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UNDERSTANDING MODAL CHOICES FOR LEISURE ACTIVITIES. IS IT JUST OBJECTIVELY DETERMINED ?

Abstract

Most studies on the link between the built environment and modal choice characterize and model this relationship by objectively measurable 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. 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 active leisure activities 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 simultaneous 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 be determined correctly and thus insights in self-selection mechanisms can be gained.

Samenvatting

De meeste studies over de interactie tussen de bebouwde omgeving en vervoerswijzekeuze gebruiken objectief meetbare eigenschappen zoals dichtheid en diversiteit om deze relatie te modelleren en analyseren. Recent wordt tevens aandacht besteed aan het belang van subjectieve invloeden zoals de percepties en voorkeuren van het individu met betrekking tot de bebouwde omgeving. Dit gebeurde vooral binnen het debat over residentiële zelfselectie, maar zelfselectie kan ook op andere punten optreden. Daarom wordt in dit artikel de analyse uitgebreid zodat subjectieve kenmerken ook op andere niveaus van het model voorkomen (bijvoorbeeld, niet alleen levensfase maar ook leefstijl, niet alleen autobezit maar ook algemene mobiliteitsattitudes, niet alleen vervoerswijzekeuze maar ook attitudes tegenover specifieke vervoerswijzen). Daartoe is een model voor vervoerswijzekeuze voor actieve vrijetijdsbesteding geschat. Dit model werd ontwikkeld op basis van gegevens uit een internetenquête over persoonlijke leefstijlen en attitudes, en werd geanalyseerd met behulp van een padmodel dat bestaat uit een reeks van gelijktijdig geschatte vergelijkingen tussen de geobserveerde variabelen. De resultaten verduidelijken dat het effect van de bebouwde omgeving en autobeschikbaarheid op de vervoerswijzekeuze pas correct geïnterpreteerd kunnen worden indien men controleert voor subjectieve leefstijlen en attitudes. Daarenboven verkrijgt men inzicht in de mechanismen van zelfselectie.

INTRODUCTION

Common studies on the interaction between the built environment and modal choice might come across as deterministic: modal choice is explained by objective spatial characteristics only without considering the underlying behavioural mechanisms. Higher densities, more diversity and better local accessibility are often believed to result in less car use, more public transport and more cycling/walking (for a more comprehensive review, see, e.g., van Wee, 2002; Ewing and Cervero, 2010). However, not all people that reside in such an urban neighbourhood travel by definition by public transport or walk and bike instead of using their cars. Recently, some researchers have argued in favour of including more subjective variables such as personal lifestyles, attitudes and preferences. After all, different travel patterns still exist within socio-economically and demographically homogenous population groups (van Wee, 2002). 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., Lyon, 1984; Gärling et al., 1998; 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 interaction between the built environment and modal choice.

Only recently, subjective variables were introduced in empirical work on the relationship between the built environment and travel behaviour, and especially in those studies that question the issue of causation (Handy et al., 2005; 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., Cao et al., 2006; Bhat and Guo, 2007; Naess, 2009). People might select themselves into a neighbourhood according to their personal attitudes, preferences and lifestyles. For example, a household with public transport preferences will likely choose a 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, especially for those social groups that have the financial resources and, thus, can afford to act upon their 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 subjective variables. This is supported by Bagley and Mokhtarian (2002) and Cao et al. (2006): after controlling for residential self-selection, the built environment was found to have little effect on travel behaviour. However, Bhat and Guo (2007) and Pinjari et al. (2007) found the opposite. Furthermore, 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. This travel-related type of self-selection is, however, less studied compared to residential self-selection. A second aim of this paper is therefore to study the interaction between the built environment and modal choice, while unravelling the complex interdependencies with underlying attitudes and lifestyles.

The paper is structured as follows. Section 2 describes the model structure that will be estimated by what is called a path model (Byrne, 2001; Kline, 2005). Section 3 introduces the data. Results are presented and discussed in Section 4. Our analysis focuses on the modal

choices for active leisure activities (e.g., practicing sports instead of watching sports, playing theatre instead of going to the theatre) because we assume that lifestyles and the built environment have a larger impact on discretionary trips than on recurrent trips (like commuting). Due to the habitual and regular character of recurrent trips like commuting, modal choices for commuting might be more a matter of personal and job-related characteristics (e.g., job type, work regime, work hours) instead of lifestyles and the built environment. Moreover, some studies (Meurs and Haaijer, 2001; Scheiner, 2010a) have indicated that especially non-work travel is influenced by lifestyles and the built environment. Section 5 presents our most important conclusions for future research and policy-making.

