Transit Oriented Urban Environments Reduce Travel – A Fairytale !/?

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1. Introduction

There is a tendency among professional of different feathers to overrate the impact, importance and relevance of their decisions. Urban pla nners and designers are no exception in this regard. The underlying thrust of many planning concepts is that morphology and urban form have a strong influence on human behaviour. This premise seems to have dominated the evolution of many concepts. The rece nt discussion on sustainability is no exception. There is a belief that transport-oriented urban environments with mixed land use, high density and high quality public transport will reduce car use and mobility and hence increase the market share of slow modes of urban transport.

Fortunately, in addition to pure beliefs, this topic has generated a substantial amount of empirical research, which examined the relationship between urban form and mobility patterns. For example, several authors have reported positive effects of neo-traditional and related designs on mode choice (Friedman, *et al*, 1994; Cervero and Gorham, 1995; Cervero, 1996; Nasar, 1997 and Florez, 1998). Other studies report empirical evidence of the relationship between mode choice and higher densities or mixed land use (e.g., Handy,1993; Frank and Pivo, 1994; Næss, *et al*, 1995; Næss and Sandberg, 1996;; Schimek, 1996; Kitamura, *et al*, 1997; Jacobsen, 1997). Other studies on the influence of urban form on travel behaviour in North America and Europe include Breheney (1995), Owens (1996), Giuliano and Small (1993, 1998) and Gordon and Richardson (1996).

Unfortunately, however, the majority of these research endeavours does not seem to satisfy a minimum set of methodological requirements to rule out other explanations of the found relationships. At least three commonly made mistakes can be identified. First, sociodemographics tend to be highly correlated with urban form characteristics. Consequently, even if a significant correlation is found with mobility, it is not readiliy evident whether differences in mobility can be attributed to differences in urban form, or to sociodemographics, or to both. Simply ‘controlling” for sociodemographics is not good enough. Ideally, already at the stage of sample design, one needs to ensure that environmental characteristics are (almost) uncorrelated with sociodemographics.

Alternatively, one should test alternative causal structures, using advances statistical methods.

Secondly, most studies tend to focus on single trips. However, there is a substantial amount of empirical evidence in the literature about compensating effects: less travel across the week is associated with more weekend travel and vice versa; less travel for work is associated with more leisure travel. Thus, examining integral (weekly) activity-travel patterns as opposed to trips for specific purposes would constitute of better basis for assessing the impact of urban form on mobility.

Finally, much research contains serious methodological flaws. Often, individual-level data on mobility and socio-demographics is correlated with neighbourhood level characteristics of urban form. This implies that independent measures and thus a larger sample are assumed, but this assumption is false. In effect, the sample size is smaller. The false assumption of independent observation leads to smaller standard errors, and hence larger t-statistics. Thus, much of this research has falsely concluded that particular effects were statistically significant whereas in reality they were not.

It is against this background that I will argue in this paper that the impact of transport-oriented urban environments on travel is less than many planners and designers would like to believe. To this end, I will first discuss some claims in favour of transport-oriented urban environments. Then, I will express some thoughts on the implications of the accumulated empirical evidence on planning policy. Where possible, I will discuss evidence of Dutch research.

2. If we Build it, They Will Come

Transit-oriented environments have often been suggested as a solution to sustainable transport systems and urban environments. According the European Union, a sustainable transport system is one that:

a. allows the basic access and development needs of individuals, companies and societies to be meet safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;

b. is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development

c. limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise.

d. In other words, "sustainable transport may de defined as an evolving set of strategies designed to provide effective transport services, while keeping the internal and external costs of such service within acceptable limits.

Transit is typically seen as an example. Different public transport models should be organized as a seamless network, with maximum ease of interchange between one mode and another. Land use planning should support such development in terms of mixed land use and higher densities.

It does not take long to realize that the above definition is a typical political definition: it lacks rigor, is vague and potentially inconsistent. Regardless, it seems to be based on the notion that if we build such sustainable (transit-oriented) systems and urban environments, people will use it. Where did we hear this before? Is there any empirical evidence to support this view?

3. Empirical evidence

In this section of the paper, I will summarize some research in the Netherlands, that I was involved in that shed some light on the influence of characteristics of the urban environment, including public transport on travel patterns and mobility.

CASE STUDY 1.

