; Scheiner, 2010a). The analysis is based on the simultaneous estimation of a set of regression equations between observed variables, or what is called a path model (Byrne, 2001; Kline, 2005; Raykov and Marcoulides, 2000).

Only recently, additional subjective variables were introduced in empirical work on the relationship between the built environment and travel behaviour (e.g., Bagley and Mokhtarian, 2002; Kitamura et al., 1997; Scheiner and Holz-Rau, 2007; Schwanen and Mokhtarian, 2005; van Wee et al., 2002) and especially in those studies that question the issue of causation (Handy et al., 2005; Kockelman, 1997; van Wee, 2009). For example, under certain conditions, the built environment seems to influence modal choice, but this finding can mask underlying linkages that are more important. Ultimately, the challenging question is whether modal choice is influenced by the built environment itself or by these underlying linkages for which the built environment is only a proxy. The question of residential self-selection is a clear example (e.g., Bagley and Mokhtarian, 2002; Bhat and Guo, 2007; Cao et al., 2006; Naess, 2009; Pinjari et al., 2007; Walker and Li, 2007). People might select themselves into a residential neighbourhood according to their personal attitudes, preferences and lifestyles. For example, a household with public transport preferences will likely choose a residential neighbourhood with good public transport services so that they are able to travel in accordance with their travel preferences. Consequently, the connection between the built environment and modal choice may be in part a matter of personal attitudes, preferences and lifestyles. Moreover, this suggests that the true influence of the built environment cannot be determined without accounting for the effects of these personal attitudes, preferences and lifestyles. Recently, this framework of residential self-selection has been extended to study social inequality in travel while accounting for differences in lifestyles and attitudes (Hesse and Scheiner, 2009; Ohnmacht, 2009; Scheiner, 2010a)

However, people can self-select themselves in many more ways than with respect to residential choice only. For example, people who like cars and car driving and have a car-oriented lifestyle might almost obviously own a car (or more than one) and use their cars more often than other people with the same income, household structure, etc. but with different travel preferences and lifestyles. According to van Wee (2009) ignoring this type of self-selection might result in an overestimation of the interaction between the built environment and modal choice. Suppose that a new bus service is introduced into an existing neighbourhood that previously lacked good access by public transport. In that case, current models assume that this new bus service will result in an increased public transport use. However, this share of public transport use is likely to be overestimated if little initial preference for public transport existed in that specific neighbourhood. This travel-related type of self-selection is, however, less studied compared to residential self-selection. This paper will therefore consider the importance of attitudes, preferences and lifestyles for residential as well as travel-related self-selection.

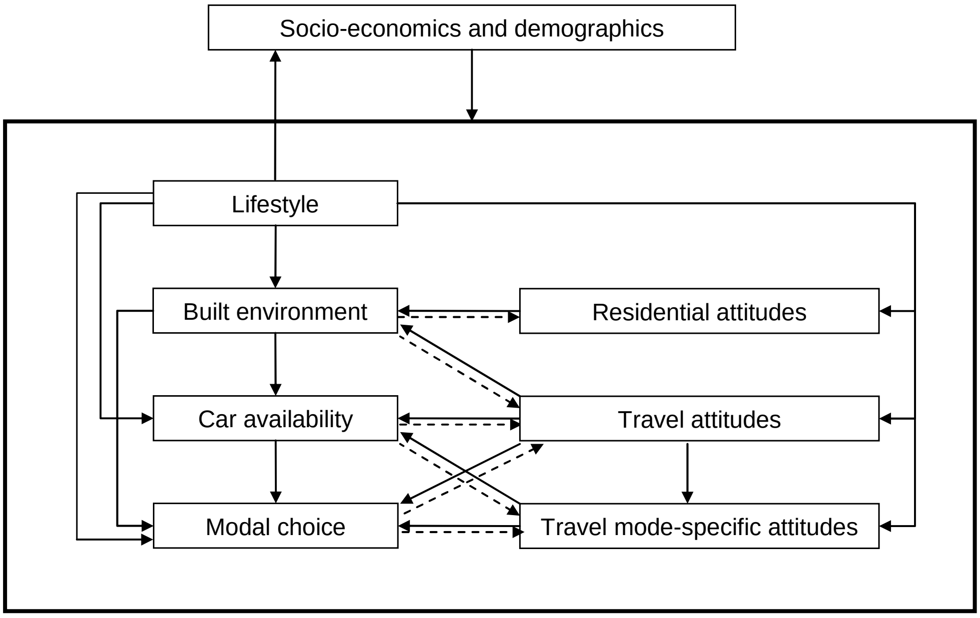

Figure 1. Complex relationships between the built environment and modal choice

Clearly, the relationship between the built environment and modal choice is much more complex than initially assumed. Figure 1 clarifies this complexity and also the model structure that will ultimately be estimated and discussed in this paper. Figure 1 (left-side) considers a hierarchical structure of decisions made by individuals in which higher levels refer to longer-term decisions (Salomon and Ben-Akiva, 1983; Van Acker et al., 2010a). The longest term decision is the choice of a lifestyle, which refers to an individual's way of living and which is influenced by his or her outlook on life and motivations, including beliefs, interests and general attitudes (Bourdieu, 1984; Ganzeboom, 1988; Weber, 1972). Short-term modal choice decisions and medium-term decisions on car availability (e.g., the decision to own one or even several cars) and residential location are made by the individual to satisfy his or her lifestyle decision. This way, lifestyle also influences daily travel behaviour. This decision hierarchy might come across as "physicalist", as considering only the observable behaviours and not the underlying individual's motivations and intentions. Some general motivations and intentions are already included in the decision hierarchy by the lifestyle concept, but these are different from subjective attitudes specifically related to the choices of the residential neighbourhood, owning a car (or more than one) and travel modes (Van Acker et al., 2010a). Therefore, attitudes underlie the decision hierarchy presented in Figure 1 (right-side). Note also that the relationships between attitudes and behaviour (i.e., residential choice, car availability, modal choice) could be bi-directional. Perhaps the most commonly assumed hypothesis is that attitudes cause behaviour. That is, people's decisions (and, thus, behaviour) are based on their attitudes about their available alternatives. But once choices are made and someone gains experience about his/her alternatives, perceptions and attitudes about the alternatives might change (Bohte et al., 2009; Dobson et al., 1978; Lyon, 1984). For example, a positive attitude toward public transport might encourage someone to use public transport for daily travel, but using public transport regularly might also reinforce (or diminish) this positive attitude. This in turn might have repercussions for other earlier decisions. For example, it justifies (or challenges) the decision to not own a car and to reside in a neighbourhood with easy access to public transportation. The current paper attempts to report on these feedback mechanisms.[4]

The relationships depicted in Figure 1 will be estimated in this paper. The paper is, therefore, organized as follows. Section 2 introduces the data. We conducted an Internet survey between May and October 2007 since information on personal lifestyles and attitudes is generally not included in traditional travel surveys or diaries. This paper is part of a series of studies based on this Internet survey. Van Acker et al. (2009) focussed on the measurement of lifestyles, which are subjective variables at the level of the longest-term decisions in our model (see Figure 1), and a subsequent paper (Van Acker et al., 2010b) discussed the specification of residential and travel attitudes underlying decisions on residential location and car availability. The current paper specifically assesses the added value of these subjective variables in explaining modal choices. We expand our analyses by including subjective variables at other levels of our model, such as residential and travel attitudes as well. The third section discusses the methodology. We use path models which can simultaneously handle complex relationships among observed variables. Results are presented and discussed in Section 4. Finally, in Section 5, our most important conclusions for future research and policy-making are summarized.

2. Data and measurement of key variables

2.1 Description of the sample

For practical reasons, the Internet survey was initially made known to students and staff members of the University of Antwerp and the Faculty of Sciences at Ghent University (May 2007-October 2007). Since this resulted in an overrepresentation of highly-educated respondents concentrated in the cities of Antwerp and Ghent (Flanders, Belgium), a second announcement was published in regional information magazines of several villages in the larger urban region of Ghent (Destelbergen, Gent, Lochristi, Merelbeke and Oosterzele). In total, 2,363 persons completed the survey, of which (after data cleaning) 1,878 were retained for further analyses. Figure 2 illustrates the residential locations of these respondents. At the end of the Internet survey, we asked respondents to fill out their street address and ZIP-code so that we geocode their residential location in ArcGIS 9.2 and add objectively measured spatial characteristics of their residential neighbourhood (see section 2.3). We did not ask for house numbers so that we must be aware that the geocoded locations might not always be the accurate ones. However, precisely because we did not ask for house numbers, almost 80% (1,878/2,363) of the respondents were willing to provide us with the necessary information to geocode the home address.

[4] The feedback mechanisms between attitudes and behaviour will be modelled in this paper. However, the feedback loops between behaviours at various time-scales are not considered due to issues such as model complexity and identification. Consequently, this second type of feedback mechanism is not indicated in Figure 1.