MODEL STRUCTURE AND METHODOLOGY

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., 2010). 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 (Weber, 1972; Bourdieu, 1984; Ganzeboom, 1988). Although a lifestyle is partly influenced by stage of life or household composition (e.g., high-income groups are able to obtain a more materialistic lifestyle), a lifestyle on its turn could also influence socio-economic and demographics such as household composition (e.g., a family-oriented lifestyle is likely to result in larger household sizes). Consequently, Figure 1 considers a dual relationship between lifestyles and socio-economic and demographics. 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 (of more than one) and travel modes. Therefore, attitudes underlie the decision hierarchy presented in Figure 1 (right-side).

Note also that the relationships between attitudes and behaviour 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 (Lyon, 1984; Bohte et al., 2009). This in turn might have repercussions for other earlier decisions. 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 which in turn 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.¹

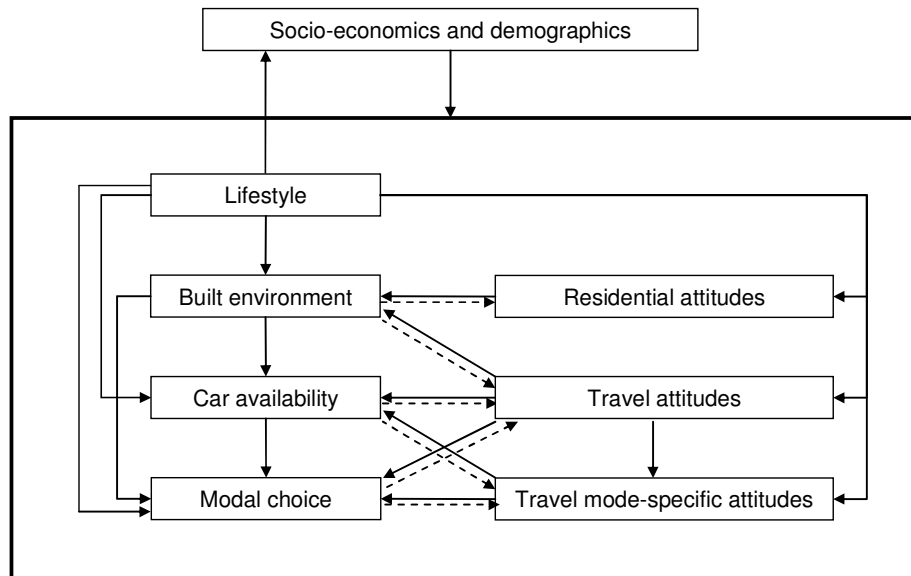


Figure 1: Complex relationships between the built environment and modal choice

The complex relationships, as depicted in Figure 1, 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 which values are based on underlying manifest variables (or indicators) that represent the latent variable. This measurement model, as it is called, therefore defines the relationships between a latent variable and its indicators. However, we only use directly observed variables so that our analysis is solely based on the regression aspects of SEM. A SEM with only observed variables is called a path 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). Exogenous variables are not influenced by any other variable in the model, but instead exogenous variables influence other variables. Endogenous variables are influenced by exogenous variables, either directly or indirectly through other 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. We used the software package M-plus 4.21 because of its ability to model categorical endogenous variables. After all, our final outcome variable, modal choice, is binary and thus, not normally distributed (see Section 3). In that case, using the standard estimation technique maximum likelihood (ML) is not appropriate. By default, M-plus then uses an alternative estimator: a mean- and variance-adjusted weighted least squares parameter estimator (WLSMV) (Muthén, 1983; Yu and Bentler, 2000).

DATA

The analysis is based on data collected via an Internet survey (May 2007-October 2007). 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.