The first study that I will discuss (Snellen, Borgers and Timmermans, 2002) adheres to most methodological principles discussed in the introduction of this paper. Thus, a quasi-experimental design was used to ensure that socio-demographics were largely independent from urban form characteristics and multi level analysis was applied to account for different number of observations of different levels of spatial resolution. The goal of this research project was to analyse the relationship between urban form, road network type and indicators of mobility. Neighborhoods were selected in two stages. First, a number of cities was selected such as to reflect differences in morphological urban form and network types for the main road system for motorised transport. Within these cities neighbourhoods were selected. Based on the literature on historic and more recent urban forms, six different forms (Figure 1) were selected: concentric city (1), the lobe city (2), the linear poly-nuclear city (3); the concentric poly-nuclear city (4), the linear city (5) and the grid city (6).

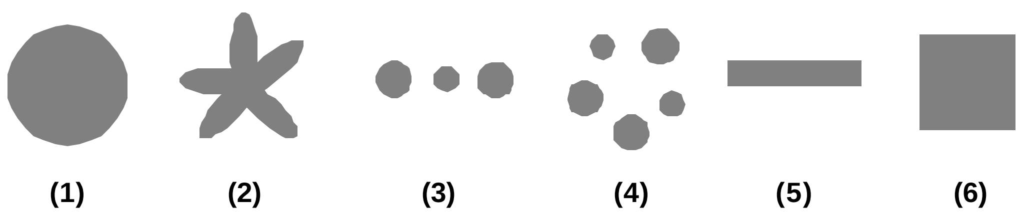

Figure 1: *morphological urban forms*

The second basic element of an urban concept was the transportation network. In theory, networks for motorised transport (the road network for the car), non-motorised transport (network for bicycles and/or pedestrians) and for public transport can be distinguished. However, since not all cities have separate networks for non-motorised transport and the public transport networks in all cities are very similar, only networks for motorised transport were considered in the choice of cities. Five elementary networks were distinguished: the linear network (1), the radial network (2), the ring (3), the grid (4) and the shifted grid (5) (Figure 2).

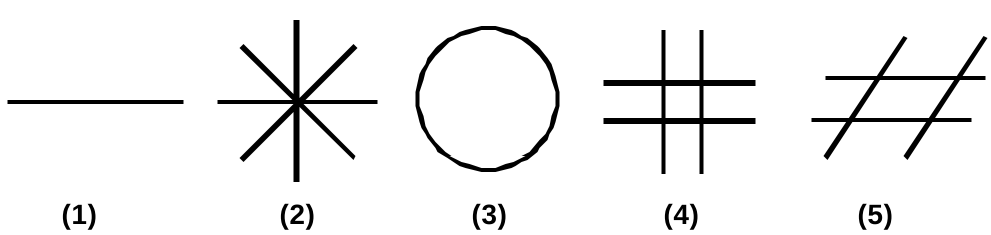

Figure 2: *Elementary transportation networks*

Based on these two basic characteristics cities were chosen for data collection. In total, 10 cities were selected. Having selected the cities, the next step involved choosing the neighbourhoods within these cities. Because activity-travel patterns are known to be influenced by the relative location of individuals and household to such elements as the downtown area, the main IC-train station and, if present, regional shopping centres, neighbourhoods were selected such that they would have low correlation on these dimensions. In particular, three central considerations dictated the choice of neighbourhood: 1) two neighbourhoods per city; 2) two neighbourhoods in every ring from the city centre and 3) best possible combinations with regard to the other dominant urban elements. A total of 19 neighbourhoods were selected. The characteristics of the chosen neighbourhoods were tested for correlations to check if the chosen neighbourhoods actually allow us to test the relationships between characteristics of the urban environment and activity and travel patterns. Correlations were calculated for 10 characteristics: morphological urban form, city road network type, neighbourhood road network type, local street network type, employment (number of jobs/businesses), location of city within the Netherlands (inside or outside the Randstad Holland), distance from neighbourhood to city centre, distance from neighbourhood to IC-station, distance from neighbourhood to the regional centre, and density (inhabitants and/or dwellings). The results indicated that most characteristics were only (modestly) correlated. More specifically, only a few spatial characteristics showed associations, exceeding 0.5. Distance to city centre is highly correlated with distance to the main train station because the main train station is usually located in the city centre. Most importantly, however, there is no evidence of any significant correlations between the selected physical attributes and the socio-demographic characteristics. In fact, all these correlations are very low indeed.

