Preferences for Modes, Residential Location and Travel Behaviour: the Relevance for Land-Use Impacts on Mobility

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EJTIR, **2**, no. 3/4 (2002), pp. 305-316

Received: First presented at STELLA FG4 workshop 3&4 May 2002
Accepted: February 2003

Nowadays almost all researchers focusing on the impact of land use on travel behaviour examine personal and household variables such as income, age and household type. Still, within 'homogeneous' groups there may be preferences for travel modes (especially car or public transport), and these may have an impact on the influence of land use on travel behaviour – a subject for which available literature is scarce. This paper represents then an endeavour to relay results of empirical research on this matter and also attempts to answer the following questions:

1. *Are there preferences for modes?*
2. *Is there a relationship between preferences and neighbourhood characteristics?*
3. *Have preferences for modes played a role in residential choices of households?*
4. *Do preferences for modes add explanatory power to models for travel behaviour that include personal and household characteristics, and land-use variables?*

Results obtained reveal positive answers to all four questions; but this then confronts us with the following question: Do land-use policies then make no sense? Yes, in our opinion, these policies certainly do make sense, in the least because they allow people who prefer certain modes to live in an area that meets their preferences. However, this does not mean that land-

use alternatives leading to the lowest car use levels should always be recommended. Rather, what is needed is a broad evaluation of all the pros and cons of these alternatives.

1. Introduction

People travel mainly because they want to participate in activities such as living, working and recreating at different locations. Therefore travel can be regarded as the result of spatial and infrastructure patterns, which makes it plausible that land-use policies will have an impact on travel behaviour. The impact can be related to overall mobility levels, to modal choice or to the locations where vehicles are driven[1].

Land use may, at first sight, have a strong impact on travel behaviour; however, this is a discussion that has been going on for a long time, both in policy-making processes and among researchers. It is partly the result of the failure of some researchers to find any or hardly any impact of land use on travel behaviour, while others have concluded the impact to be significant.

Most researchers who have indeed found an impact in which personal and household variables are concluded to be more important for explaining travel behaviour than land-use variables. Therefore research into the impact of land use on travel behaviour should always include the personal and household variables. This is now currently accepted as the state-of-the-art in this research.

But suppose that people have preferences for modes, apart from their age, income, education level, household structure etc. In general, researchers do not include these other preferences in their studies, and literature on these preferences is very scarce. Our objective in this paper is therefore to focus on these preferences, with the aim of answering the following questions:

1. Are there preferences for modes?
2. Is there a relationship between preferences and neighbourhood characteristics?
3. Have preferences for modes played a role in residential choices of households?
4. Do preferences for modes add explanatory power to models for mobility that include personal and household characteristics, and land-use variables?

Section 2 will focus on a few of the studies covering preferences for modes; the data used in our research and results will be described in sections 3 and 4, respectively. Section 5 will discuss the implications of our findings and section 6 the most important conclusions and recommendations for further research.

2. Research into preferences for modes

Research into the impact of land use on mobility carried out in the past decade examines almost without exception personal and household variables. The concept of 'homogeneous

[1] These locations hardly receive any attention in the literature but may be very relevant for the impact of transport on the environment, congestion and road safety. A car driving on a busy road can easily have a congestion impact, contrary to a car driving on a road with hardly any traffic. Accident risk factors strongly vary with road type. A car driving on a road with many dwellings at a short distance from the road causes a greater noise impact than a car driving on a road without dwellings nearby.