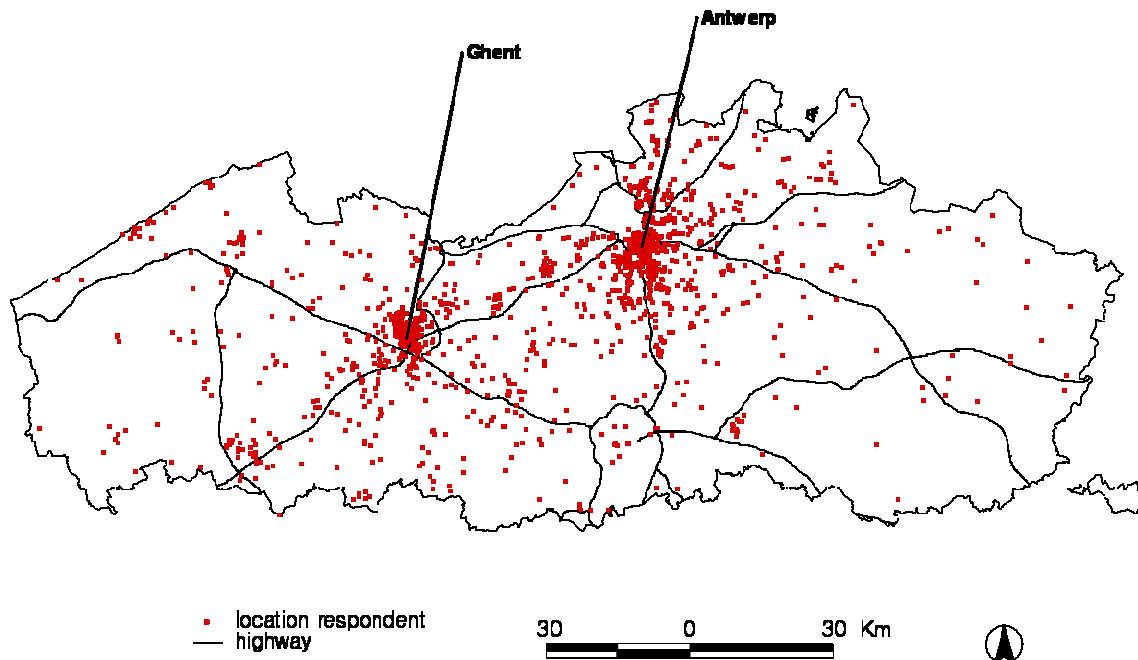


Figure 2: Locations of respondents in Flanders

Despite our efforts, we did not obtain a well-balanced sample. Women, married couples, people with full-time employment and younger people are somewhat overrepresented. But the most remarkable difference is in education. Highly-educated respondents are heavily overrepresented in the sample: 66% has 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 self-selection bias in the data. 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. 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. The sample still permits demonstration of our premise that, conditional on a given level of education, subjective variables can still explain a significant additional amount of variance in modal choices. Furthermore, the sample allows us to perform some preliminary analyses and to gain insights into the complex relationships between lifestyles, attitudes, the built environment, car availability and modal choices. Especially for this specific sample of highly-educated people who probably have the resources to act upon their attitudes, it might be possible that the formerly assumed effect of the built environment on modal choice is, at least to some degree, due to underlying residential and travel-related attitudes. Nevertheless, one should keep in mind that the results and findings apply to this specific sample and cannot be automatically translated to a wider population.

Lifestyles, residential attitudes and travel attitudes

The Internet survey included many questions on lifestyle orientation, residential attitudes and travel attitudes. We used separate factor analyses (principal axis factoring, promax rotation) 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.ⁱⁱ

In this paper, we limit ourselves to a short description of the factors, but more detailed information can be found in Van Acker et al. (2011).

Lifestyles refer to the individual's orientations toward general themes such as leisure, family and work (Salomon and Ben-Akiva, 1983; Bootsma et al., 1993; 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 a list of more than 100 types of holiday aspects, literary interests as well as 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 or novels) and how they spent their weekends (e.g., visiting family and friends, practicing sports, or simply staying at home). Five lifestyles could be defined: i.e., culture lover (*ls1*), friends and trends (*ls2*), low-budget and active/creative (*ls3*), home-oriented but active family (*ls4*), and home-oriented traditional family (*ls5*).

Respondents were also asked to rate 16 aspects that could have influenced their residential location choice on a five-point Likert scale ranging from "unimportant" to "very important". These 16 variables were then factor analyzed into five underlying dimensions: open space and quietness (*ra1*), car alternatives (*ra2*), accessibility (*ra3*), safety and neatness (*ra4*), and social contact (*ra5*). 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 *ta1*, pro-environment *ta2* and frequent car user according to family and friends *ta3*), and two mode-specific attitudes for each transport mode (comfort *ac1 apt1 acw1*, and the repercussions for the environment and an individual's image or health *ac2 apt2 acw2*). Related to public transport, we found a third attitude referring to time-saving (*apt3*).