Multilevel models were estimated for four types of frequent trips (work, grocery shopping, other shopping and leisure) separately. Two levels, neighbourhood and individual were used. Separate models were estimated for (i) the total number of kilometres, (ii) the total number of trips, (iii) the number of kilometres per mode, (iv) the number of trips per mode, and (v) mode shares for both kilometres and trips. Models were estimated using data from respondents who indicated that they actually participated in these activities. The models for total kilometers and trips (by mode) give an indication of the total mobility, while the models for mode shares give an indication of the relationship between the choice of modes for certain trips and the independent variables. Mode share was measured as the proportion of times a particular transport mode was chosen. Several independent variables were selected for analysis. One group of variables described the spatial context in which the travel behaviour was measured, and constitutes the neighbourhood level in the multi-level analysis. A second group of variables described the socio-economic characteristics of the individuals, and constitutes the individual level in the multi-level analysis.

The neighbourhood characteristics included the following variables: urban form, transportation network type at the city level, and transportation network type at the neighbourhood level, local street network type, location of city within the country (inside or outside Randstad, the most urbanised area in the Netherlands), distance to city centre, distance to inter city station, employment level in the city, defined as the number of jobs in the city per 1000 inhabitants, land use mix in the neighbourhood, locally available shopping facilities, defined in terms of five levels, locally available sports facilities, describing whether the neighbourhood has sports facilities, housing density, population density and degree of urbanisation, defined in terms of a number of classes.

The variable 'transportation network type neighbourhood' describes the type of network that can be discerned for the neighbourhood as a whole. The range of basic transportation networks was found not adequate for the description of the differences between neighbourhoods. Therefore, additional types were distinguished, which typically are compounds or specific manifestations of the basic forms (Figure 3).

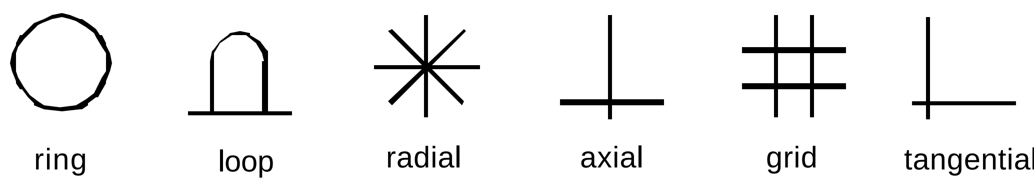

Figure 3: *Transportation network types neighbourhood*

The variable 'local street network type' refers to the network type that can be discerned within a neighbourhood at the street level. This low level gives an indication of the network type in the immediate proximity of the dwellings. Again additional network types were identified, some of which are composites (Figure 4).

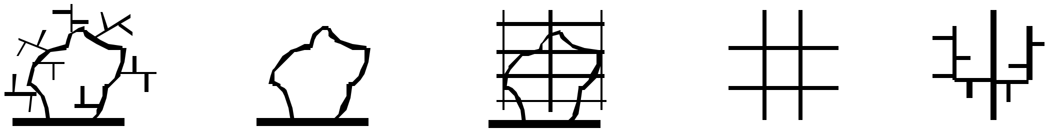

Figure 4: *local street network types*

The degree of urbanisation was defined in terms of a number of classes. For each address in a neighbourhood, the average number of number of addresses per square kilometre within a 1 kilometre radius was calculated. These numbers were then averaged across addresses in a specific neighbourhood. Based on this density measure, 5 degrees of urbanisation were distinguished: 'very strongly urbanised' (address density of 2500 and over), 'strongly urbanised' (address density between 1500 and 2500), 'moderately urbanised' (address density between 1000 and 1500), 'weakly urbanised' (address density between 500 and 1000) and 'not urbanised' (address density below 500). Data was obtained from Statistics Netherlands and the municipalities in question.

The socio-economic variables at the individual level included age, gender, level of education, personal income, driving license, car availability, employment status., household income, household type, and dwelling type, and the average distance per trip to the chosen location for the purpose in question.

The results indicated that the effect of urban form on the various indicators of mobility is negligible. Significant parameters were only found for home-to-work trips, not for any of the other activities, and then only for the lobe city. The share of motorised kilometres travelled for work trips by inhabitants of lobe cities is reduced 0.8 percent more with an increasing distance to work than in a grid city. The results indicate that in lobe cities public transport is used more for home-to-work trips. Given that most Dutch medium-sized cities have a radial public transport network, this result is as one would expect.

As for city transportation network type, city network type, the results indicated that network type has no significant effect on any mobility indicator in the case of grocery shopping and leisure. In the case of non-grocery shopping, there is an effect on the number of kilometres travelled by car. The number of motorised kilometres in cities with a ring network is significantly higher for those individuals that always have a car at their disposal. However, when interpreting this result, one should realise that some significant results can be expected for statistical reasons only.

