

The Built Environment as a Décor of Unfolding Housing Careers and Activity-Travel Patterns: Reflection and Research Agenda

Aida Pontes de Aquino

Faculty of Architecture, Building and Planning - Eindhoven University of Technology - P.O. Box 513 - 5600MB Eindhoven - The Netherlands – a.p.pontes@bwk.tue.nl,

Harry Timmermans

Faculty of Architecture, Building and Planning - Eindhoven University of Technology - P.O. Box 513 - 5600MB Eindhoven - The Netherlands - H.J.P.Timmermans@tue.nl

ABSTRACT

This paper reviews the existing literature on the relationship between the built environment and travel behaviour. It takes a critical stance and argues that even after discounting those studies that are hampered by methodological flaws most studies did not provide convincing evidence that characteristics of the built environment are causally related to facets of travel behaviour. This is in part due to inherent limitations of fitting functions to survey data, and in part to the fact that some more comprehensive approaches were not always very critical in fine-tuning the approach to the specific aim of the study. Keeping these considerations in mind, most empirical evidence seems to suggest that the causal relationship between the built environment and activity-travel patterns is relatively weak: the built environment is the décor of unfolding housing and activity-travel patterns, not the trigger. Based on this view, it is argued that a more comprehensive conceptual framework is needed to better understand and qualify the relationship between the built environment and activity-travel patterns.

INTRODUCTION

The study of the relationship between urban form and (facets of) activity-travel patterns has received an overwhelming amount of attention in transportation, urban design and urban planning research. Literally, thousands of papers and studies must have been published on this subject. Yet, there are conflicting outcomes: some studies claim to have found evidence of the significance of the relationship between characteristics of urban form and particular aspects of travel behaviour, such as mode choice or distance travelled, while others report that this relationship is statistically insignificant. Furthermore, some positive evidence should be disregarded because it may be spurious, for example, due to ignoring multi-level effects

which will lead to inflated t-statistics. The significance of effects also tends to disappear when longer periods of time and multiple activities are taken into account.

Part of the solution to this situation is the use of more advanced models. However, even when such models are used, the potential flaw of this line of research is that evidence is typically based on cross-sectional statistical relationships between characteristics of the built environment and travel patterns. This is insufficient to conclude whether urban form is just the décor of unfolding activity-travel patterns and housing careers or it features of the environment indeed trigger people to behave in sustainable ways. Many authors seem nowadays obliged to refer to the issue of self-selection, perhaps because they know that otherwise reviewers would mention it. However, apart from very fuzzy discussions on this topic and some very limited statistical treatments, our research community is far removed from a generally accepted methodology to examine self-selection.

In this paper, we argue the potential for examining the subject matter in the larger context of a life trajectory approach. During their life course individuals and households will develop various careers: housing career, job career, mobility career etc. Dynamic activity travel patterns can be understood as shorter-term actions that should largely be consistent with these careers and their underlying plans, and that may be driven by a combination of these careers. This means that the study of the relationship between urban form and travel behaviour should be captured in this larger context. Moreover, in this approach, spurious correlation can be better tested, and that the influence of the built environment can be understood as a mediator of various life trajectory processes.

The paper gives a critical review of the existing literature, explains the larger conceptual framework and demonstrates how more subtle analyses can be made. A research agenda will be developed.

LITERATURE REVIEW - EXAMPLES

Urban form versus urban function

An examination of the relevant literature suggests that most authors use the term urban form to describe aspects of urban space that encompass characteristics traditionally classified as urban form and urban function in urban design and urban planning . We argue however that this distinction is also relevant in research about urban form and travel behaviour.

As it is defined in urban design and urban planning, form is a term used specifically for morphology. It refers to the urban design literature with a focus on different forms (grid, radial, etc) for the design of cities, neighbourhoods and transportation systems. In contrast, urban function refers to the set of functions available in a neighbourhood or within some distance or travel time band.