Stage of life, the built environment, car availability and modal choice

Socio-economic and socio-demographic variables might be correlated with each other, and factor analysis could provide interesting new factors. We extracted three factors, all referring to stage of life: students living at home (*stl1*), older family with employed adults (*stl2*), and a young family (*stl3*). 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%).

Spatial characteristics of the respondent's residence 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).ⁱⁱⁱ We are aware that not all of these built environment variables are leisure-oriented, but data on leisure facilities are not easily available. 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. Density, diversity and accessibility can thus be conceived as measuring the same phenomenon. To the extent that that is the case, the combination of these *specific* spatial characteristics by a factor analysis into one measure provides us with a more *general* spatial description of the neighbourhoods. A factor analysis thus resulted in five factors: location in relation to a local centre (*be1*), location in relation to a regional centre (*be2*), local accessibility (*be3*), regional accessibility (*be4*), and density (*be5*).

Car availability (*ca*) is 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 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 in order to construct one general factor related to car availability.

Modal choice is the final outcome variable in our path models. In our Internet survey, respondents had to report which travel modes (car *cu*, public transport *pt*, cycling/walking *cw*) they generally use for active leisure activities (e.g., practicing sports instead of watching sports, playing theatre instead of going to the theatre). For each travel mode, we estimated a separate path model so that we ended up with three models to be estimated (one model for car use, one model for public transport, one model for cycling/walking). In each of these models, modal choice is defined as a binary variable (e.g., in the car use model: 0 = no car used for active leisure trips, 1 = car used for active leisure trips).

RESULTS

Before presenting the model results, we have to discuss two important model specification issues: (i) outliers, and (ii) model fit.

Since not all of our endogenous variables are continuous, outliers cannot be detected by calculating the commonly used Mahalanobis distance or the loglikelihood for each observation. However, M-plus also calculates Cook's D (Cook, 1977) 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. Removing the outliers led to minimal changes in the overall model fit and individual parameter estimates. However, 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 residing in a neighbourhood with pronounced spatial traits (especially urban neighbourhoods with good local accessibility and rural 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 results are based on the full dataset.

Secondly, the quality of the model specifications must be assessed before the results can be interpreted. 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 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. Cut-off values indicating adequate model fit are: $\chi^2/df < 2.0$, CFI and TLI > 0.95 , RMSEA < 0.05 and WRMR < 1.00 (Hu and Bentler, 1999; Yu, 2002). Table 1 reports fit indices for our estimated models. According to most indices, model fit is generally less than adequate but still acceptable.

Table 1: Model fit

| | Chi ² (df) p | Chi ² / df | CFI | TLI | RMSEA | WRMR |
|--------------------------------|-------------------------|-----------------------|------|------|-------|------|
| car use (<i>cu</i>) | 184.63 (142) 0.01 | 1.30 | 0.96 | 0.96 | 0.02 | 1.02 |
| public transport (<i>pt</i>) | 187.55 (146) 0.01 | 1.28 | 0.95 | 0.96 | 0.02 | 1.02 |
| cycling/walking (<i>cw</i>) | 189.25 (146) 0.01 | 1.30 | 0.95 | 0.96 | 0.02 | 1.02 |

Having specified some important model specification issues, we now turn our attention to the model results. Table 2 illustrates the influences of objective and subjective variables on modal choices for active leisure activities. 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, especially for car use ($R^2 = 62.2\%$).

Moreover, the modelling results for public transport use tend to resemble the results for cycling/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/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.

The causal influence of the built environment and residential self-selection on modal choice

The built environment has the expected influence on modal choice. High densities (*be5*), good local accessibility (*be3*) and a short distance between the residence and the city centre (*be4*) seem to discourage car use and to encourage public transport and cycling/walking. This suggests that spatial planning policies encouraging further densification, developing residential quarters near city centres, and providing facilities such as shops and leisure activities within the residential neighbourhood might have the desired effect on modal choices. We must however stress that this mainly holds for discouraging car use. The built environment has an important (direct) effect on car use, contrary to public transport and cycling/walking (see Table 2).