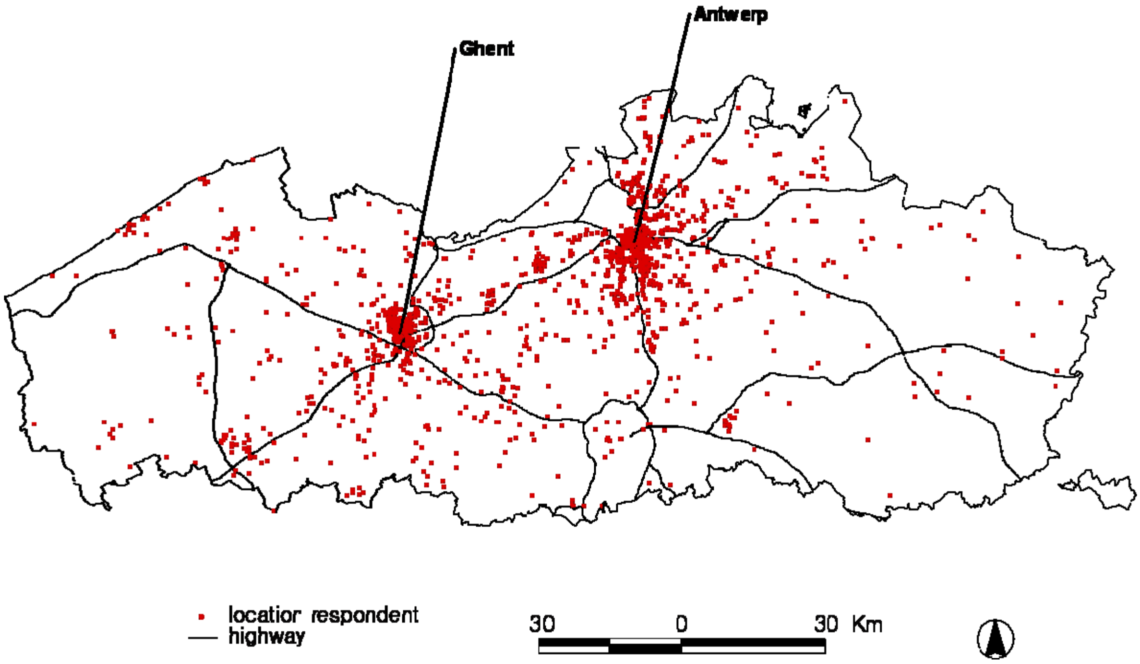

Figure 2. Locations of respondents in Flanders

Table 1. Socio-economic and socio-demographic characteristics of the respondents

	Sample (survey)		Reference (Flanders)	
Gender, female	58.7%		51.1%	
Marital status				
single	23.6%		37.7%	
married/cohabiting	74.5%		62.3%	
Education				
primary school	0.2%		20.7%	
secondary school, 3 years	1.5%		21.6%	
secondary school, 6 years	32.4%		33.4%	
college, university	66.0%		24.7%	
Employment, full-time	82.4%		76.3%	
Monthly household income				
	0-749 €	9.6%	0-833 €	19.1%
	750-1,499 €	6.7%	834-1,666 €	32.1%
	1,500-2,249 €	14.2%	1,667-2,500 €	21.2%
	2,250-2,999 €	18.6%	2,501-3,333 €	10.4%
	3,000-3,749 €	24.8%	3,334-4,166 €	6.6%
	3,750-4,499 €	13.2%	+ 4,167 €	10.5%
	4,500-5,249 €	6.2%		
	5,250-5,999 €	3.8%		
	+ 6,000 €	2.9%		
Possession driving licence	81.5%		81.0%	
Average age	30.6 years		40.8 years	
Average car ownership	1.4 cars/household		1.2 cars/household	

These efforts to balance the sample were only partially effective, as can be seen in Table 1. Women, married couples, people with full-time employment and younger people are overrepresented. But the most remarkable difference is in education. Highly-educated respondents are heavily overrepresented in the sample: 66% have a college or university degree, which is considerably higher than the average of 25% for Flanders. This is mainly due to the sampling procedure. Respondents were not recruited by a random procedure, but (partly) by public announcement which allows for even more sampling bias in the data than usual. Although the sample is not representative of the entire population of Flanders, we feel that this does not devalue it for our research purposes and results. Groves (1989) presents an extended discussion of the differences between collecting data for descriptive purposes as opposed to modelling purposes (such as our analysis); one such difference is the importance placed on representativeness of the sample. Our purpose is to model relationships among lifestyles, attitudes, the built environment, car availability and modal choices, and not to ascertain the univariate distributions of these variables in isolation from one other and to aggregate or extrapolate these variables to a higher level (e.g., Flanders) for which a representative or properly weighted sample would be essential. By this we mean that our analysis can still properly capture, for example, the conditional influence of having a given level of education on modal choice, even if the proportion of people having that amount of education differs between our sample and the population (Babbie, 2010). Even more important, the sample also permits demonstration of our premise that, conditional on a given level of education, subjective variables such as personal attitudes, preferences and lifestyles can still explain a significant additional amount of variance in modal choices.

2.2 Subjective variables

The Internet survey included many questions on lifestyle orientation, attitudes toward the residential neighbourhood and attitudes toward mobility in general and various travel modes in particular. These questions are inspired by similar surveys on lifestyles, attitudes and mobility (e.g., for the Netherlands: Bohte et al., 2008; and for the USA: Bagley and Mokhtarian, 1999). We used separate factor analyses to reveal the data structure and to reduce the many observed variables into a smaller number of underlying factors. The scores on these factors will then be used as input for the path models which estimate the relationships between modal choice, the subjective and the objective variables. Some variables are in fact binary. Although the procedure is generally performed on continuous (or at least ordinal) variables, Rummel (1970) points out that any data whatsoever can be factor analyzed. However, factor-analyzing binary variables must be done with caution. Therefore, we checked the distributions of all binary variables and excluded those variables with too large (or too small) a proportion of responses in any category.

Lifestyles

Lifestyles refer to the individual's opinions and motivations, or orientations toward general themes such as leisure, family and work (Salomon and Ben-Akiva, 1983; Bootsma et al., 1993; or for a more comprehensive review see Kitamura, 2009). It describes the individual in a more comprehensive context than commonly-used descriptors such as income, age and family structure. Using this definition of lifestyle, the Internet survey included among other variables a list of more than 100 types of holiday aspects, literary interests and leisure activities. For example, respondents had to mark how they spent their holidays (e.g., cultural activities, sports, or just relaxing), on what subjects they had recently read (e.g., newspaper, novels) and how they spent their weekends (e.g., visiting family and friends, practicing sports, or simply staying at home). These questions actually refer to aspects of lifestyle expressions (behaviours) instead of the underlying orientations. Nevertheless, these orientations are internal to the individual and hard to observe by an outsider. Therefore, we used these lifestyle expressions as indicators of the underlying lifestyles. For convenience, we will refer to our measures as "lifestyles" in the remainder of this paper. In Van Acker et al. (2009) the concept of lifestyles and the estimation of the lifestyle factors are explained into full detail, and a more brief description is provided in Appendix 1. It was found that five lifestyles could be defined: i.e., culture lover, friends and trends, low-budget and active/creative, home-oriented but active family, and home-oriented traditional family.

Residential attitudes

The Internet survey contained 16 statements on attitudes toward residential locations. Respondents were asked to indicate on a five-point Likert scale ranging from "unimportant" to "very important" which aspects influence their residential location choice. These 16 variables were then factor-analyzed into five underlying dimensions (see Appendix 1): open space and quietness, car alternatives, accessibility, safety and neatness, and social contact. Van Acker et al. (2010b) report the estimation of these residential attitudes in more detail.

Travel attitudes

The Internet survey included 13 statements related to travel in general as well as 12 statements related to travel modes specifically (car, public transport, cycling/walking). Factor analyses resulted in three general travel attitudes (frustrated traveller, pro-environment and reduced-driving social expectations), and two mode-specific attitudes for each mode (comfort, and the repercussions for the environment and an individual's image or health) (see Appendix 1). Related to public transport, we found a third attitude referring to time-saving. This aspect did not emerge as a separate dimension for cars or cycling and walking, but in those cases was included in the comfort factor. More information on these travel attitudes is presented in Van Acker et al. (2010b).

2.3 Other (objective) variables

The Internet survey also gave information on various objective variables. The survey included a section on socio-economic and demographic characteristics of the respondents and their households. We also geocoded the respondent's address in ArcGIS 9.2 in order to add spatial information from various land use and transportation databases. Since this paper emphasizes the added value of subjective variables, we only present a brief description of these other objective variables. More information can be found in Van Acker and Witlox (2010a, b).

Stage of life

Socio-economic and socio-demographic variables might be correlated with each other, and factor analysis could provide interesting new factors. We expected to obtain one factor referring to social status (related to education, employment status and household income) and one factor referring to stage of life (related to age, marital status and household composition). Instead, we extracted three factors, all referring to stage of life (principal axis factoring, promax rotation, 59.5% variance explained, see Appendix 1): students living at home, older family with employed adults, and a young family. However, this is not surprising since our sample consists of a large group of students in higher education (42.7%) and another large group of highly-educated workers (46.5%). The high share of students living at home (36.0% of all respondents) has important consequences for studying residential self-selection since the residential choice is normally made by the parents (and not by these students themselves). We should keep this in mind when discussing the results.