The results for network type of the neighbourhoods, indicated that the network type of the neighbourhood has some influence on both types of shopping trips, but not on leisure or home-to-work trips. For grocery shopping, there is a positive parameter for share of motorised kilometres in loop structured neighbourhoods. For other shopping trips, radial neighbourhood networks reduce the number of motorised trips, while loop networks increase this number (for those people who sometimes have a car available).

Overall then, the results of this study indicate that urban form and network type in this Dutch sample only have a modest effect on mode choice decisions for frequently conducted activities. Many potential effects were non-significant. Moreover, for statistical reasons only, one will always find some effects to be significant, even though they have no apparent substantial meaning or interpretation.

CASE STUDY 2.

Unlike the previous case study, which focused on individual trips/activities, in another study involving the same neighbourhood, Snellen, Arentze, Borgers and Timmermans (2001) analysed differences between neighbourhoods for a set of indicators, based on the Albatross model (Arentze and Timmermans, 2001, 2004), developed for the Dutch Ministry of Transportation [11]. These indicators summarize aspects of activity-travel patterns. They included average travel time, average total travel distance, average car travel time, average travel distance by car, travel time ratio car – public transport, travel time ratio car – slow transport, average number of car trips, average number of tours, trip – tour ratio, ration single stop – all *tours, distance ratio car driver – total , distance ratio public and distance ratio slow traffic – total.*

To test whether differences in these indicators were systematically and significantly related to the urban form and network types, discussed earlier, a series of regression analyses were performed. In each case, the dependent variable of the regression analysis was the performance indicator, whereas the independent or explanatory variables were indicators of urban form (concentric, lobe, polynuclear, grid) and transportation network type (ring, radial, grid) respectively. The results of the regressions, which represent the impact of urban form on activity-travel indicators, suggested that the conduct of activity patterns does not significantly depend on urban form. The only significant parameter indicates that people in lobe cities travel significantly farther distances by public transport. Overall, however, these results provided strong empirical evidence that individuals and households tend to organize their daily activity-travel patterns according to their personal preferences and ability of adjustment, and that urban form, at least in the present cities, is not a significant factor in shaping these activity patterns.

The results of the regression analyses with network type as the independent variable in general amplified the results of the regressions, involving urban form. That is, the various descriptors of activity-travel patterns were not significantly related to network type at the city level, except for travel time ratio car/slow traffic. This effect may indicate that traffic runs slower in radial cities due to busy access ways. Thus, by and large, the results of this analysis re-enforce our conclusion that, at least in these cities, city-level characteristics of urban form and network type do not significantly influence the way in which people organize their daily activities in time and space.

The regression analysis was repeated at lower levels of spatial aggregation. That is to say, each of the performance indicators was regressed against the type of network, defined at the neighborhood level, and type of network defined at the street level using effect coding. Six types of neighborhood networks were identified: ring, loop, radial, axial, grid and tangential (base). It turned out that, by and large, the conclusion remained the same. There is a lack of evidence that activity-travel patterns are significantly influenced by the type of network, designed for the neighborhood. The only significant regression coefficients relate to the distance ratio slow traffic – total, but no immediate substantive meaning should be attached to this result.

At the street level, the following types were distinguished: loop/tree, loop, loop/grid, grid, grid and tree (base). Again, effect coding was used, implying that the regression coefficients represent deviations from the overall mean. Results indicated that transportation network does not seem to significantly affect the way individuals and households organize their daily activities in time and space. Most of the effects of the regression analysis were not significant at the conventional 5 percent probability level. Exceptions are some of the parameters for the loop/tree type. However, a more detailed inspection of the data indicated that these significant results could be explained by outliers in the data. Hence, we are inclined not to attach any substantive meaning to these significant parameters.

CASE STUDY 3.

As indicated in the introduction, an alternative way of trying to disentangle the effects of urban form on travel patterns is to assume and test causal structures. Maat and Timmermans (2003) assumed the structure shown in Figure 5.