groups of people' is often used in cases where researchers monitor passenger and household variables. These groups comprise individuals with the same category of income, age, household characteristics etc. The question here is: Do preferences for modes exist within such homogeneous groups? On the basis of a literature review, Pickup and Town (1983) concluded that people with an explicit preference to travelling by public transport do not consider living in a residential location far away from public transport nodal points, such as railway stations. Muconsult (1994) carried out research into the issue of why some people do not own a car, modelling peoples' car ownership choice. The share of personal and household variables made up 40% of the explanatory power of their model, the share of land-use and infrastructure variables 20%, and the share of preferences and attitudes towards modes about 40%. In other words, preferences and attitudes have a significant impact on car ownership levels. These preferences and attitudes are related to environmental awareness, the relative usefulness of cars compared to public transport as a travel mode and the views on extending parking areas. Kitamura *et al.* (1997) carried out research into attitudes and their impact on modal choice. They concluded that the share the car takes in the total number of trips is related to the attitudes towards the car and to public transport. Bagley and Mokhtarian (2002) carried out research into the impact of attitudes and lifestyles, combined with land-use variables, on travel behaviour. They concluded that attitudes and lifestyles have much more impact on travel behaviour than residential location type.

The few research studies, carried out either directly on preferences for modes or on attitudes and lifestyles (as found in the literature) show the existence of preferences for modes and attitudes to travel. The result of the Pickup and Town study showed that preferences are more important for 'public transport lovers' than for 'car lovers'. This seems plausible since the road network is, spatially seen, much more developed than the rail (and bus) network. Therefore accessibility of locations by public transport varies much more than accessibility by car. Since only a small number of all dwellings are situated within walking distance from a railway station, the choice of location for people with a preference for public transport is more important than for people preferring the car.

3. Data and methods

We used data from Van Baren and Holwerda (2001) for our analyses. They had studied the effects of land use at the neighbourhood level on travel behaviour, sending out questionnaires to heads of 879 households (often two to a household) living in three different neighbourhoods in towns close to the Dutch city of Utrecht. Utrecht is situated in the middle of the Netherlands, and is the fourth largest city (in terms of population) in the Netherlands (260.000 inhabitants), next to Amsterdam, Rotterdam and The Hague. Depending on how one defines the exact boundaries of the region of Utrecht, towns like Nieuwegein, IJsselstein, Houten and Maarssen could be included. The region has about half a million inhabitants. Because of its central location in the Netherlands, Utrecht has motorway connections in 7 directions and railway connections in 5 directions.

The households responding numbered 446 (51%) (see Van Baren and Holwerda, 2001, for further information). Neighbourhoods here differ with respect to how attractive they are for travel by car, bicycle or public transport, whereas differences in household characteristics and types of dwellings are limited. In the neighbourhood of Wernaar in Houten it is attractive to

cycle. The use of the car is unattractive. The Achterveld neighbourhood in IJsselstein is the opposite: attractive to car lovers, unattractive to people preferring to cycle. The Zuilenstein neighbourhood in Nieuwegein takes a position somewhere in between the other neighbourhoods. All towns are connected to Utrecht by public transport systems: Wernaar (Houten) by train and the other two neighbourhoods by light rail (see Figure 1).
The relatively small difference among the neighbourhoods with respect to other characteristics is illustrated in the data on dwelling type. For example, the share of detached homes is limited to a maximum of 10% in the three neighbourhoods, and the share of apartments is less than 5%. Most dwellings are town houses and semi-detached homes. Densities (dwellings per hectare) are about equal.
Questions were asked with respect to travel behaviour variables, and personal, household and land-use variables. For our study two questions were added to those used by Van Baren and Holwerda (2001):

1. To which category do you belong? (categories: preference for car,preference for bicycle, preference for public transport, other: ……).
2. Is the choice to move into your neighbourhood related to a category chosen in the previous question (scoring was done by choosing from the answers: yes, partly, no, don't know).

The questionnaire starts with questions on several categories of variables. The first category is dwelling characteristics, followed by distances and travel-time facilities such as railway or light rail stations and bus stops. The next questions relate to mode availability and parking, and to distances, mode choice and travel frequencies to locations like schools, work, shops, recreation and friends/relatives. These are followed by questions on the attractiveness of the neighbourhood and on preferences for modes, as presented above. Finally, information on person and household characteristics is requested.
Techniques for analysis included cross-tabs, and the Chi-square test for significance and conventional multivariate regression.