The built environment

Spatial characteristics of the respondent's residential neighbourhood include density measures (population density, job density, built-up density), diversity measures (jobs-housing balance, land use mix) and accessibility measures (potential accessibility by car on several time scales ranging from 5 minutes to 60 minutes)[5]. We are aware that not all of these built environment

[5] Potential accessibility by car is defined as the number of people that can be reached within a specific time. It is basically the sum of the number of people in every census tract in the region, weighted by the travel time from

variables are leisure-oriented, but data on leisure facilities are not easily available. Furthermore, the selected spatial characteristics are easy to calculate based on the available data in Flanders (Belgium) and, moreover, can be used as proxies to detect differences in residential neighbourhood types. Design aspects could not be included in the analysis due to a lack of suitable data. However, density, diversity and accessibility are often related to each other (Cervero and Kockelman, 1997). For example, city centres are generally characterized by high densities and high diversity as well as high levels of accessibility to several opportunities within a short time span. A factor analysis (principal axis factoring, promax rotation, 73.6% variance explained) revealed five factors: location in relation to a local centre, location in relation to a regional centre, local accessibility, regional accessibility, and density.

Car availability

Figure 1 identifies car availability as one of the long-term decisions influencing daily travel behaviour. Our Internet survey provided information on not only car ownership and possession of a driving license - two traditionally-used variables in travel behaviour research - but also on the possession of a public transport pass and the temporary availability of a car. Since all four variables are related to each other, we again performed a factor analysis (principal axis factoring, 31.4% variance explained) in order to construct one general factor related to car availability. This factor is characterized by (factor loadings in parentheses): permanent car availability (0.940), possession of a driving license (0.385), number of cars in the household (0.381), and possession of a public transport pass (-0.278).

Modal choice

Modal choice is the final outcome variable in our structural equation models. In our Internet survey, respondents had to report what kind of leisure trips they perform on a monthly basis and which travel modes they generally use for this (respondents could indicate more than one travel mode). For each leisure motive (active leisure activities, family visits and fun shopping) we performed three analyses of modal choice (one for car use, one for public transportation and one for cycling/walking). In each of these structural equation models, modal choice is a binary variable.

3. Methods and modelling characteristics

The complex relationships, as depicted in Figure 1, between modal choice and various subjective and objective variables can be formalized as a series of regression equations. We use path models to simultaneously estimate these equations. Path models are a specific case of structural equation models (SEM). SEM can be considered as a combination of factor analysis and regression analysis. The factor analysis aspect in a SEM refers to the modelling of indirectly observed (or latent) variables whose values are based on underlying manifest variables (or indicators) which are believed to represent the latent variable. This measurement model, as it is called, therefore defines the relationships between a latent variable and its indicators. All previously discussed factor analyses are in fact measurement models, and the factors could be considered latent variables within a SEM. However, the complexity of the factor analyses, and especially those related to lifestyles, indicated that it would be too cumbersome to embed all submodels into the

the residence to these census tracts. We calculated potential accessibility with time restricted to 5, 15, 30, 45 and 60 minutes in order to detect differences between local and regional accessibility. Travel time is calculated in ArcGIS 9.2 as the fastest path by car along the road network. We are aware that accessibility is more than just having access to people. Access to facilities such as leisure activities would be important in our analysis that focuses on leisure trips. However, data on leisure facilities is not easily available. Consequently, we limit our accessibility measure to having access to people and use this measure as a proxy for accessibility in general.

structural model and estimate all parameters simultaneously. Thus, to reduce the dimensionality of the models, we decided to conduct separate factor analyses and incorporate these factor scores into the models as manifest variables. By doing so, we forced error correlations/covariances out of the model resulting in improved model fit. However, the decision to incorporate observed factor scores instead of latent variables is based on the reduction of the dimensionality of the models and not on the improvement of model fit. Since we consider all variables, even factor scores, to be observed (or manifest) variables, our analysis is solely based on the regression analysis aspect of SEM. A SEM with only observed variables is called a path model. Consequently, for convenience, we will generically refer to "path model" instead of the general term "structural equation model".

In such an approach, a variable can be an explanatory variable in one equation (e.g., car availability influencing modal choice) but an outcome variable in another equation (e.g., car availability influenced by the built environment). Therefore, the concepts 'endogenous' and 'exogenous' variables are used (Byrne, 2001; Kline, 2005; Raykov and Marcoulides, 2000). Exogenous variables are not influenced by any other variable in the model, but instead they influence other variables. Endogenous variables are influenced by exogenous variables, either directly or indirectly through other endogenous variables. The relationships between exogenous and endogenous variables are represented by the structural model and are defined by the matrices (Hayduk, 1987; Oud and Folmer, 2008; Van Acker et al., 2007):

$$\eta = B\,\eta + \Gamma\,\xi + \zeta$$

where η = L x 1 matrix of endogenous variables, ξ = K x 1 matrix of exogenous variables, B = L x L matrix of coefficients of the endogenous variables, Γ = K x K matrix of coefficients of the exogenous variables, and ζ = L x 1 matrix of residuals of the endogenous variables.

Path models are estimated by finding the coefficients that best match the resulting model-implied covariance matrix to the empirically-based covariance matrix for the data. As in other statistical techniques, a standard estimation technique is maximum likelihood (ML), which assumes a multivariate normal distribution of all endogenous variables in the model (Bentler and Dudgeon, 1996; Kline, 2005). However, our final outcome variable, modal choice, is binary and, thus, not normally distributed. We used the software package M-plus 4.21 because of its ability to model categorical endogenous variables. By default, M-plus then uses an alternative estimator: a mean- and variance-adjusted weighted least squares parameter estimator (WLSMV) which we used instead of ML. The parameters θ of the structural model are estimed by minimizing the objective function (Asparouhov, 2005):

$$\mathrm{F}(\theta) = \sum \left(\sigma(\theta) - \hat{\sigma}\right) W^{-1} \left(\sigma(\theta) - \hat{\sigma}\right)'$$

where W is a diagonal weight matrix with its diagonal elements equal to the estimated variances of σ (Finney and DiStefano, 2006). WLSMV is an estimator generating robust standard errors that does not require extensive computations or enormous sample sizes. In addition to robust estimation, a robust mean-adjusted and mean- and variance-adjusted chi-square test statistic can be produced (Muthén, 1983; Satorra, 1992; Yu and Bentler, 2000).

In order to keep the number of equations in the model to a manageable size, we conducted the modelling process in two steps (see Figure 3). Van Acker et al. (2010b) discuss the results of the first modelling step, in which relationships among lifestyles, attitudes, the built environment and car availability are estimated. These long-term decisions do not depend on the motives for daily travel. For example, the influence of the built environment on car availability is presumably not different for commuting or leisure trips. The results of this first modelling step showed that, while controlling for lifestyles and attitudes, the built environment still has the expected influence on car availability. Car availability tends to be lower in dense neighbourhoods with good local accessibility and that are closely located to a regional centre. However, the effects are small compared to the influence of other variables, especially stage of life and travel (mode) attitudes. Coefficients from this first modelling step are then used as if they were "true" in the second modelling step in which modal choice is explained for several leisure motives. That is, we actually replaced the observed explanatory variables in the second step with their "predicted values" obtained from the first-step model, which considerably facilitated model estimation. Doing so, we estimated the effects of lifestyles, attitudes, the built environment and car availability on modal choice. Note that this two-step estimation procedure where only "limited information" is used in each step gives estimators that are consistent but not efficient. Since the estimates from the first step are taken as "true" in the next step, the reported standard errors of the second-step estimators are not exactly correct. Therefore, we used a stricter standard for hypothesis testing on the second-step model (significant at α = 0.05) than on the first-step model (significant at α = 0.10).