Moreover, the question remains whether it is really the built environment itself that influences car use more than, or as much as, the underlying residential attitudes and preferences in the first place. Table 2 already distinguishes between direct, indirect and total effects. Due to interactions among lifestyles, attitudes and the built environment (see Figure 1), indirect effects exist. For example, Table 2 mentions small but significant indirect effects on modal choices from the residential and travel attitudes underlying to the residential location choices. Car use is positively associated with the importance of open space and quietness (*ra2*, typically for suburban and rural residents) and negatively associated with the importance of having access to locations such as workplaces and shops (*ra4*, typically for urban residents).^{iv} The opposite is true for public transport and cycling/walking. These indirect effects are in fact the result of the interaction between, among others, residential attitudes, the built environment and modal choices. Based on Table 3 we can reconstruct the paths of these interactions. Tables 2 and 3 should therefore be considered simultaneously. For example, residing in high densities discourages car use (direct effect of *be5* on *cu* is -0.388) and favours cycling/walking (direct effect of *be5* on *cw* is 0.156). But it seems that people who prefer having easy access are more likely to choose such a high-density residence in the first place (direct effect of *ra4* on *be5* is 0.236). 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 the decision to reside in an urban neighbourhood is influenced by someone's non-traditional lifestyles such as culture lovers (i.e., direct effect of *ls1* on *be5* is 0.168), whereas active lifestyles tend to reside in a suburban or rural neighbourhood (i.e., direct effect of *ls3* on *be3* is -0.097). Consequently, the supposed influence of the built environment on modal choice cannot be correctly understood without considering the underlying residential attitudes and lifestyles.

Car availability as a major determinant and travel-related self-selection

Even more important than the built environment is the influence of car availability (*ca*). High levels of car availability are associated with more car use, less public transport use, and less cycling/walking. Interesting to note is that the effect of car availability on cycling/walking is less strong compared to car use (see Table 2). This finding probably reflects that cycling/walking are supplements to driving, instead of substitutes for it. But again, the causal relation between car availability and modal choice can be questioned (see Table 3). 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 would have no important influence on modal choice. 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. A pro-environment travel attitude has an important negative influence on car availability (i.e., direct effect of *ta2* on *ca* is -0.174), whereas car availability was found positively associated with the perception of a car as a comfortable transport mode (i.e., direct effect of *ac1* on *ca* is 0.158). This illustrates again that underlying attitudes should not be neglected so that the influence of car availability can be correctly understood. Interesting to note is that Table 3 does not report direct effects of lifestyles on car availability. Lifestyles seem not to directly influence the decision to own a car, contrary to the decision where to reside.

Furthermore, Table 2 also illustrates that car attitudes not only explain car use, but also dominate the decision of using car alternatives. Public transport as well as cycling/walking are not significantly influenced by travel mode attitudes specifically toward public transport (respectively cycling/walking), but only by the specific attitude of cars as comfortable transport modes. Other travel mode-specific attitudes such as "public transport is comfortable" have been omitted from Tables 2 and 3 because of their insignificant effects on modal choices.

Table 2: Unstandardized effects on modal choices for active leisure activities (significant at $\alpha = 0.05$)