4. Results

Table 1 gives the results of answers to the question on preferences.

Table 1. Preferences for modes (%) according to neighbourhood

	Wernaar (cycle-friendly)	**Zuilenstein (in-between)**	**Achterveld (car-friendly)**
Car	40.9	58.4	73.8
Bicycle	45.5	36.6	22.8
Public transport	13.6	5.0	3.4
Total	100.0	100.0	100.0

(Significant at the 95% confidence level)

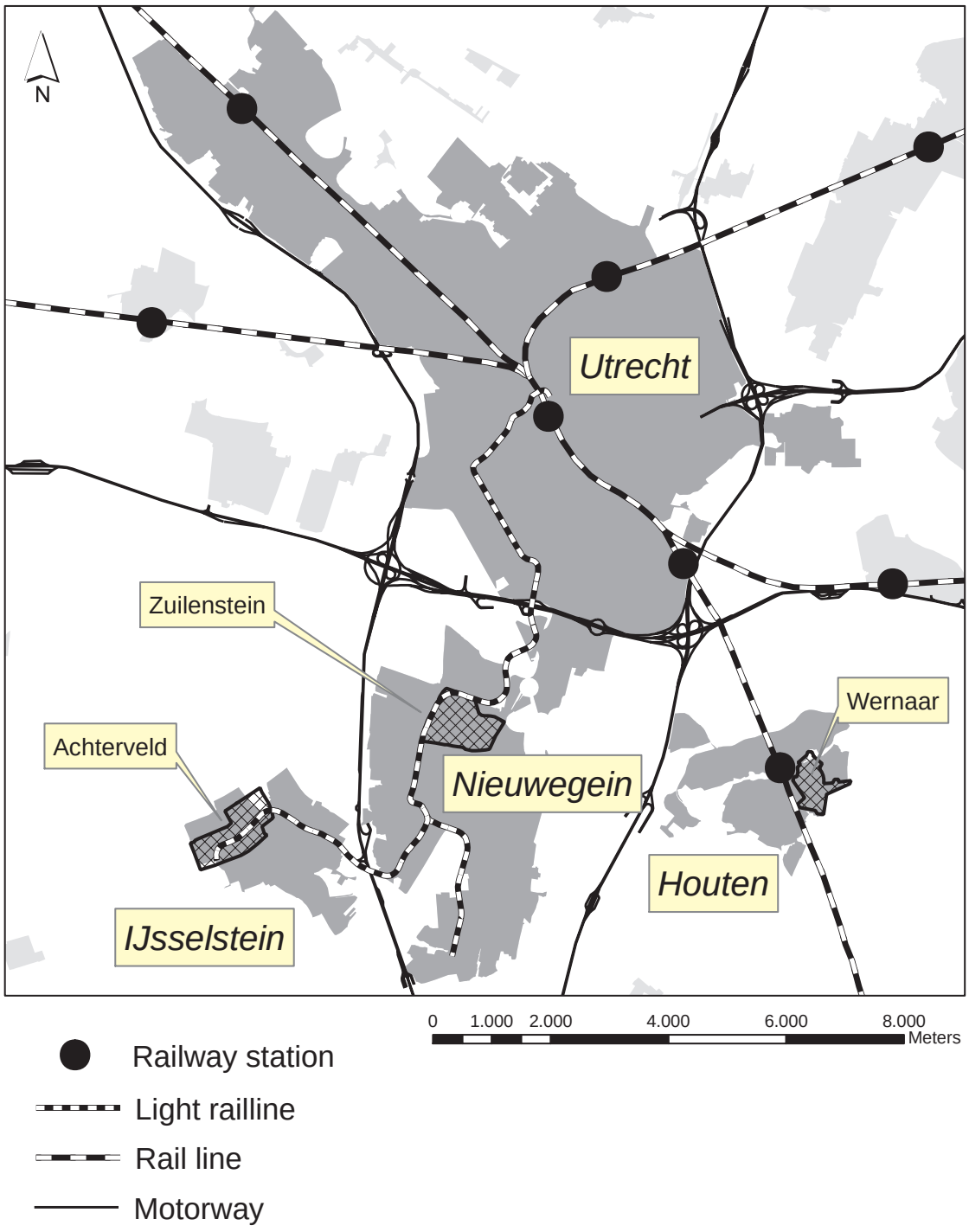

Figure 1: Situation of neighbourhoods in the region of Utrecht.

Table 1 shows preferences for modes to vary significantly among the neighbourhoods. In the cycle-friendly neighbourhood of Wernaar the share of people preferring to cycle is much higher that in the other neighbourhoods. The share of car lovers is much higher in the car-friendly neighbourhood of Achterveld. The 'in between' neighbourhood of Zuilenstein takes an 'in between' position with respect to preferences for modes. Wernaar, the neighbourhood with the best public transport connections (the only neighbourhood with a railway station), showed the highest share of people preferring to travel by public transport. However, in Achterveld, which is the least attractive neighbourhood for people preferring to travel by public transport, this share is lowest. Again, Zuilenstein takes an 'in between' position.
The results show a significant relationship between the preferences for modes and the attractiveness of neighbourhoods for the distinctive modes of transport. Theoretically, it is possible, but not very likely, that preferences change after the move to a neighbourhood (see also Bagley and Mokhtarian, 2002). This is why the second question was posed (see section 4). Table 2 gives the results.

Table 2. Relationship between preferences for modes and the responses given (%) on choice for neighbourhood as related to preference

	Car lovers	Bicycle lovers	Public transport lovers
Yes	14.2	22.8	45.5
Partly	12.8	26.0	22.7
No	73.0	51.1	31.8
Total	100	100	100

(Significant at the 95% confidence level)