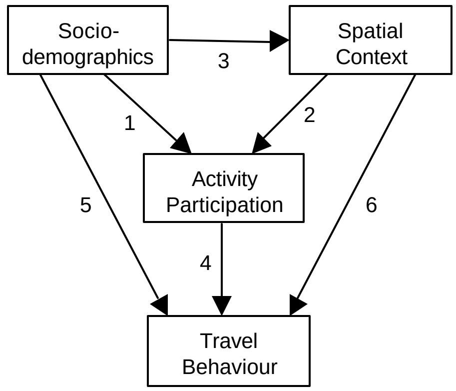

Figure 5. *Conceptual model of the relationship between socio-demographics, land use and activity participation*

First, it was assumed that travel results from a complex decision-making process in which people try to satisfy their preferences and needs by taking part in activities. The differences in the characteristics of individuals and households are reflected in their tastes and needs and subsequently determine the nature of their activity patterns. For example, men are assumed to spend more time than women on subsistence activities. Likewise, extra travel time needs to be generated in young families because of the need to bring and get children to and from school and sport clubs which, in turn, leaves less time for other activities. Secondly, choice is assumed to be also limited by the (lack of) opportunities in the spatial context. The more compact the spatial configuration – because of higher densities or mixed-use – the shorter the distance between home and the location of the activities and the easier it becomes to use the available amenities. Thirdly, it was assumed that there is a close connection between the residential environment and household characteristics. Households with children are more likely to choose a home in a suburb and resign themselves to living farther from the urban amenities. Fourthly, a crucially important relationship in this model is that travel stems from the wish to engage in activities. The number of out-of-home activities determines the number of trips and therefore has a strong influence on travel times and the number of trip chains. This relationship is complex because, on the other hand, time-budget relationships can also be inferred: saved travel time frees up more time for other activities which, in turn, may lead to new trips. Alternatively, the saved travel time can be used for more favoured destinations, possibly with a greater value. It is also assumed that activity participation is dictated principally by subsistence activities. The amount of time spent on maintenance and discretionary activities depends on the time that is left. Personal and household characteristics exercise an indirect influence on travel behaviour via activity participation. But there are also direct influences; for example, the presence of a car directly influences the amount of time it takes to reach a destination. The influence of the spatial context also runs indirectly via activity participation, but a direct relationship exists as well. The more compact the built environment, the shorter the distances and the greater the savings in distance and travel time. Moreover, there is a greater chance that several destinations can be combined in a single trip chain, which also significantly cuts distance and travel time. People will be more likely to use slow forms of transport (walking, cycling) because the distances are shorter. Higher densities also offer a better support base for public transport. Finally, compactness and higher density invariably lead to lower traffic speeds and reduce opportunities for using cars. Nonetheless, time-budget effects also play a role here.

This conceptual model was tested using structural equation modelling. In order to obtain the required data, a new, comprehensive data set was collected based on a newly developed activity diary (Arentze, et al, 2002). A range of land-use and accessibility indicators was developed from a variety of spatial data sources. The research covered 57 neighbourhoods in a central and highly urbanized part of the Netherlands, which includes the cities of Amsterdam and Utrecht and some smaller towns, suburbs and villages. The neighbourhoods were chosen carefully such as to encompass a wide variety of urban forms.

The survey was conducted in the spring and autumn of 2000, involving a total of 3,412 individual questionnaires and diaries, covering 1,960 households. The main survey involved a questionnaire with a list of questions related to the household and residential context plus a personal questionnaire focusing on demographic and socio-economic characteristics, a personal questionnaire about customary activity patterns, and an activity-travel diary. All the respondents were asked to record their activities and trips in the diary for two consecutive days, with the pairs of days staggered across the seven days of the week.

The spatial data were derived from a variety of sources and pre-processed with the aid of a GIS. Dwellings were obtained from the LBV National Database of Real Estate (1999), and the number of employed persons from the LISA Register of Businesses (1999). The Basic Register of Points-of-Sale (1999) contains detailed information on shops, including the amount of floor space devoted to sales, broken down for daily shopping and non-daily shopping. The data were assigned to their locational position with the aid of postal codes, which provide highly detailed spatial information. Distances and travel times between origins and destinations were calculated using the Basis Network (2000).

To reflect the characteristics of the built environment, data on urban land use were converted into several indicators. Density was measured in single-use indicators, namely the number of houses, jobs, and shopping floor space, as well as the proportion of multi-storey dwellings. Furthermore, a density index was developed, which used one figure for each cell to express the total density of housing, employment, and shopping. Since these categories are measured in units that are not comparable, the variables were standardized with the national totals. The entropy index was used as a measure of land-use mix of housing, employment and shopping.