This distinction between urban form and urban function is important from the perspective of interpreting the results of the analyses. A focus on urban form implicitly involves a test of the hypothesis that different forms (morphologies) will induce particular behaviours. This seems a rather indirect relationship. In contrast, a focus on urban functions implies examining a more direct relationship in the sense that activity participation and travel behaviour by definition involve activity locations and therefore urban functions.¹

Considering this distinction, relatively few studies have examined the influence of urban form on travel behaviour. Most of these studies analyzed the difference between neighbourhoods (or cities) according to the characteristics of the street network. Usually this difference was related to the question whether the neighbourhood had either a grid-like either a cul-de-sac street network. In a few cases, the research included neighbourhoods that were a mix of these two characteristics (e.g. Crane and Crepeau, 1998; Schwanen and Mokhtarian, 2005).

Some studies found a positive relationship between urban form and travel behaviour. Cervero and Radish (1996) concluded that pedestrian-oriented design and compact neighbourhoods in the San Francisco area, USA encourage people to drive less and walk or ride transit more. Urban form is also an important tool to slow down the level of motorization in the study in four neighbourhoods in Shanghai (Pan et al., 2007). However, this study concluded that there are other triggers, such as income, affecting travel behaviour.

Other researchers found a weak relationship between urban form of neighbourhoods and travel behaviour in Northern California (Handy et al., 2005; Cao et al., 2006; Cao et al., 2009; and Schwanen and Mokhtarian, 2005). Often, these studies found a stronger influence of urban form on non-motorized and public transportation travel modes. Crane and Crepeau (1998) found no significant effect on travel mode when controlling for land uses and densities around the trip origin, trip costs and traveller characteristics. Moreover, these studies concluded that attitudes, lifestyle and residential self-selection exert stronger influence on travel behaviour than urban form.

Snellen et al. (2001; 2002) concluded that the effect of urban form on activity-travel behaviour is negligible. These studies analyzed urban form at the city and at the neighbourhood level. Nine cities in the Netherlands were chosen according to two components of urban form: the shape of the cities, and the street network for motorized transportation. They considered the shape of the cities as lobe city, poly-nuclear city and grid city; and the transportation network as radial, ring, (shifted) grid, or linear networks. Within the cities, 19 neighbourhoods were analyzed according to the following characteristics of urban form: location in relation to the city centre, location vis-à-vis the main train station, and location with respect to a services sub-centre at the district level (when present). They concluded that "individuals and households tend to organize their daily activity-travel patterns

¹ A strict focus on morphology may also easily lead to tautological explanations. Consider the example of two neighbourhoods that only differ in scale/dimension. Assuming identical behavioural patterns, *ceteris paribus*, the city of the larger scale (i.e. larger distances) will show higher distances travelled. These distances thus do demonstrate an influence of the built environment on the outcomes of travel decisions, but not on the underlying behavioural processes themselves. In case of policy-assessment, this is a non-issue. However, if the focus of the study is to show that the built environment triggers particular choices and behavioural patterns, this analysis will lead to equivocated conclusions.

according to their personal preferences and ability of adjustment", and that urban form exerts no significant influence on that.

In contrast, the number of studies on urban functions is much larger. Most studies have examined the influence of variables such as density, mixed land use, and distance to bus and train stations. Nearly all papers that analyzed urban function considered more than one aspect. Density and (mixed) land-use characteristics usually prevail in these studies. Transport network and accessibility were investigated less often in the literature.

Some studies found a significant relationship between aspects of urban function and activity-travel behaviour. Frank and Pivo (1994) concluded that urban function characteristics have an effect on mode choice when controlling for non-urban factors. Cervero (1995) found that density has a stronger influence on motorized transport mode while land use exerts more influence on non-motorized commuting. Cervero and Kockelman (1997) found evidence of a weak relationship between urban functions and travel demand. Maat and Timmermans (2009) found that work locations with high density reduce commuting and that the work location has more effect on commuting mode choice than does the residential environment.

Other analyses suggest that attitudes related to travel exert a stronger influence on travel behaviour than urban function, although urban function still plays an important role in travel distance and transport mode choice (Handy, 1996a; Kitamura et al., 1997).