| | Car use (cu) | | | Public transport (pt) | | | Cycling/walking (cw) | | |
|---------------------------------------|--------------|---------------|---------------|-----------------------|----------|--------|----------------------|---------------|---------------|
| | direct | indirect | total | direct | indirect | total | direct | indirect | total |
| Gender | | | | | | | | | |
| female | - | 0.153 | 0.153 | - | -0.012 | -0.012 | - | -0.122 | -0.122 |
| Stage of life | | | | | | | | | |
| stl1 | - | <i>-0.045</i> | <i>-0.045</i> | - | 0.139 | 0.139 | - | <i>0.035</i> | <i>0.035</i> |
| stl2 | - | 0.392 | 0.392 | - | -0.251 | -0.251 | - | -0.185 | -0.185 |
| stl3 | - | 0.364 | 0.364 | - | -0.093 | -0.093 | - | -0.125 | -0.125 |
| Lifestyle | | | | | | | | | |
| ls1 | -0.257 | <i>0.010</i> | -0.246 | - | -0.004 | -0.004 | - | 0.042 | 0.042 |
| ls2 | - | 0.040 | 0.040 | - | 0.012 | -0.012 | - | -0.014 | -0.014 |
| ls3 | - | 0.140 | 0.140 | - | -0.019 | -0.019 | - | -0.062 | -0.062 |
| ls4 | - | <i>0.002</i> | <i>0.002</i> | - | 0.005 | 0.005 | 0.160 | <i>0.006</i> | 0.166 |
| ls5 | 0.424 | -0.103 | 0.321 | - | 0.001 | 0.001 | - | <i>-0.027</i> | <i>-0.027</i> |
| Built environment | | | | | | | | | |
| be1 | 0.391 | -0.066 | 0.326 | - | 0.006 | 0.006 | -0.176 | 0.016 | -0.160 |
| be2 | 0.516 | <i>0.011</i> | 0.526 | - | -0.044 | -0.044 | -0.221 | <i>-0.015</i> | -0.236 |
| be3 | -0.297 | <i>0.011</i> | -0.286 | - | 0.039 | 0.039 | - | <i>0.006</i> | <i>0.006</i> |
| be4 | -0.291 | 0.066 | -0.224 | - | 0.001 | 0.001 | - | -0.001 | -0.001 |
| be5 | -0.388 | <i>0.081</i> | -0.306 | - | 0.034 | 0.034 | 0.156 | <i>-0.026</i> | 0.130 |
| Residential attitudes | | | | | | | | | |
| ra1 | | 0.103 | 0.103 | | 0.001 | 0.001 | | 0.001 | 0.001 |
| ra2 | | 0.226 | 0.226 | | -0.025 | -0.025 | | -0.096 | -0.096 |
| ra4 | | -0.047 | -0.047 | | 0.008 | 0.008 | | 0.018 | 0.018 |
| Travel attitudes | | | | | | | | | |
| ta1 | - | 0.019 | 0.019 | - | | | - | | |
| ta2 | - | -0.447 | -0.447 | - | 0.159 | 0.159 | - | 0.241 | 0.241 |
| ta3 | - | 0.029 | 0.029 | - | -0.006 | -0.006 | - | -0.022 | -0.022 |
| Car availability | | | | | | | | | |
| ca | 1.295 | 0.039 | 1.334 | -0.690 | -0.001 | -0.691 | -0.461 | -0.019 | -0.480 |
| Travel mode-specific attitudes | | | | | | | | | |
| ac1 | - | 0.211 | 0.211 | - | -0.109 | -0.109 | -0.303 | -0.086 | -0.389 |
| acw2 | -0.233 | <i>-0.003</i> | -0.236 | - | | | - | | |
| R^2 | | 62.2% | | | 23.8% | | | 29.8% | |

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

Table 3: Unstandardized direct effects (significant at $\alpha = 0.05$)