Important to the present discussion are the results pertaining to the influence of land use variables on travel patterns. A large number of land-use variables were tried in the model, experimenting with various densities, the entropy index for mixed-use and proportion of multi-storey dwellings. Eventually, it was found that only two measures resulted in an acceptable goodness-of-fit: the composite density index and the entropy index. It transpired, however, that in this model entropy had no effect on any of the endogenous variables. Moreover, the explained variance of density as an independent variable is low (only 7 percent). The effects of socio-demographics are plausible. In particular, the availability of a car was negatively related to density, while a discount ticket for public transport was positively related to density. People with children in both age groups (and higher) tend to opt for lower-density areas.

The influence of density as a predictor of activities and travel indicated that as density increases more time is spent on maintenance and discretionary activities. This can be explained by the fact that higher densities go hand in hand with amenities. It also has a positive direct influence on the number of trips and an indirect positive influence through the activities. This is an interesting and important result: although one would like to believe that density has a direct negative effect on travel time, this is appears not the case in this study. In fact, travel time tends to increase as a result of the indirect effect of the extra trips in high-density neighbourhoods.

The empirical findings discussed above seems to suggest that in an equilibrium situation the impact of urban form on mobility and activity-travel patterns seems highly modest at best, at least in the Netherlands. Individuals and households apparently give highest priority to the activities they need and especially wish to pursue, and space does not have a major impact on this decision-making process. However, one might also argue that by creating transport-oriented urban environments one will attract those individuals and households who either rely on public transport or desire to live a certain urban lifestyle, including the use of public transport systems (the argument of self selection). If this reasoning make sense, the influence of transport facilities on residential choice behaviour should be significant. Is there evidence to that effect in the Netherlands/Benelux? In the following, I will summarize several case studies that I have been involved in since the mid 1980s.

CASE STUDY 4:

This study (Louviere and Timmermans, 1990) was conducted in Roermond, a medium-sized town in the Netherlands. Using a sample consisting of 315 respondents, who just changed residence, the purpose of this study was to assesses the relative importance of house attributes, attributes of the residential environment, economic and social ties and relative location in the residential choice decision. The latter decision construct measured accessibility to respectively primary school, bus stop, neighborhood shopping center, regional shopping center, work and urban recreational facilities. The decision construct "attributes of the house" was represented by (i) number of rooms, (ii) type of house, (iii) mortgage/rent, (iv) size of backyard, (v) building period, and (vi) tenure. Using an experimental design approach, respondents judged attribute profiles on a category rating scale ranging from "extremely bad" (0) to "excellent" (10).

Similarly, six attributes were selected to describe the environment: distance to parking facilities, amount of traffic, view, privacy, greenery and children's playgrounds. Attribute profiles were evaluated using the same rating scale as the one used for the house attributes. The same design and rating scale was used for the relative location/accessibility construct.

Finally, the economic and social ties decision construct was represented by four two-level attributes: relatives in municipality, friends in municipality, work in municipality and previous place of residence. Respondents rated attribute profile descriptions in the same manner as they evaluated the other decision constructs.

An integrated design was constructed by treating the evaluations of the decision constructs as a factor with three ratings levels (2, 5, and 8). These ratings were chosen to span the rating scale. Nine rating combinations were selected using an orthogonal fractional factorial design. Next, each of these combinations was treated as a two-level (absent-present) factor and sixteen choice sets were created by selecting an orthogonal fraction of the 2^9 design. Respondents were requested to choose from each choice set the description they liked best. A multinomial logit model was used to estimate the parameters of the utility function.

In light of the aim of the present paper, we report only the estimated parameters of the four decision constructs. It turned out that the accessibility construct was the least important. The most important construct, on average, was the house construct, followed by residential environment and social and economic ties.

CASE STUDY 5.

This study (van de Vijvere, Oppewal and Timmermans, 1998) was designed to compare the validity of a classical stated preference experiment against a hierarchical information integration experiment with integrated choice experiments (Oppewal, Louviere and Timmermans, 1994). Data were collected for a convenience sample of 120 respondents who just moved to Louvain-la-Neuve, Belgium, a new town discussed with students and young urban people in mind. Consistent with the theory of hierarchical information integration, we assumed that individuals when choosing a house base their opinion on higher order decision constructs. In this case: house - residential environment-accessibility. Each of these higher order decision constructs was represented by a series of attributes. House was represented by availability of garage, dwelling type, number of bedrooms, monthly payments and building period. Likewise, residential environment was represented by quietness, greenery and socio-economic status, and accessibility was represented in terms of distance to respectively friends and relatives, work, bus stop, grocery store, shopping center and school. Thus, a total of 14 attributes was varied in the experiment.