Table 2 shows that mode preference played a role in people's residential choice, especially for public transport lovers. The preference of car lovers is of much less importance for the residential choice. This is consistent with expectations, as already presented in section 2: preferences are more important for 'public transport lovers' than for 'car lovers' since the road network is, spatially seen, much more developed than the rail (and bus) network. Therefore accessibility to locations by public transport varies much more than accessibility by car. Bicycle lovers take an in-between position. In summary, a spatial selection related to preferences for modes does exist, and forms at least part of the result of people's residential choices.
An important question here is: Are the preferences for modes related to personal and household variables? If so, ignoring them will hardly have consequences for policy-making and research. Assume that preferences are one-to-one related to income, and that income is included in the research but preferences for modes are not. In this case, there is no problem in ignoring preferences: i.e. including preferences in addition to income adds no additional explanatory power to models for travel behaviour. But if preferences are either not, or only partly, related to personal and household variables, ignoring these preferences results in an overestimation of the impact of land use on travel behaviour. For this reason, we analysed the additional explanatory power of preferences. We estimated multivariate regression models, starting with models with travel-behaviour variables as dependent variables, and personal, household and land-use variables as independent variables. Preferences were then added as additional independent variables. This method allows for estimating the additional explanatory power of preferences. Besides, we estimated the explanatory power of only

preference variables. In other words, we estimated regression models that only include preference variables as explanatory power. Results are given in Table 3, where only significant variables are included.