| Effects from ... ↓ on ... → | ls1 | ls2 | ls3 | ls4 | ls5 | stl3 | be1 | be2 | be3 | be4 | be5 | ra1 | ra2 | ra4 | ta1 | ta2 | ta3 | ca | ac1 | acw2 | cu | pt | cw |
|--------------------------------|---------------|--------|--------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| female | 0.445 | - | 0.122 | -0.612 | 0.497 | | - | - | - | - | - | 0.152 | 0.196 | - | - | - | - | - | - | -0.116 | - | - | - |
| stl1 | <i>-0.047</i> | 0.195 | -0.282 | 0.196 | 0.162 | | - | 0.198 | - | - | -0.193 | 0.185 | 0.168 | - | - | - | - | -0.236 | 0.080 | | - | - | - |
| stl2 | <i>-0.088</i> | -0.284 | 0.314 | -0.343 | -0.160 | | - | -0.174 | - | - | - | -0.119 | - | - | 0.056 | - | - | 0.381 | -0.074 | | - | - | - |
| stl3 | -0.514 | -0.134 | <i>0.096</i> | -0.179 | 0.151 | | - | - | - | - | - | - | - | - | - | - | - | 0.136 | - | | - | - | - |
| ls1 | | | | | | 0.569 | - | - | - | - | 0.168 | 0.089 | 0.128 | 0.082 | -0.093 | 0.187 | - | - | -0.082 | 0.069 | -0.257 | - | - |
| ls2 | | | | | | - | - | - | - | - | - | -0.106 | <i>-0.068</i> | - | - | -0.085 | - | - | - | -0.119 | - | - | - |
| ls3 | | | | | | 0.135 | - | - | -0.097 | - | - | 0.133 | 0.333 | - | - | 0.101 | - | - | 0.095 | - | - | - | - |
| ls4 | | | | | | - | - | - | - | - | - | - | 0.114 | - | -0.084 | 0.049 | - | - | - | - | - | - | 0.160 |
| ls5 | | | | | | -0.504 | - | - | - | -0.134 | - | -0.142 | -0.311 | 0.141 | - | -0.224 | - | - | 0.175 | - | 0.424 | - | - |
| be1 | | | | | | | | | | | | -0.180 | -0.231 | - | - | - | - | - | | | 0.391 | - | -0.176 |
| be2 | | | | | | | | | | | | -0.275 | -0.293 | - | - | - | - | 0.074 | | | 0.516 | - | -0.221 |
| be3 | | | | | | | | | | | | 0.410 | 0.270 | - | - | - | - | -0.066 | | | -0.297 | - | - |
| be4 | | | | | | | | | | | | 0.656 | - | -0.051 | - | - | - | - | | | -0.291 | - | - |
| be5 | | | | | | | | | | | | 0.268 | 0.696 | - | - | - | - | -0.074 | | | -0.388 | - | 0.156 |
| ra1 | | | | | | | - | - | - | -0.457 | - | | | | | | | | | | | | |
| ra2 | | | | | | | - | - | - | - | -0.736 | | | | | | | | | | | | |
| ra4 | | | | | | | 0.078 | - | - | - | 0.236 | | | | | | | | | | | | |
| ta1 | | | | | | | - | - | - | - | - | | | | | | | - | - | -0.080 | - | - | - |
| ta2 | | | | | | | -0.092 | - | - | - | 0.254 | | | | | | | -0.174 | -0.283 | 0.201 | - | - | - |
| ta3 | | | | | | | - | - | - | - | - | | | | | | | - | 0.056 | -0.071 | - | - | - |
| ca | | | | | | | | | | | | | | | -0.079 | - | 0.175 | | - | -0.084 | 1.295 | -0.690 | -0.461 |
| ac1 | | | | | | | | | | | | | | | | | | 0.158 | | | - | - | -0.303 |
| acw2 | | | | | | | | | | | | | | | | | | - | | | -0.233 | - | - |
| cu | | | | | | | | | | | | | | | | | | | 0.057 | - | | | |
| pt | | | | | | | | | | | | | | | | | | | - | - | | | |
| cw | | | | | | | | | | | | | | | - | 0.124 | -0.113 | | - | - | | | |

Note: - = direct effect estimated but found insignificant and therefore constrained to zero, direct effects significant at $\alpha = 0.10$ in italics

Attitudes and behaviour

The estimated models also include reciprocal relationships between attitudes and behaviour to test whether attitudes underlie behavioural decisions or vice versa.

Related to residential location choices, interactions work in both ways. Table 3 illustrates that the preference of having access to various facilities might be one of the reasons why people like to reside in a high-density neighbourhood (i.e., direct effect of *ra4* on *be5* is 0.236). Residing in such a neighbourhood might result in an even more positive assessment of urban characteristics such as having car alternatives available (i.e., direct effect of *be5* on *ra1* is 0.268). But we also found that at least some residents of a high-density neighbourhood dislike these high densities and tend to prefer open space and quietness instead (i.e., direct effect of *be5* on *ra2* is 0.696) which on its turn might affect the residential choice again (i.e., direct effect of *ra2* on *be5* is -0.736). This interaction via residential attitudes is one of the reasons of the positive indirect effect of density, opposite to its negative direct effect, on car use (see Table 2).

Table 3 also illustrates the interaction between modal choices and the underlying travel (mode) attitudes. It seems that modal choices are not so much affected by general travel attitudes, but instead our attitudes toward travel in general are based on our daily modal choices. Cycling/walking encourages a pro-environment attitude (i.e., direct effect of *cw* on *ta2* is 0.124), whereas car use reduces this pro-environment attitude (i.e., direct effect of *cu* on *ta2* is -0.113). This contrasts with the interaction between modal choices and travel mode specific attitudes which runs in both ways. There seems to be a trade-off between car and cycling/walking: considering the car as a comfortable mode of travelling discourages cycling/walking (i.e., direct effect of *ac1* on *cw* is -0.303) and considering cycling/walking as positive for someone's health and/or the environment discourages car use (i.e., direct effect of *acw2* on *cu* is -0.233). The reverse interaction, 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 any travel-related attitude. However, using cars seems to result in a positive perception of the car as a comfortable transport mode (i.e., direct effect of *cu* on *ac1* is 0.057).