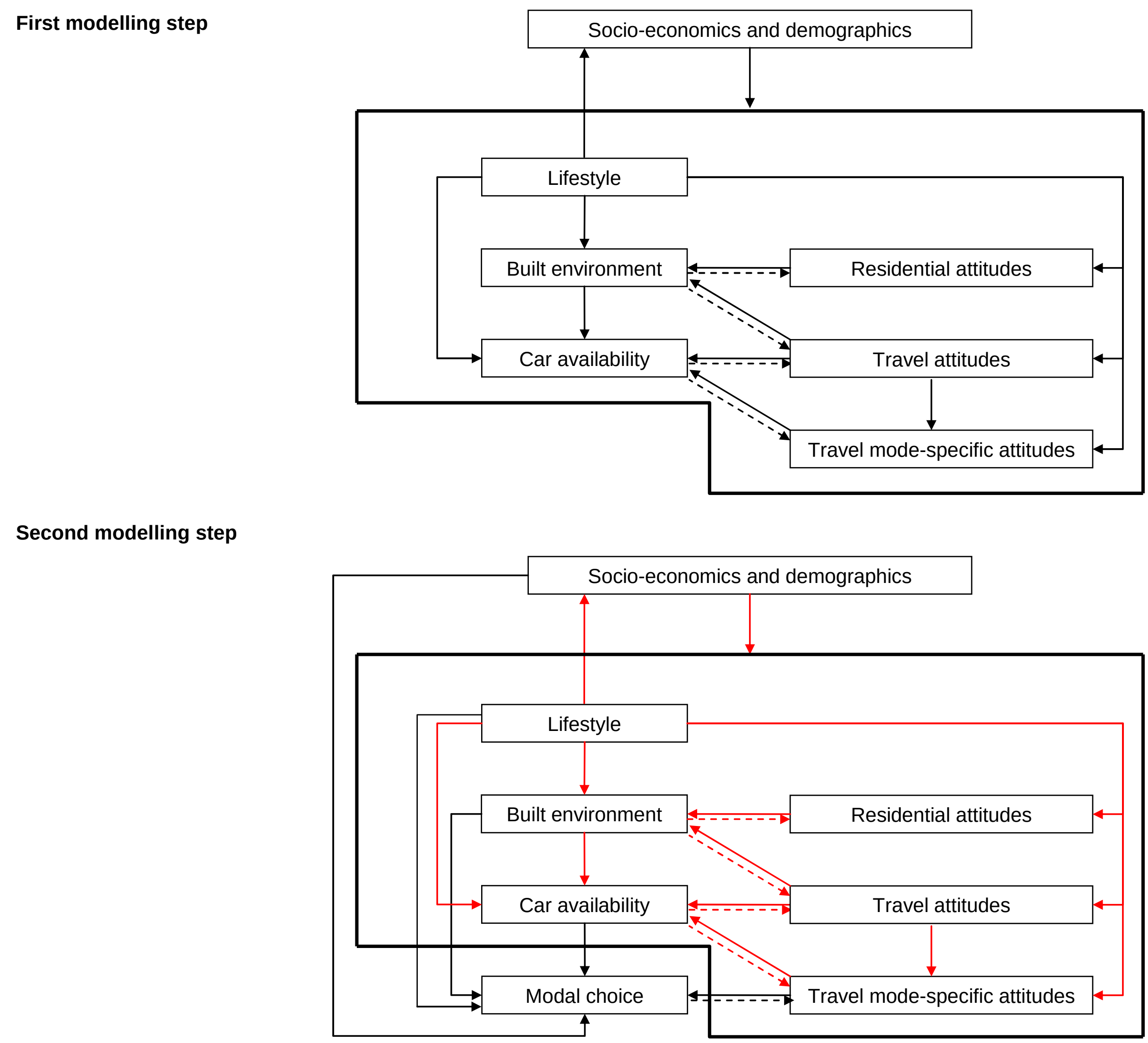

Figure 3. Two-step estimation procedure

Another model specification issue is the effect of outliers. Outliers are commonly detected by calculating the Mahalanobis distance and the loglikelihood for each observation. The Mahalanobis distance requires continuous endogenous variables and the loglikelihood assumes ML-estimators, two assumptions that are not fulfilled in our model. However, M-plus also calculates Cook's D (Cook, 1977, 1979) and a loglikelihood distance influence measure adjusted for weighted least squares estimators (Cook and Weisberg, 1982) for each observation. By plotting these outlier scores against the scores for modal choice, we were able to detect outliers for each model presented in Section 4. Removing the outliers led to changes in the overall model fit and individual parameter estimates, but the effects were only minimal. The overall model fit did not change considerably in any of the models and only a limited number of individual parameter estimates became insignificant. However, by removing outliers the means and variances of all variables in the reduced samples were different from the ones in the original sample. Outliers generally correspond to respondents with a pronounced lifestyle or to respondents living in a residential neighbourhood with, for this analysis, interesting spatial traits (especially neighbourhoods with good local accessibility and neighbourhoods distant from a regional city centre). Those outliers are interesting for our analysis. After all, we want to estimate the influence of lifestyles and the built environment on modal choices. Consequently, we decided to retain all outliers and model results in Section 4 are based on the full dataset.

Finally, the quality of the model specifications has to be assessed before the model results can be interpreted. Most software packages report a large variety of model fit indices. The χ^2-statistic is a commonly used model fit index which measures the discrepancy between the empirically-based and the model-based covariance matrices. However, χ^2 values increase with sample size and, thus, models based on large sample sizes might be rejected based on their χ^2 value even though only small differences exist between the empirically-based and model-based covariance matrices. The standard χ^2-statistic is, therefore, transformed into a dozen alternative model fit indices. Studies such as Bollen (1989), Hu and Bentler (1999) and Kline (2005) suggest cut-off values for these model fit indices: $\chi^2/df < 2.0$, CFI and TLI > 0.95, RMSEA < 0.05 and WRMR < 1.00 for adequate model fit. Yu (2002) confirmed these cut-off values for models with categorical outcomes. In correspondence with these various scholars, Table 2 reports model fit indices from several different index families (i.e., indices of comparative fit to a baseline model, error-of-approximation-based indices, and residual-based indices). According to most indices, model fit is generally less than adequate but still acceptable.

Table 2: Model fit

	Chi² (df) p	Chi² / df	CFI	TLI	RMSEA	WRMR
Desired values	p > 0.05	< 2	> 0.95	> 0.95	< 0.05	< 1.00
car use for AL	184.63 (142) 0.01	1.30	0.96	0.96	0.02	1.02
car use for FV	243.66 (151) 0.00	1.61	0.94	0.94	0.03	1.12
car use for FS	190.66 (128) 0.00	1.49	0.92	0.93	0.03	1.09
public transport for AL	187.55 (146) 0.01	1.28	0.95	0.96	0.02	1.02
public transport for FV	229.13 (148) 0.00	1.55	0.94	0.94	0.03	1.11
public transport for FS	188.18 (126) 0.00	1.49	0.92	0.92	0.03	1.10
cycling/walking for AL	190.25 (146) 0.01	1.30	0.95	0.95	0.02	1.02
cycling/walking for FV	237.54 (153) 0.00	1.55	0.94	0.94	0.03	1.12
cycling/walking for FS	191.93 (130) 0.0	1.48	0.92	0.93	0.03	1.08

Note: AL = active leisure activities, FV = family visits, FS = fun shopping

4. Results

Having specified the measurement of the key variables and some important model specification issues, we now turn our attention to the model results. Table 3 summarizes the results of the second modelling step and illustrates the influences of objective and subjective variables on car use, public transport use, and cycling and walking, respectively, for active leisure activities, family visits and fun shopping. The explained variance values for each model are quite large for models on disaggregate data. This suggests that the hypothesized models account for a significant amount of variation in modal choice for leisure trips, especially for car use for fun shopping (R^2 = 80.5%).

For each travel mode, the influences of objective and subjective variables tend to be similar for active leisure activities and family visits as well as fun shopping. Moreover, the modelling results for public transport use generally resemble the results for cycling and walking, but are opposite to those for car use. Or in other words, if a variable has a positive effect on car use, it generally has a negative effect on public transport use and cycling and walking. Unlike the findings of other studies (e.g., Scheiner and Holz-Rau, 2007), this suggests a dichotomy in modal choice between cars and car alternatives rather than between motorised and non-motorised transport or between public and individual transport. Note however that the sizes of the coefficients differ in some cases between the results for public transport use and cycling and walking. For example, the built environment has a strong effect on cycling and walking for active leisure activities and fun shopping but not for family visits. The opposite is true for public transport use.

4.1 The causal influence of the built environment on modal choices for leisure trips

The built environment has the expected influence on modal choice. High densities, good accessibility and a short distance between the residence and the city or town centre seem to discourage car use and to encourage public transport as well as cycling and walking. Based on the standardized total effects, the built environment seems to considerably influence modal choices but especially the decision to drive by car for leisure trips, to use public transport for family visits, and to cycle or walk for active leisure activities and for fun shopping. This suggests that spatial planning policies encouraging further densification, developing residential quarters near town or city centres, and providing facilities such as shops and leisure activities within the residential neighbourhood might have the desired effect on modal choices.

However, the question remains whether it is really the built environment itself that influences modal choices more than, or as much as, the underlying residential attitudes and preferences in the first place. Table 3 illustrates that residential and travel attitudes fundamental to the residential location choices have small but significant indirect effects on modal choices (for more details, see Van Acker et al., 2010b). Residential attitudes such as "safety and neatness" and "social context" have insignificant effects on modal choices in all models and are, therefore, omitted from Table 3. Car use is positively associated with the importance of open space and quietness (typically for suburban and rural residents with high levels of car availability, e.g., the standardized direct effect of the "open space and quietness" preference on "density" is -0.629), and negatively associated with the importance of having access to locations such as workplaces and shops (typically for urban residents with low levels of car availability, e.g., the standardized direct effect of the "accessibility" preference on "density" is 0.171). The opposite is true for public transport use, and cycling and walking. This finding indicates that residential self-selection occurs to some extent. This is also supported by the influence of lifestyles on modal choice. Table 3 indicates that lifestyles exhibit a consistent influence on modal choice for leisure trips. For all leisure activity types, non-traditional (i.e., culture lover) and low-budget (i.e., low-budget and active) lifestyles seem to be associated with less car use, and more public transport use and especially more cycling and walking. The opposite is true for family-oriented (i.e., active family, traditional family) and active (i.e., friends and trends, active family) lifestyles. The interrelations between lifestyles and modal choice are not always that strong. It depends on which travel mode and which leisure activity type is considered. For example, a traditional-family lifestyle is likely to have a strong direct (positive) effect on car use for family visits, whereas a low-budget-and-active/creative lifestyle tends to strongly (positively) influence cycling and walking for active leisure activities. It is no surprise that these two lifestyles have an important effect on these leisure trips in particular. After all, these leisure trips (family visits, and active leisure activities) are an essential part of the lifestyles concerned (traditional family, and low-budget and active/creative respectively). However, because of the interaction with among others the built environment, the influence of lifestyles is in many cases mainly indirect. Van Acker et al. (2010b) pointed out that non-traditional lifestyles such as culture lovers might prefer to reside in an urban neighbourhood (i.e., standardized effect of "culture lover" on "density" is 0.123), whereas active lifestyles tend to reside in suburban or rural neighbourhoods (i.e., standardized direct effect of "home-oriented but active family" on local accessibility is -0.062). Consequently, the supposed influence of the built environment on modal choice is partly explained by residential preferences of particular lifestyles.