Table 3. Results of analyses showing additional explanatory power of preferences in multivariate regression models

Dependent variable	Preference variable	Additional explanatory power (% increase)	Explanatory power of only preference variables	Direction of impact of preference variable on dependent variable
Number of trips by car	Preference for car	9	23.1	+
Total distance travelled by car	,,	3	10.3	+
Number of trips by bicycle	Preference for bicycle	30	24.5	+
Total distance by bicycle	,,	15	16.7	+
Number of walking trips	,,	3	0.6	-
Number of trips by public transport	Preference for public transport	60	12.4	+
Total distance travelled by public transport	,,	30	9.9	+

Table 3 shows the additional explanatory power of the preference for car, on car use (number of trips and distance travelled) to be limited but significant. Additional explanatory power of preferences for the bicycle on the number of trips and distance travelled by bicycle is much larger (30 and 15%, respectively). The largest additional explanatory power results from adding the preference for public transport to the number of trips and distance travelled by public transport: 60 and 30%, respectively. Note that column 3 in Table 3 shows the *additional* explanatory power of the preference variables only. Column 4 shows the explanatory power of only the preference variable. The column shows preferences to have a substantial explanatory power. for both the number of trips by the distinctive modes and distance travelled, whether by car, bicycle or public transport. The explanatory power of preferences for the number of trips is greater than in the distance travelled, varying from 12 to 24% for the number of trips and from 5 to 17% for the distance travelled.

This paper does not have the intention to present all models for the number of trips and the total distance travelled for all modes, with or without preference variables. However, in order to illustrate the impact of adding preference variables, we present the model for the total distance travelled by public transport. A public transport model is preferred, because the impact of preference variables is relatively great for public transport variables (see Table 3). Distance and not the number of trips is preferred, because for several policy aspects, such as emissions, energy use, noise, infrastructure implications and financial aspects, distance is

more relevant than the number of trips. Table 4 presents the models with or without preference variables. Only significant variables are included in the models.

Table 4. Models for total distance travelled by public transport, without and with preference variables

A. model without preference variables

			Standardized Coefficients	t	Sig.	Rsquare	Adjusted Rsquare
	B	Std. Error	Beta				
(Constant)	21.42	7.60		2.82	0.005	0.21	0.20
distance dwelling - work	0.69	0.09	0.28	7.74	0.000		
car ownership	-31.85	6.13	-0.19	-5.20	0.000		
distance train station < 500 m	28.13	5.96	0.17	4.72	0.000		
appartment / flat	52.50	16.88	0.11	3.11	0.002		
distance to social-recr. destinations	0.10	0.03	0.11	3.13	0.002		
two or more cars	-8.72	3.36	-0.10	-2.59	0.010		
age (lineair, square)	0.00	0.00	-0.08	-2.19	0.029		
live in neighbourhood Achterveld	-7.27	3.66	-0.08	-1.98	0.048		

B. model with preference variables

			Standardized Coefficients	t	Sig.	Rsquare	Adjusted Rsquare
	B	Std. Error	Beta				
(Constant)	14.86	7.40		2.01	0.045	0.26	0.25
preference for public transport	40.39	5.88	0.25	6.87	0.000		
distance dwelling - work	0.66	0.09	0.27	7.68	0.000		
distance train station < 500 m	26.17	5.76	0.16	4.54	0.000		
car ownership	-21.85	6.09	-0.13	-3.59	0.000		
appartment / flat	44.35	16.33	0.10	2.72	0.007		
age (lineair, square)	0.00	0.00	-0.12	-3.33	0.001		
two or more cars	-7.44	3.25	-0.09	-2.29	0.022		
distance to social-recr. destinations	0.08	0.03	0.09	2.61	0.009		
live in neighbourhood Achterveld	-7.11	3.54	-0.07	-2.01	0.045		

Table 4 firstly shows the strong increase in the R square value, i.e. from 0.20 to 0.26, so an increase of 30%, as already presented in table 3. Secondly, apart from the preference variable, the same eight variables are included in the models. This implies that the significance of these variables did not fall below the 95% level. Thirdly, Table 4 shows that, apart from the preference variable, four out of the eight variables included are land-use and transport related, i.e. distance between dwelling-place and work, short distance to train station, distance to social-recreational destinations and the dummy for living in the car-

friendly neighbourhood of Achterveld. This illustrates the relatively great importance of these variables. Fourthly, the standardised coefficients as well as the t-values of almost all variables decrease and the significance diminishes after adding the preference variables. The only exception is the increase of the dummy for living in the neighbourhood of Achterveld. This variable has a negative sign, as expected, which means that people living in that neighbourhood, ceteris paribus, travel less kilometres by public transport. The t-value of this dummy increased after adding the preference variable.