Fractional factorial designs were used to create profiles by independently varying the attributes levels of interest and the remaining decision constructs for each decision construct separately. Three orthogonal main-effects designs, each involving thirty-two profiles were used. These profiles were randomly assigned to sixteen choice sets. In addition, a traditional fractional full profile experimental design, consisting of sixty-four profiles was constructed. These profiles were randomly assigned to thirty-two choice sets. Multinomial logit models were used to estimate the preference function and choice model.

The results indicated that the parameter estimates for the two design approaches were the same within statistical limits. Important for the present study is the analysis of the relative importance of the decision constructs. It turned out that the relative importance of the housing construct was estimated at 0.57, the importance of the residential environment at 0.52 and the importance of accessibility at 0.39. Thus, this study again suggests that accessibility is the least important decision construct for people choosing a house, even for people for decided to move to a especially designed urban environment, and who have less access to cars.

CASE STUDY 6.

This study (Timmermans and van Noortwijk, 1995) was conducted in the municipalities of Utrecht, The Hague (2nd and 3rd largest cities in the Netherlands), Tilburg, Oss, Hillegom, Naarden and Nieuwkoop in the Netherlands in the Spring of 1991. A total of 278 respondents participated in a SP experiment, varying type of dwelling, number of bedrooms, price/monthly rent and accessibility. Accessibility was categorized into four levels: near city center, other location in the city, suburban location and rural area. Although this is not a direct measurement of accessibility, the way neighborhoods are designed in the Netherlands implies that accessibility to the number and variety of facilities will tend to decrease with these levels. To estimate the choice model, profiles that differed in terms of these attribute levels were created. More specifically, an orthogonal main-effects-plus-cross effects fractional factorial design was created, resulting in thirty-two choice sets. A constant base was added to each choice set, described as "none of these". Because the multinomial logit model cannot be used to estimate a context-dependent model, a choice model not characterized by the independence-from-irrelevant-alternatives property was estimated.

The importances of the attributes that were varied in the experiment were estimated separately for the owner-occupied sector and the rental housing sector. The results suggested that price is the most important variable for both sectors. For the rental sector, it is even more important in absolute terms than for the owner-occupied sector. This was followed by type of dwelling. Accessibility was the least important variable for the owner-occupied sector. As expected, it was slightly more important for the rental sector, as this sector is dominated by low income households. Thus, the findings of this study seem to suggest that on average if people have a choice they do not prefer the central city areas.

There is a group of more constrained people who have less choice and hence are more dependent on such environments.

CASE STUDY 7.

In another SP experiment in the same municipalities among 240 recently divorced respondents, Timmermans, et al (1996) estimated a universal logit model of housing choice. Both the total number of attributes and the measures of accessibility were higher as compared to the previous case study. Housing submarkets were defined by three attributes: tenure, dwelling type and monthly payments. In addition, the following attributes were varied: building period, number of bedrooms, residential environment, social environment, accessibility to shopping, accessibility to work and availability of public transport. Hence, the stated choice experiment involved a total of 10 attributes. Tenure, monthly payments, building period, and availability of public transport were assigned two levels; the remaining attributes all had four levels.

The design of an experiment for this choice problem is not straightforward. In this study, the following design strategy was used. First, an orthogonal fraction of the 2^2 x 4 full factorial design was used to define the segments. This resulted in 8 segments. Next, an orthogonal fraction consisting of 32 profiles of the 2^2 x 4^5 full factorial design was selected to create profiles of the remaining attributes. These profiles were placed into choice sets. Sets were created from a fraction of the full factorial design, the levels of which were the presence or absence of each housing segment. Sixteen choice sets were selected. Each choice set thus differed in terms of size and composition. To ensure that each profile occurs at least once within each segment, four copies of this choice set design were created. Separately for each segment, the 32 profiles were assigned randomly to the available segment positions in the choice sets. A constant base alternative, described as "none of these" was added to each choice set.

As for the results, again, dwelling type and monthly payments were the most important variables. Accessibility, measured as distance to public transport, was the least important attribute of all ten attributes, varied in the experiment. Thus, the results of this study indicate that even for a group of recently divorced people, which often coincides with reduced budgets, accessibility to public transport is not a key concern nor a driver of residential choice.

CASE STUDY 8.