Note also that many of the total effects of the built environment characteristics on modal choice are smaller than their direct effects, indicating opposite direct and indirect effects. This is mainly due to the feedback mechanisms between the built environment characteristics and the underlying residential attitudes. For example, Table 3 illustrates that high densities directly discourage car use for various leisure trips (e.g., β = -0.289 for active leisure activities). But we also found that residents of a high density neighbourhood dislike these high densities and tend to prefer "open space and quietness" (i.e., the standardized direct effect of "density" on "open space and quietness" is 0.815) which in turn might affect the residential choice again (i.e., the standardized direct effect of "open space and quietness" on "density" is -0.629). This interaction via residential attitudes finally results in a positive indirect effect of density, opposite to its negative direct effect on car use.

4.2 Other important influences on modal choice for leisure trips

Modal choices seem to be mainly influenced by car availability. High levels of car availability are associated with more car use, less public transport use, and less cycling and walking. In other words, car use tends to be higher for respondents who have several cars, who possess a driving license (and not a public transport pass) and/or who have cars permanently available. Our results suggest that car availability has a strong effect on car use and public transport use, but a less strong effect on cycling and walking (probably reflecting that those modes are often adjuncts or supplements to driving, not just substitutes for it). Other variables have a comparable effect or even a more pronounced effect on cycling and walking for leisure trips, especially the built environment for fun shopping.

Again, the causal relation between car availability and modal choice can be questioned. Car availability generally has a strong direct effect on modal choice. Nevertheless, general travel attitudes and specific travel mode attitudes underlie the decision to own a car. Note that this does not mean that car availability itself has no important influence on modal choice. On the contrary, the magnitudes of the standardized direct effects of car availability reported in Table 3 point out that car availability is one of the most important influences on modal choices. However, we argue that for at least some people the decision to own a car is largely influenced by their overall (dis)liking for travelling by car in the first place. Ignoring the interaction between car availability and travel attitudes might result in a misspecification of the effect of car availability on modal choice. Van Acker et al. (2010b) found that a pro-environment travel attitude has an important negative direct influence on car availability (standardized direct effect = -0.156), whereas car availability was found positively associated with the perception of a car as a comfortable transport mode (standardized direct effect = 0.138). Table 3 indicates an important indirect effect of these travel (mode) attitudes on modal choices for leisure trips, indicating that travel-related self-selection occurs to some extent in addition to the direct effect of car availability on modal choices. Respondents with a pro-environment attitude are more likely than their less supportive counterparts to use public transport and to cycle and walk, and less likely to drive their cars, and our results also indicate that perceiving driving a car as comfortable is associated with more car use and less use of car alternatives. This seems to confirm the dichotomy between cars and car alternatives. Other travel (mode) attitudes only have a small effect on modal choice. A frustrated travel attitude is associated with more car use. This indicates that frustrated travellers, who do not enjoy being on the road, tend to use travel modes that might be perceived as more private than public transport or faster than cycling and walking. Respondents whose family and friends thought they should use non-auto modes more and drive as little as possible tend to currently use their cars more often than others, which possibly refers to the existence of habits in modal choices. Interesting to note is that public transport as well as cycling and walking are not significantly influenced by travel mode attitudes specifically toward public transport (respectively cycling and walking), but only by the specific attitude of cars as comfortable transport modes. It indicates that car attitudes not only explain car use, but also dominate the decision of using car alternatives. Other travel mode-specific attitudes such as "public transport is comfortable" have been omitted from Table 3 because of their insignificant effects on modal choices for all types of leisure trips.

Furthermore, our results suggest that stage of life and gender influence modal choice for leisure trips, but mainly indirectly. Students living at home are likely to use travel modes other than cars. They are more likely than others to use public transport for active leisure activities and fun shopping, and to cycle and walk more often for family visits. Contrary to students, young and older families seem to prefer their car for all types of leisure trips. A remarkable difference in modal choice can be noticed between women and men. Women are significantly less likely than men to cycle or walk for leisure, whereas the opposite holds for car use for active leisure activities and family visits, and for public transport for fun shopping. However, the relationship between gender and modal choice is negligible compared to other objective and subjective variables (except for public transport for fun shopping).

4.3 Attitudes and behaviour

We also simultaneously estimated reverse relationships, to test whether travel attitudes are influenced by modal choices (see Table 4). The effect of modal choices on travel (mode) attitudes is generally small and, moreover, the use of public transport does not seem to significantly influence travel-related attitudes. However, car use and cycling and walking do have a significant direct effect on some particular travel (mode) attitudes which is even more important than the reverse effect. We found that a pro-environment attitude is significantly influenced by modal choices. Cycling and walking encourages a pro-environment attitude, whereas a pro-environment attitude is reduced by car use. Initial car use also encourages frequent car use, especially for family visits, whereas cycling and walking prevent frequent car use (according to family and friends). Furthermore, using cars seems to result in a positive perception of the car as a comfortable transport mode, whereas the opposite holds for cycling and walking.

Table 3. Standardized direct and total effects on modal choice for different leisure trips

	Car use			Public transport			Cycling and walking		
	AL N = 633 (53.7% no, 46.3% yes)	FV N = 903 (25.2% no, 74.8% yes)	FS N = 577 (46.8% no, 53.2% yes)	AL N = 633 (90.4% no, 9.6% yes)	FV N = 903 (87.4% no, 12.6% yes)	FS N = 577 (62.0% no, 38.0% yes)	AL N = 633 (37.3% no, 62.7% yes)	FV N = 903 (68.5% no, 31.5% yes)	FS N = 577 (56.0% no, 44.0% yes)
SED characteristics									
student living at home	-0.031	0.005	0.019	0.133*	-0.043	0.416*	0.029	0.241*	-0.130*
	-	-	-	-	-	_0.242*_	-	_0.189*_	-
older family, working	0.235*	0.125*	0.228**	-0.213*	-0.184*	-0.293*	-0.144*	-0.109*	-0.044
	-	-	-	-	-	-	-	-	-
young family	0.222*	0.103*	0.137*	-0.081*	-0.123*	-0.110*	-0.101*	-0.061*	-0.071*
	-	-	-	-	-	-	-	-	-
Gender (female)	0.046*	0.090*	0.006	-0.005*		0.259*	-0.051*	-0.060*	-0.024
	-	-	-	-	-	_0.274*_	-	-	-
Lifestyles									
culture lover	-0.136*	-0.014	-0.069*	-0.004*	0.072*	-0.013*	0.032*	0.006	0.078*
	_-0.142*_	-	-	-	-	-	-	-	-
friends & trends	0.025*	-0.004	-0.008	-0.011*	0.008**	-0.008*	-0.012*	-0.161*	-0.137*
	-	-	-	-	-	-	-	_-0.153*_	_-0.137*_
home-oriented but active family	0.068*	0.058*	0.114*	-0.013*	-0.112*	-0.034*	-0.040*	-0.018*	-0.080*
	-	-	-	-	-	-	-	-	-
low-budget & active/creative	0.001	-0.144*	0.016*	0.004*	-0.018*	0.006*	0.137*	0.169*	0.108*
	-	_-0.150*_	-	-	-	-	_0.131*_	_0.166*_	0.124*
home-oriented traditional family	0.157*	0.096*	-0.047*	0.001*	0.058*	-0.008*	-0.019	-0.020**	0.061*
	_0.207*_	_0.139*_	-	-	-	-	-	-	-
Built environment									
location relative to local centre	0.229*	0.087	0.449*	0.006*	-0.239*	0.019*	-0.153*	0.003*	-0.437*
	_0.276*_	_0.129*_	_0.523*_	-	_-0.330*_	-	_-0.168*_	-	_-0.494*_
location relative to regional centre	0.383*	0.199*	0.439*	-0.045*	-0.454*	-0.044*	-0.232*	-0.021*	-0.516*
	_0.376*_	_0.228*_	_0.488*_	-	_-0.526*_	-	_-0.218*_	-	_-0.573*_
local accessibility	-0.247*	-0.131**	-0.323*	0.048*	0.331*	0.223*	0.006	0.023*	0.184*
	_-0.257*_	_-0.177*_	_-0.410*_	-	_0.436*_	_0.192*_	-	-	_0.255*_
regional accessibility	-0.148*	-0.107*	-0.297*	0.000*	0.222*	0.152*	-0.001**	0.000*	-0.002*
	_-0.192*_	_-0.138*_	_-0.370*_	-	_0.292*_	_0.197*_	-	-	-

Note: direct effects shown in italics, - = direct effect estimated but found insignificant and therefore constrained to zero, * significant at $\alpha = 0.01$, ** significant at $\alpha = 0.05$