Note that results will depend on the neighbourhoods selected for the research. If neighbourhoods with more differences between relevant neighbourhood characteristics had been chosen, the impact of spatial selection and preferences for modes would have been larger. Fewer differences between neighbourhoods would have resulted in smaller impacts. Therefore the results do not refer to the general impact of neighbourhood characteristics. For example, more research is needed for estimating the impact on a national level.

Although the regression analyses as presented in Table 3 relate to the additional explanatory power of the variables, preferences are not completely independent of person and household characteristics (see also Table 4). Tables 5 and 6 present personal and household variables that significantly (at a 95% confidence level) relate to preferences for modes. In the analyses people who answered, 'I don't know', to the question on whether their residential choice was related to their preferences were excluded.

Table 5. Personal and household characteristics related to preferences for modes

Variable	
Household size	One- and two-person households more often have a preference for public transport, and less often for the car and bicycle, compared to other households.
Age	People under 46 relatively often have a preference for cars, older people for public transport.
Income	People with higher incomes (> 1350 euro per month, after paying tax) more often have a preference for cars and less often for public transport
Car ownership	People owning a car much more often have a preference for cars (61%) compared to those not owning a car (5%); this at the cost of the preference for both the bicycle and public transport For a household with two cars or more the preference for cars is even stronger
Sex	Women less often have a preference for cars and more often for the bicycle.

Table 6: Personal and household characteristics related to the question of preferences for modes influenced residential choice

Preference for modes played a larger role for:	
Household size	One- and two-person households
Age	People over 45
Car ownership	People not owning a car

The results of Table 5 more or less conform to expectations. People owning a car, people with higher incomes and people with larger households have a more than average preference for cars. Also men and people younger than 46 have a strong preference for cars. This influence may come from two directions: 1) people with a preference for cars will – ceteris paribus – more likely own a car, or 2) car ownership and car use may result in a preference

for cars. Results here (see Table 6) are also according to expectations. People with a preference for cars are less likely to adapt their residential location according to their preference than people who prefer to travel by public transport (see also section 2 and Table 2). Table 6 therefore includes variables that are related to preference for public transport.

5. Discussion of the implications

An important question here has to do with the implications of these results for research and policy-making. It is clear that the omission of relevant variables generally leads to an overestimation of the impact of other variables. In this case the exclusion of preferences for modes may easily lead to an overestimation of the impact of other variables on travel behaviour, land-use variables included. This section focusses on the relevance for the impact of land use on travel behaviour. The results show that model preference seems to be strongly associated with both travel behaviour and the choice of residential location. If this is ignored, it might lead to an overestimation of the effects of land use on travel behaviour. Therefore, also models based on empirical research ignoring these preferences may overestimate the impact of land use on travel behaviour.

The importance of this overestimation is dependent on several factors. Firstly, the overestimation of the impact on public transport use is very likely to be greater when compared to the impact on car use. Preferences for cars are of less relevance for the impact of land-use variables on travel behaviour than preferences for public transport, the explanation being that locations vary much more with respect to public transport accessibility than to car accessibility (see sections 2 and 4). Secondly, the overestimation of the impact of a change in the already built-up environment (such as the opening of a new station) will probably be greater than in a new situation. In the already built-up environment, people will have chosen their residential location based on the characteristics of the neighbourhood in the situation before the change. In a neighbourhood that still has to be built people will make choices according to the new situation. Spatial selection will occur according to the new situation. An example to illustrate this follows. Let us assume that in a neighbourhood already built, a new railway station is to be constructed. According to empirical research that ignores preferences for modes, this will probably lead to train use being lower than expected. This is because the neighbourhood in which the new station is to be built has relatively few public transport lovers. People living in that area will use the train less frequently than people living in an area where there has been a station for a long time. Only after a long time – when many people have moved – will the predicted effects occur.