Molin, Oppewal and Timmermans (1999) explored the possibilities of developing group-based stated preference models, using residential choice behavior as an example. The attributes were assigned to two decision constructs: *housing* and *location*. Housing included the attributes housing type, number of bedrooms, size of the bedroom for children, monthly costs and tenure. The location construct included type of neighborhood, frequency of public transport and travel time to respectively work of father, work of mother, and school. To combine the attribute levels into residential profiles, an orthogonal fraction of the full factorial design was selected involving 16-profiles for each subexperiment. This design allowed the estimation of a main-effects-only model, which implies that all interaction effects are assumed to be equal to zero.

Families were requested to jointly express their overall preference for each of the 16 profiles on a 0 to 20-point scale. The extremes of this scale were labeled as 'very unattractive' (0) and 'very attractive' (20). Families participating in the present study were all residents of Eindhoven, the fifth largest city in the Netherlands, or residents of its smaller neighbor, the municipality of Veldhoven. All families consisted of a father, a mother and at least one child of 14 years of age or older. A total of 147 families completed the SP survey.

A simple main-effects-only model was estimated across the families. The findings suggested that *monthly costs* and *dwelling type* were the two most important attributes, which both belong to the housing construct. Third in importance is the *child's travel time*, which is thus the most important location attribute. *Number of bedrooms* is the next most important attribute, again a housing construct attribute. Next in importance is *mother's travel time* and *size of children's bedroom,* which is followed by *father's travel time*. Hence, families on average attach most importance to the child's travel time, followed by the mother's travel time, while they attach least importance to father's travel time. This is likely to reflect the typical task allocation in the Netherlands, where females often have part-time jobs and spend more time on child-raising and maintenance tasks. *Tenure* is the last housing attribute in the importance ranking. The relatively low importance of tenure is somewhat surprising given the large demand for owner-occupied houses in the Netherlands. Tenure is closely followed in importance by *type of neighborhood.* Clearly the least important attribute is *frequency of public transport*.

Hence, the housing attributes were clearly regarded as more important than the location attributes. Four housing attributes were among the five most important attributes against only one location attribute. The higher importance attached to housing attributes was also illustrated by the sum of the importance for each construct. Housing attributes accounted for 62.1% of the total importance, while the location attributes account for only 37.9%. If the location attribute *type of neighborhood* is ignored, then the other attributes, which can be regarded as accessibility attributes, have a joint importance of just 31.9%. Frequency of public transport by far had the lowest importance.

In conclusion, these five case studies, which span a period of almost a decade, involve different cities and study areas, have used different SP designs and have applied various model specifications, suggest that accessibility considerations in general and the availability and quality of public transport in particular are significantly less important than housing attributes and attributes related to the neighborhood. It seems that as long as people have the opportunity to afford flexible means of transport, the impact of accessibility and public transport on their residential choice behavior is relatively limited. This may be dfferent for people who necessarily rely on public transport. However, at least in the Netherlands, this does not constitute a sufficiently sizeable group to have a substantial policy impact. It suggests that the direct living environment generates more utility to people, on average, than the disutility of necessary travel. These consistent findings are at variance with some findings in the transportation literature (e.g., Gayda, 1998; Kaysi and Abed, 1999; Cooper et al, 2002; Walker, et al, 2002). Hence, there may be cultural differences. However, many of these studies have only varied a limited number of (transportation-related) attributes, often ignoring the attributes that turned out to be most important in our study. Hence, one cannot rule out the possibility that the results of such studies may be an artifact of their limited scope.

4. Further Thoughts

What are implications for land use and transportation policy? The results of all these cases indicate that land use and transportation policy cannot expect to have a substantial impact on housing/residential choice in terms of reducing mobility patterns. After health, a nice house in a pleasant and safe residential environment is probably of the highest utility to the majority of the people. They will search for that house and environment, subject to budget constraints, until they find it, and accessibility only plays a minor role. There is even some evidence that very close proximity to facilities and public transport has a negative effect on utility (Katoshevski and Timmermans, 2002). There may be a threshold in the sense that congestion on the road become so bad, that public transport has a clear advantage, but it seems this threshold is high and it also seems that such advantage can only be created in the multi-million world cities.

However, although accessibility is a less important variable in the choice of house, good accessibility and the associated land use mix may still increase the choice that people will use the facilities and hence may result in lower mobility at least for some trip purposes. Hence, although the strength is weak, this should be no reason for policy not to create accessible neighborhoods. The impact of policy may be stronger (at least in the Benelux) if marketing efforts would be made in an attempt to create a better fit between lifestyles, physical characteristics of neighborhoods, including accessibility to various (transportation) services and socio-demographics. Thus, there is no reason to argue that the policies as such are wrong. However, expectations may be too high.

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