AL = active leisure activities, FV = family visits, FS = fun shopping

Continued Table 3. Standardized direct and total effects on modal choice for different leisure trips

	Car use			Public transport			Cycling and walking		
	AL N = 633 (53.7% no, 46.3% yes)	FV N = 903 (25.2% no, 74.8% yes)	FS N = 577 (46.8% no, 53.2% yes)	AL N = 633 (90.4% no, 9.6% yes)	FV N = 903 (87.4% no, 12.6% yes)	FS N = 577 (62.0% no, 38.0% yes)	AL N = 633 (37.3% no, 62.7% yes)	FV N = 903 (68.5% no, 31.5% yes)	FS N = 577 (56.0% no, 44.0% yes)
Built environment									
density	-0.229* _-0.289*_	_-0.219*_ _-0.313*_	-0.457* _-0.635*_	0.036* -	0.448* _0.656*_	0.035* -	0.129* _0.155*_	0.017* -	0.421* _0.605*_
Residential attitudes									
car alternatives	0.060* -	0.042* -	0.114* -	0.000* -	-0.088* -	-0.058* -	0.000** -	0.000* -	0.001* -
open space and quietness	0.145* -	0.137* -	0.285* -	-0.023* -	-0.279* -	-0.022* -	-0.082* -	-0.011* -	-0.263* -
accessibility	-0.025* -	-0.031* -	-0.052* -	0.006* -	0.061* -	0.007* -	0.013** -	0.003* -	0.046* -
Travel attitudes									
frustrated traveller	0.011* -	-	-	-	-	-	-	-	-
pro-environment	-0.223* -	-0.095* -	-0.220* -	0.114* -	0.201* -	0.148* -	0.161* -	0.090* -	0.128* -
reduced-driving social expectations	0.015* -	0.002* -	0.006* -	-0.005* -	-0.005* -	-0.006* -	-0.016* -	-0.009* -	-0.001** -
Travel mode attitudes									
car = comfortable	0.105* -	0.036* -	0.083* -	-0.078* -	-0.073* -	-0.097* -	-0.266* _-0.209*_	-0.152* _-0.116*_	-0.022** -
bike/on foot = positive effects	-0.138* -0.137*	-	-	-	-	-	-	-	-
Car availability	0.624* _0.606*_	0.259* _0.253*_	0.598* _0.567*_	-0.489* _-0.488*_	-0.499* _-0.499*_	-0.555* _-0.555*_	-0.308* _-0.295*_	-0.266* _-0.264*_	-0.164* _-0.160*_
R^2	_62.2%_	_22.3%_	_80.5%_	_23.8%_	_62.3%_	_49.6%_	_29.6%_	_18.3%_	_49.7%_

Note: direct effects shown in italics, - = direct effect estimated but found insignificant and therefore constrained to zero, * significant at α = 0.01, ** significant at α = 0.05

AL = active leisure activities, FV = family visits, FS = fun shopping

Table 4. Standardized direct and total effects on travel (mode) attitudes

	Travel attitudes			Car attitudes		Public transport attitudes			Cycling and walking attitudes	
	Frustrated traveller	Pro-environment	Reduced-driving social expectations	Comfortable	Negative effects	Comfortable	Positive effects	Time-saving	Comfortable	Positive effects
Car use for AL	-0.001* -	 -	0.003* -	0.115* _0.114*_	 -	-0.002* -	-0.002* -	-0.001* -	-0.002* -	-0.001* -
Car use for FV	-0.005* -	-0.158* _-0.154*_	0.135* _0.121*_	0.245* _0.187*_	-0.025* -	-0.006* -	-0.028* -	-0.003* -	-0.013* -	-0.041* -
Car use for FS	-0.005* -	-0.183* _-0.173*_	0.011* -	0.242* _0.178*_	-0.021* -	-0.006* -	-0.031* -	-0.003* -	-0.006* -	-0.038* -
Public transport for FS	 -	 -	 -	 -	 -	0.174* -	 -	 -	 -	 -
Cycling/walking for AL	0.003* -	0.207* _0.200*_	-0.172* _-0.158*_	-0.069* -	0.037* -	0.004* -	0.033* -	0.002* -	0.014* -	0.050* -
Cycling/walking for FS	0.003* -	0.196* _0.191*_	-0.137* _-0.127*_	-0.067* -	0.022* -	0.004* -	0.031* -	0.002* -	0.011* -	0.174* _0.123*_

Note: direct effects shown in italics, - = direct effect estimated but found insignificant and therefore constrained to zero

* significant at α = 0.01, ** significant at α = 0.05

AL = active leisure activities, FV = family visits, FS = fun shopping

4.4 Ignoring subjective variables in travel behaviour research

In this section we assess the consequences of ignoring subjective variables in travel behaviour research by comparing the results of the previously discussed models which included objective as well as subjective variables to the results of models with only objective variables.

Comparing Table 2 with Table 5 illustrates that ignoring subjective variables in travel behaviour research does not result in poor model fit. All our models with only objective variables obtain good model fit. This finding is not that surprising since the more complex the model, the larger the risk of ignoring a certain interrelation between any two variables. In path analysis, therefore, simple models tend to have better fit. However (see Table 6), more interesting is the finding that explained variances of car availability and modal choice for leisure trips tend to be lower for models that do not account for subjective influences (see, e.g., Barrett, 2007; Biddle and Marlin, 1987; and Goffin, 2007 for discussions about goodness of fit versus "predictive ability" or explained variance in path models, including the observation that a model can fit nearly perfectly while explaining very little variance, or not fit well despite explaining a great deal). In other words, it seems that lifestyles, residential attitudes and travel attitudes have an important influence of their own on modal choice for leisure trips.

Furthermore, our findings suggest that ignoring subjective influences results in an *under*estimation of the effects of the built environment on modal choice for leisure trips (compare Table 3 with Tables 6). Spatial characteristics such as location relative to a town or city centre and accessibility have a significant effect, even when subjective influences are accounted for, but this effect diminishes if subjective influences are ignored. This is surprising: within the debate of self-selection, we would expect the opposite. Most studies find a substantially reduced (sometimes insignificant) influence of the built environment after controlling for attitudes and lifestyles, indicating that the spatial influences were entirely due to these underlying attitudes and lifestyles (Cao et al., 2009). However, some studies have found, as our results also indicate, that the impact of the built environment is smaller *without* the inclusion of underlying attitudes and lifestyles than *with* them (Chatman, 2009; Ewing and Cervero, 2010; Lund et al., 2006). Or in other words: we find that the built environment exerts some influence of its own, independently from the individual's preferences to locate in that neighbourhood in the first place. According to our findings, ignoring the effect of subjective influences might also result in a misspecification of the effect of car availability on modal choices.

Table 5. Model fit while ignoring subjective influences

	Chi² (df) p	Chi² / df	CFI	TLI	RMSEA	WRMR
Desired value	p > 0.05	< 2	> 0.95	> 0.95	< 0.05	< 1.00
car use for AL	26.46 (23) 0.28	1.15	0.99	0.99	0.02	0.78
car use for FV	27.28 (23) 0.24	1.19	1.00	0.99	0.01	0.83
car use for FS	27.19 (20) 0.13	1.36	0.99	0.98	0.02	0.84
public transport for AL	28.46 (26) 0.34	1.09	1.00	1.00	0.01	0.82
public transport for FV	26.61 (22) 0.23	1.21	1.00	0.99	0.02	0.82
public transport for FS	26.97 (20) 0.14	1.35	0.99	0.98	0.02	0.84
cycling/walking for AL	28.23 (25) 0.30	1.13	1.00	0.99	0.01	0.81
cycling/walking for FV	30.02 (24) 0.18	1.25	0.99	0.99	0.02	0.87
cycling/walking for FS	27.71 (21) 0.15	1.32	0.99	0.98	0.02	0.85

Note: AL = active leisure activities, FV = family visits, FS = fun shopping

Table 6. Standardized direct and total effects on modal choice for different leisure trips while ignoring subjective influences