Does the spatial selection with respect to modal preferences mean that land-use policies aiming to influence travel behaviour are not relevant? We think the answer to this question is ‘no’: these policies are still relevant. By building attractive locations for people who prefer to travel by public transport or by bicycle, those with such preferences are able to travel accordingly. This has special advantages for sustainability issues that very often constitute a reason for implementing land-use concepts that affect travel behaviour. These issues include emissions of pollutants and impacts of infrastructure on nature, the landscape etc. Sometimes possibilities to travel or to participate in activities also form part of the sustainability discussion in referring to the social aspect of sustainability (apart from the economic and environmental aspects). Despite there being fewer effects than predicted, overall benefits of

such planning concepts may exceed the costs. A broad inventory of all costs and benefits should lay the basis for policies with respect to land use and transport. Such an inventory may include:

1. Preferences of people for living in specific neighbourhoods and spatial settings. Financial aspects, both for the government and the people living in specific areas, as well as for firms having shops, offices etc. in those areas.
2. Environmental implications, from the local level (e.g. noise nuisance, local air pollution) to the global level (CO_2 emissions).
3. Accessibility implications, including not only those related to congestion but also the implications from a geographical perspective: to what extent can people participate in activities at different locations?
4. Safety, both conventional (number of people killed or injured in accidents) and subjective safety, with limitations on behaviour due to the poor level of safety (e.g. children who can not play on the street).
5. Land take/open space conservation, both in terms of acreage and limitations due to infrastructure.

(Van Wee, 2002).

Sometimes it is argued that land-use policies should not be considered for such reasons as the reduction of CO_2 emissions (VROM-raad, 1999): other options, such as technological improvements, are supposed to be more (cost-effective). We think such a comparison is difficult. In countries with a planning tradition, land-use development (new residential areas, new areas for offices etc.) is planned anyway. The question then is: What are the advantages and disadvantages of land-use alternatives? We think travel demand, and its impacts, should be included in ex ante evaluations even if they are small; this should be no reason for excluding them.

6. Conclusions and recommendations for further research

The main conclusions of our research follow:

1. There is hardly any literature on preferences for modal choices within so- called homogeneous groups of people and on the impact of these preferences on residential choices.
2. Preferences for modes do exist and have an impact on people's residential choices. In particular, people with a preference for public transport include public transport accessibility in their residential choice.
3. Preferences for modes have a significant impact on the number of trips, as well as on the distance travelled by mode. This conclusion holds for car use, the use of public transport and cycling.
4. The omission of preferences for modes may result in an overestimation of the impact of land use on travel behaviour. This does not make land-use policies resulting in a lower level of car use unattractive: such policies give people with preferences for public transport or cycling the opportunity to travel according to their preferences.

It was relatively easy to carry out this research because we were able to combine it with research into the impact of neighbourhood characteristics on travel behaviour. This combination also resulted in limitations, for example, with respect to the desegregation of analyses because of the sample size. It is recommended to further investigate the existence of preferences for modes and to analyse the relationships with other personal and household variables, along with land-use variables. Structural equation models are able to deal with the interrelationships between such variables (Bagley and Mokhtarian, 2002). Besides, not only could mode preferences be a subject for study, but also preferences with respect to other travel behaviour aspects like travel time and distance. In other words, a broad selection of preferences, attitudes and life styles should be the subject of study. We also recommend research into the relevance of these preferences, attitudes and life styles for the impact of land use on travel behaviour. This may be revealed-, but also stated-, preference research. Longitudinal research, as distinguished from research based on cross-section data, may also give further insights. Finally, we advise carrying out such research into different types of countries and regions, since the results of such research in the USA may differ from results in EU countries or Japan.

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