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 active leisure trips. Moreover, our analysis also accounts for complex interrelations due to issues such as self-selection and reciprocal interactions between attitudes and behaviour.

Our results indicate that, at first sight, the built environment seems to influence modal choices to a large extent. 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. Similarly, car availability seems to be a major influence on modal choice, but its influence cannot be correctly understood without the underlying travel attitudes. 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. We should keep in mind that these findings only apply for our specific (unbalanced) sample of mainly highly-educated people. It remains

unclear whether similar findings hold for other social groups which are underrepresented in our sample such as low-income groups. A lack of financial resources may inhibit certain people of acting on particular attitudes they hold and, consequently, the indirect influence of residential attitudes might be less strong in that case.

Besides making cars directly more expensive to own and operate (i.e., through registration fees, gasoline taxes, road pricing and parking regulations), our findings suggest that 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, 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 contrary to active and family-oriented lifestyles groups and people with a positive attitude toward open space and quietness who prefer a suburban or rural neighbourhood. The latter neighbourhoods are generally associated with more car use instead 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/walking by underlining its positive effects for the environment and, especially for cycling/walking, personal health. Consequently, integrating spatial planning and transport planning seems useful.

The explained variance values of some models are quite high, especially for car use, but improvement is still possible. For further research, bear in mind that our models did not account for factors such as trip distance that have a larger influence on car alternatives than on car use (Scheiner, 2010b). Moreover, our analysis focused on the individual without considering interactions among individuals. This might become important, especially for leisure trips since leisure activities are often jointly performed with other individuals (Dugundji et al., 2008; Ohnmacht et al., 2009). Furthermore, our analysis paid attention to subjective factors such as perceptions and attitudes, which are rather reasoned processes. This gives the impression that we consider behaviour as the result of rational decisions. Individuals are nevertheless not constantly conscious of their behaviour (Van Acker et al., 2010) and, therefore, some authors suggest a trade-off between attitudes and habits in the prediction of behaviour (Triandis, 1977). Socio-psychological studies such as Bamberg et al. (2003) and Verplanken et al. (1994, 1998) confirmed that this trade-off also exists in travel behaviour, but neglected the influence of the built environment. Consequently, further research on the interaction between lifestyles, the built environment and travel behaviour would benefit from an integration with the social-psychological trade-off between reasoned (i.e., attitudes) and unreasoned (i.e., habits) behaviour.

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ⁱ We are aware that feedback mechanisms might also exist between behaviours at various time-scales (e.g., daily modal choices might influence the decision to buy a car, or having several cars available might result in a move to a suburban neighbourhood). However, these feedback mechanisms are not considered due to issues such as modal complexity and identification. Consequently, this second type of feedback mechanisms is not indicated in Figure 1.

ⁱⁱ These 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 indicated that it would be too cumbersome to embed all submodels into the 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. Consequently, we consider all variables, even factor scores, to be observed (or manifest) variables, and our analysis is solely based on the regression analysis aspect of SEM. We also have to note that various input variables are in fact binary variables. Although it 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.

ⁱⁱⁱ *Population density* at the census tract level is defined as the number of inhabitants per square km.

Job density at the traffic analysis zone (TAZ) level is defined as the number of jobs per square km.

Built-up density equals the percentage of built-up surface at the census tract level. It is derived from the land use database of the Agency of Spatial Information Flanders which offers a categorization between built-up surfaces and open surfaces.

Jobs-housing balance at the traffic analysis zone (TAZ) is defined as the ratio between the number of jobs and the number of inhabitants.

Land use mix quantifies the degree of balance across residences, services and commerce, recreation and tourism, and regional and local industry. Information on these land use types is obtained from regional zoning plans and recalculated at the census tract level in ArcGIS 9.2. A value of 0 means that the land use pattern is exclusively determined by a single land use, whereas a value of 1 indicates a perfect mixing of different land uses.

Potential accessibility by car is defined as the number of people that can be reached by car within several time scales ranging from 5 to 60 minutes. For each residence, accessibility is calculated using the regional travel demand forecasting model Multimodal Model Flanders. It is basically the sum of the number of people of every census tract in the region, weighted by the travel time from the residence to these census tracts. Travel time is calculated in ArcGIS 9.2 as the fastest path by car along the road network.

^{iv} Other residential attitudes such as “safety and neatness” (*ra3*) and “social context” (*ra5*) have insignificant effects on modal choices and, therefore, omitted from Tables 2 and 3.