	Car use			Public transport			Cycling and walking		
	AL	FV	FS	AL	FV	FS	AL	FV	FS
	N = 684 (53.1% no, 46.9% yes)	N = 969 (24.5% no, 74.6% yes)	N = 617 (46.8% no, 53.2% yes)	N = 684 (90.5% no, 9.5% yes)	N = 969 (87.5% no, 12.5% yes)	N = 617 (61.8% no, 38.2% yes)	N = 684 (37.9% no, 61.2% yes)	N = 969 (68.4% no, 31.6% yes)	N = 617 (56.1% no, 43.9% yes)
SED characteristics									
student living at	-0.002	-0.073*	-0.001	0.107*	-0.180*	0.364*	0.033	0.241*	-0.142*
home	-	-	-	-	_-0.257*_	_0.306*_	-	_0.193*_	-
older family,	0.147*	0.165*	0.156*	-0.187*	-0.200*	-0.325*	-0.207*	-0.087*	0.022
working	-	-	-	-	-	_-0.229*_	_-0.124*_	-	-
young family	0.072*	0.223*	0.077*	-0.069*	-0.219*	-0.169*	-0.031*	-0.036*	-0.013
	-	_0.156*_	-	-	_-0.137*_	_-0.130*_	-	-	-
gender (female)	0.019*	0.003*	-0.160*	-0.003*	-0.004*	0.227*	-0.002*	-0.002*	-0.020*
	-	-	_-0.176*_	-	-	_0.229*_	-	-	-
Built environment									
location relative	0.265*	0.039*	0.372*	-0.044*	-0.047*	-0.025*	-0.020*	-0.020*	-0.397*
to local centre	_0.218*_	-	_0.322*_	-	-	-	-	-	_-0.388*_
location relative	0.444*	0.071*	0.424*	-0.080*	-0.086*	-0.045*	-0.036*	-0.037*	-0.535*
to regional centre	_0.361*_	-	_0.334*_	-	-	-	-	-	_-0.519*_
local accessibility	-0.349*	-0.059*	-0.271*	0.066*	0.072*	0.231*	0.030*	0.031*	0.215*
	_-0.280*_	-	_-0.200*_	-	-	_0.195*_	-	-	_0.202*_
regional	-0.206*	-	-0.250*	-	-	0.148*	-	-	-
accessibility	_-0.206*_		_-0.250*_			_0.148*_			
density	-0.382*	-0.207*	-0.484*	0.086*	0.334*	0.048*	0.145*	0.040*	0.493*
	_-0.293*_	_-0.132*_	_-0.389*_	-	_0.242*_	-	_0.106*_	-	_0.477*_
Car availability	0.471*	0.431*	0.506*	-0.401*	-0.538*	-0.293*	-0.244*	-0.233*	-0.111*
	_0.471*_	_0.431*_	_0.506*_	_-0.401*_	_-0.538*_	_-0.293*_	_-0.244*_	_-0.233*_	_-0.111*_
R^2	_16.7%_	_23.9%_	_48.8%_	_16.1%_	_45.6%_	_30.0%_	_10.4%_	_9.7%_	_29.7%_

Note: direct effects shown in italics, - = direct effect estimated but found insignificant and therefore constrained to zero, * significant at α = 0.01, ** significant at α = 0.05

AL = active leisure activities, FV = family visits, FS = fun shopping

5. Conclusions

This paper aimed at contributing to the research on the link between the built environment and travel behaviour by evaluating the objective and subjective influences on modal choice for leisure trips. Moreover, our analysis also accounts for complex interrelations due to issues such as residential and travel-related self-selection. The dataset we used, stemming from an 2007 Internet survey on personal attitudes, preferences and lifestyles, allowed us to include subjective influences on each level of the hypothesized model. Doing so, our analysis results are controlled for the influence of subjective personal characteristics (i.e., lifestyles), subjective attitudes toward the built environment (i.e., residential attitudes), and subjective attitudes toward mobility and travel (i.e., general travel attitudes and specific travel mode attitudes). By comparing the results of models with only objective variables and the results of models with both objective and subjective variables, we found that subjective variables seem to explain an important additional amount of variance in modal choice for several types of leisure trips. Moreover, neglecting subjective variables likely result in a misspecification of the effect of the built environment on modal choice. Our findings also suggest that modal choice is more a question of car use versus use of car alternatives (public transport, walking/cycling) rather than the assessment of individual (car, walking/cycling) versus public transport or motorized (car, public transport) versus non-motorized (walking/cycling) transport.

Based on our results, it is hard to say which one is more important: objective variables or subjective variables. For example, car use and public transport use are considerably influenced by stage of life. However, a traditional family lifestyle is strongly associated with car use for active leisure activities and, thus, the influence of lifestyles cannot always be ignored. Another example is the assessment of the influence of objective and subjective spatial characteristics. At first sight, the built environment seems to influence modal choices to a larger extent than residential attitudes. However, residential attitudes have an important influence on selecting the spatial characteristics of the built environment in the first place (i.e. the residential location decision), supporting the need to account for residential self-selection in assessing the impacts of the built environment on modal choice. A last example refers to objective and subjective travel aspects. Car availability seems to be a major influence on modal choice, but our results indicate that travel attitudes and travel mode attitudes should be accounted for as well. This refers to a second type of self-selection with respect to travel. We suppose it is more accurate to say that modal choice can be explained properly only by a mix of objective and subjective variables.

The explained variance values of some models are quite high, especially for the models explaining car use for active leisure activities and fun shopping. Other models indicate that improvement is still possible. For further research, one should keep in mind that our analysis focuses on the individual and his or her modal choice for leisure trips. We did not take into account the interactions among individuals. This might become important, especially for leisure trips since leisure activities are often jointly performed with other individuals (Axhausen, 2008; Dugundji et al., 2008; Ohnmacht et al., 2009). Consequently, it seems appropriate to analyze the individual's travel behaviour within a broader social context. Moreover, some factors such as trip distance that have a larger influence on public transport use and cycling/walking than on car use were not included in our models (Scheiner, 2010b).

Based on our findings some policy implications might be formulated as well. The results suggest that objective spatial characteristics remain important in the discussion on the link between the built environment and daily modal choices. Spatial planning can contribute to a more sustainable mobility by means of (i) densifying, (ii) fostering residential developments close to town and city centres, and (iii) providing facilities at neighbourhood-level. However, our results also point out that these suggested spatial planning policies might only be successful for a specific group of respondents. Non-traditional lifestyles and people with a positive attitude toward having access would possibly prefer to reside in such urban neighbourhoods. The suggested spatial planning policies seem likely to be unsuccessful for active and family-oriented lifestyle groups and people with a positive attitude toward open space and quietness, who prefer a suburban or rural neighbourhood. These neighbourhoods are generally associated with more car use and less use of car alternatives. However, there still exist some possibilities to reduce car use, especially by means of transport planning. Our results suggest that car use is influenced by a positive attitude toward cars. Transport planning policies should focus on improving the image of travelling by public transport or cycling and walking. This can be done by underlining their positive effects for the environment and, especially for cycling and walking, their relaxing (and physical health) effects. After all, these two aspects were found to be associated with a positive attitude toward public transport use and cycling and walking. Consequently, an integration of spatial planning and transport planning seems useful. Moreover, policy should not only focus on designing and developing objective plans (e.g., a more sustainable lay-out of residential neighbourhoods), but should also be aware of their subjective implications (e.g., image building of travel modes).

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Appendix: Factor analyses undertaken to determine lifestyles, attitudes, stage of life and the built environment

The Internet survey included various questions referring to three aspects of leisure: (i) holidays, (ii) literary interests, and (iii) recreational activities (sports, attending cultural events, recreational activities, hobbies). Factor analysis was, then, used in order to reduce the considerable amount of information found in the observed indicators to a feasible number of lifestyle factors. Because of the large number of candidate variables, it made sense to initially factor-analyze them in groups, rather than all together. However, since several constructs (e.g. family orientation, culture lover) appeared across more than one group, we decided to perform a second-order factor analysis. The factors extracted from this second factor analysis are called "second-order" factors (Arnau, 1998; Thomas, 1995).

Pattern matrix for holiday-related factors

Holiday-related factors → Holiday statement ↓	Low-budget, active & adventurous	Frequent traveller with second home	Self-organized, family-oriented	All-in-one	Culture lover	Close to home and unadventurous
What type of accommodation? camping site	0.742					
What type of accommodation? hotel	-0.531				0.240	
Who organizes the holiday? myself	0.486					
What aspects are important? inexpensive, low-budget	0.425		-0.264			0.200
How many holidays lasted one week or longer?		0.818				
How many times did you spend a holiday the last year?		0.766				
What type of accommodation? second home		0.256				
How do you travel? by car			0686			
What type of accommodation? rental house			0.389			
How do you travel? by train	0.275		-0.277			
What aspects are important? sunny				0.582		
What aspects are important? relaxation				0.408		
What aspects are important? good food				0.329		
What aspects are important? sports accommodation				0.307		
What aspects are important? luxury	-0.246					
What type of accommodation? resort, holiday village				0.229		
What aspects are important? culture					0.437	
What type of accommodation? local people					0.387	
How do you travel? by airplane			-0.290		0.341	
What aspects are important? nature	0.248		0.243		0.328	
What aspects are important? familiar places						0.340
What aspects are important? close to home						0.324
What aspects are important? no language problems						0.251
What aspects are important? unfamiliar places, adventure	0.221				0.211	-0.226

Pattern matrix for factors related to literary interests

Factors related to literary interests → On which subjects have you read a book or magazine in the last 12 months ↓	Home improvement, cocooning	Fantasy world, fiction	Style and trends	Culture and current events	Non-emotional, non-fiction
Literary subjects: housing/decoration	0.581				
Literary subjects: gardening	0.558				
Literary subjects: do-it-yourself	0.481				
Literary subjects: cooking	0.380				
Literary subjects: health	0.338				
Literary subjects: pets	0.259				
Literary subjects: thriller, adventure		0.549			-0.288
Literary subjects: fantasy, SF		0.427			
Literary subjects: horror		0.421			
Literary subjects: detective, crime story		0.400			-0.300
Literary subjects: humor, comedy		0.387	0.233		0.271
Literary subjects: comic book, cartoon		0.356			
Literary subjects: women's magazine			0.582		
Literary subjects: fashion			0.528		
Literary subjects: entertainment, showbiz			0.365		
Literary subjects: science			-0.318		
Literary subjects: environment, nature	0.286		-0.294		
Literary subjects: history				0.612	
Literary subjects: art, architecture				0.522	
Literary subjects: politics, news magazine				0.375	
Literary subjects: religion, spirituality				0.337	
Literary subjects: novel				0.232	-0.391
Literary subjects: computer, ICT					0.331
Literary subjects: sports					0.325
Literary subjects: men's magazine					0.242
Literary subjects: finances, business, trade					0.242

Pattern matrix for factors related to leisure activities

Factors related to leisure activities → Statement on leisure activities ↓	Traditional family activities	Sports	Social nest-builders	Socially engaged	Culture lovers	Party people	Creativity
Hobbies: doing chores, do-it-yourself	0.670						
Hobbies: gardening	0.598		-0.283				
Recreational activities: gardening	0.560		-0.342				
Recreational activities: doing chores, do-it-yourself	0.555						
Cultural activities: flea market	0.323						
Hobbies: constructing and repairing furniture	0.272						
Sports: cycling	0.253						0.213
Cultural activities: parade	0.239						
Cultural activities: commodity exchange	0.214						
Recreational activities: practicing sports		0.853					
Hobbies: practicing sports		0.846					
Sports: jogging, running		0.391					
Sports: soccer		0.271					
Sports: badminton, (table) tennis, squash		0.271					
Recreational activities: going to the movies, cinema			0.537				
Recreational activities: staying at home and relaxing			0.506				
Recreational activities: shopping			0.467				-0.258
Recreational activities: watching TV, movies, DVD			0.464				
Cultural activities: going to the movies, cinema			0.441				
Recreational activities: going out for diner, to restaurant			0.362				-0.250
Recreational activities: listening to the radio, to music			0.342				0.239
Recreational activities: visiting family and friends			0.298				
Recreational activities: inviting family and friends			0.241				
Recreational activities: cooking			0.216				-0.203
Recreational activities: volunteering, club/social life				0.903			
Hobbies: volunteering, club/social life				0.888			
Member of a club				0.240			
Cultural activities: museum, exhibition					0.526		
Cultural activities: opera, musical					0.509		
Cultural activities: concert					0.411		0.251
Hobbies: reading					0.385		
Cultural activities: library					0.350		
Cultural activities: ballet, dance performance					0.285		
Sports: walking	0.260				0.278		
Hobbies: playacting					0.258		
Recreational activities: a night out in a disco or at a party						0.896	
Cultural activities: party						0.617	
Cultural activities: disco, club						0.569	
Hobbies: computer, web design							0.376
Hobbies: playing music							0.356
Hobbies: photography							0.244
Recreational activities: cultural and creative activities							0.235

Pattern matrix for the final second-order lifestyle factors

Second-order lifestyle factors → First-order factors related to holidays, literary interests and leisure activities ↓	Culture lover	Friends-and-trends	Home-oriented but active family	Low-budget and active/creative	Home-oriented traditional family
Leisure: socially engaged	0.843				
Literary interests: culture and current events	0.444				
Holiday: culture lover	0.423				
Literary interest: non-emotional readers	-0.305				
Leisure: party people		0.937			
Leisure: sports			0.741		
Literary interests: home improvement, cocooning			0.628		
Holiday: self-organized, family-oriented			0.253		
Leisure: creative				0.922	
Literary interests: non-emotional, non-fiction				0.289	
Holiday: low-budget, active and adventurous				0.246	
Leisure: traditional family activities		-0.246			0.607
Literary interests: style and trends		0.262			0.598
Holiday: all-in-one					0.444
Holiday: frequent traveller with second home					-0.200

Pattern matrix for factors related to residential attitudes

Factors on residential attitudes → Suppose you have to choose a new residential location. What aspects are important to you ? ↓	Car alternatives	Open space and quietness	Safety and neatness	Accessibility	Social contact
Presence of bike paths	0.863				
Presence of sidewalks	0.822				
Traffic safety	0.420		0.403		
Close to public transport	0.375			0.334	
Presence of green areas		0.918			
Quietness		0.793			
Social safety, no crimes			0.766		
Neatness, tidiness		0.286	0.552		
Sufficient parking places			0.454		
Outlook of buildings, architecture			0.318		
Close to shops, groceries				0.738	
Close to leisure activities				0.687	
Close to family and friends				0.391	
Close to work				0.349	
Frequent contact with neighbours					0.777
Good contact with neighbours					0.761

Pattern matrix for factors related to general travel attitudes

Factors on general travel attitudes → Do you agree with the next statements on mobility ↓	Frustrated traveller	Pro-environment	Reduced-driving social expectations
Daily travel is boring	0.876		
I love being on the road	-0.757		
Travel time is wasted time	0.643		
Arriving at my destination is the only good thing about daily travel	0.562		
Traffic makes me nervous	0.368	0.270	
I like to discover new and unfamiliar places	-0.294		
Car traffic causes serious problems		0.637	
I myself can contribute to a solution for traffic problems		0.596	
It does not matter whether I use my car or not. Other people still drive their cars.		-0.486	
According to family and friends, traffic problems are over exaggerated		-0.263	
According to family and friends, I should use public transport more often			0.757
According to family and friends, I should bike more often			0.724
According to family and friends, I should use my car only when absolutely necessary		0.301	0.323

Pattern matrix related to travel mode-specific attitudes

CAR ATTITUDES			
Factors on car attitudes → Which aspects characterize car use ? ↓	Comfortable	Negative effects	
Reliable	0.625		
Comfortable	0.616		
Flexible	0.596		
Time-saving	0.582		
Privacy-offering	0.472		
Safe	0.454		
Relaxing	0.372		
Good for image	0.294		
Activities while travelling	0.207		
Healthy		-0.677	
Cheap		-0.483	
Environment-friendly		-0.480	
CYCLING/WALKING			
Factors on cycling/walking attitudes → Which aspects characterize cycling/walking ? ↓	Comfortable	Positive effects	
Privacy-offering (cycling)	0.634		
Privacy-offering (walking)	0.606		
Comfortable (cycling)	0.515		
Comfortable (walking)	0.461		
Time-saving (cycling)	0.374		
Time-saving (walking)	0.223		
Safe (cycling)	0.357		
Safe (walking)	0.331		
Flexible (cycling)	0.353	0.322	
Flexible (walking)	0.346	0.215	
Reliable (cycling)	0.331		
Reliable (walking)	0.321	0.333	
Good for image (cycling)	0.233		
Good for image (walking)	0.267		
Cheap (cycling)		0.658	
Cheap (walking)		0.615	
Healthy (cycling)		0.618	
Healthy (walking)		0.650	
Environment-friendly (cycling)		0.626	
Environment-friendly (walking)		0.557	
Relaxing (cycling)		0.265	
Relaxing (walking)		0.304	
PUBLIC TRANSPORT			
Factors on public transport attitudes → Which aspects characterize public transport ? ↓	Comfortable	Positive effects	Time-saving
Comfortable	0.781		
Relaxing	0.471		
Environment-friendly		0.650	
Activities while travelling		0.340	
Safe	0.296	0.319	
Cheap		0.301	0.218
Good for image		0.249	
Healthy		0.248	
Flexible			0.633
Time-saving			0.323
Reliable			0.284
Privacy-offering			0.249

Pattern matrix for factors related to built environment characteristics

Built environment factors → Built environment characteristic ↓	Location in relation to local centre	Regional accessibility	Density	Location in relation to regional centre	Local accessibility
Distance to railway station level 1, 2, 3, 4, 5	1.061				
Distance to railway station level 1, 2, 3, 4, 5, 6	0.995				
Distance to railway station level 1, 2, 3, 4	0.768				
Distance to railway station level 1, 2, 3	0.443			0.361	
Potential accessibility 60 minutes		1.023			
Potential accessibility 45 minutes		0.969			
Distance to city level 1		-0.918			
Potential accessibility 30 minutes		0.553			0.464
Distance to railway station level 1		-0.440		0.356	
Population density			0.953		
Built up index			0.718		
Job density			0.532		
Land use mix			-0.407		
Distance to city level 1, 2, 3				0.929	
Distance to city level 1, 2, 3, 4				0.797	
Distance to city level 1, 2				0.705	
Distance to railway station level 1, 2		-0.314		0.622	
Distance to city level 1, 2, 3, 4, 5	0.350			0.515	
Potential accessibility 10 minutes					0.994
Potential accessibility 15 minutes					0.860
Potential accessibility 5 minutes			0.356		0.625

Note: City levels correspond to categories defined in the Spatial Structure Plan of Flanders, a spatial policy plan for the Flanders region, where 1 = metropolitan area (+200,000 inhabitants), 2 = regional urban area, 3 = large urban area, 4 = medium-sized urban area, 5 = small city.

Railway station levels correspond to categories used by the Belgian national railway, where 1 - 5 have the same meaning as for city level, and 6 = local village.

Pattern matrix for factors related to stage of life

Factors related to stage of life → Socio-economic and demographic statement ↓	Student living at home	Older family, working	Young family
presence of children in the household	0.946	0.242	0.361
number of older children in the household (+18 y.)	0.938		-0.271
household position as a child	0.739	-0.321	
highly educated	-0.390	0.273	
age		0.558	
household income		0.446	
full-time employment	-0.320	0.444	
number of young children in the household (-6 y.)			0.937