Another group of studies found no significant influence of urban function on activity-travel behaviour. Maat et al. (2005) pointed out that high density and mixed land-use do not induce people to travel less or to travel in a more sustainable way. Krizek (2003) found that change in urban function does not trigger changes in overall modal split, what leads him to support the self-selection theory. According to this theory, "a household with a predisposition toward a certain type of travel 'self-selects' a residential location enabling the pursuit of that preferred type of travel" (Schwanen and Mokhtarian, 2005).

Besides density and land use, two other characteristics of urban function that received attention were transport network and accessibility. Naess and Sandberg (1996) studied the interdependencies between workplace location, modal split, and energy use in Oslo, Norway. They concluded that public transportation facilities and parking conditions directly affect car travel. Handy (1996b) analyzed how accessibility influences travel behaviour for non-work travel in San Francisco Bay Area, USA. She defines accessibility as a reflection of the distribution of potential destinations around a place and the character of the activity found there. Her study suggests that higher accessibility is associated with shorter average trips, a greater range of destinations, higher trip frequencies, and a greater number of walking trips.

This brief overview of the exemplary studies in the literature shows that with some exceptions, the majority of studies on urban form did not find strong relationships between urban form and facets of travel behaviour.² In part this has been explained in terms of self-

² The relevant literature tends to focus on the significance of estimated coefficients/effects, This over-rates the theoretical and policy significance of the statistical concept of significance. Non-significant effects may be the results of small sample size. Ceteris paribus, even very small effects

selection. Other authors argued that a broader perspective is required to examine the relationship between urban form/function and activity-travel patterns. Especially, the inclusion of attitudes and lifestyles in the analyses has been advocated.

Attitudes and lifestyle

Studies incorporating attitudes and lifestyle had the aim of understanding to which extent travel-related predispositions influence residential location and in turn travel behaviour. It represents an attempt to explain (part of) the unexplained variance in activity-travel patterns after including characteristics of the built environment and socio-demographics. Various types of personalities, lifestyles and travel attitudes were studied in the literature.

Salomon and Ben-Akiva (1983) argued that people in a similar lifestyle group share preferences for the choice of transport mode and destination for shopping trips. If their argument is accepted, it would mean that to the extent that individuals belonging to different lifestyle groups live in the same neighbourhood, the strength of the relationship between neighbourhood characteristic and transport mode and destination choice will be reduced if lifestyle is not incorporated into the analysis.

Several studies even suggest that attitudes towards transportation better explain people's travel behaviour than the built environment (Handy et al., 2005; Cao and Mokhtarian, 2005; Kitamura et al., 1994; Bagley and Mokhtarian, 2001). Most of these studies found some relationship between urban form and travel behaviour, nevertheless they claim that attitudes exert a stronger influence or may have a more direct effect than urban form. A common way to collect data on attitudes and lifestyle is to ask respondents to rank statements related to attitudes toward travel and toward life. To measure attitudes related to travel, Mokhtarian and collaborators (Kitamura et al., 1997; Bagley and Mokhtarian, 2001; Schwanen and Mokhtarian, 2005) asked respondents to scale 39 statements related to attitudes toward private automobile, ridesharing, public transportation, congestion and air quality, time use, housing preferences, and economic policies related to transportation. To measure lifestyle, the respondents should select activities and interests in a list of 100 types. From the data collected, different lifestyles such as culture-lover, homebody, and relaxer and pro-environment, pro-transit, and workaholic attitudes were derived.

Handy, Mokhtarian and Cao (Cao et al., 2006 and 2009; Handy et al., 2005) asked respondents whether they agreed or disagreed with a series of 32 statements. After using factor analysis, six attitudes related to travel were identified: pro-bike, pro-travel minimizing, pro-transit, safety of car, and car dependent. Van Acker et al. (2010) analyzed lifestyle

may become significant with an appropriately large enough sample. Hence, conclusions about significance should always be viewed in the context of the chosen (practically attainable) sample size. Arguably, compared to significance, the size of the estimated effects and the nature or functional form of the relationship between the built environment and travel behaviour is more relevant. There has been scant attention exploring the functional form as most researchers have routinely and uncritically applied standard regression and structural equation modelling, implicitly or explicitly assuming that relationships under study are linear. Similar research on spatial choice behaviour, organized around different topics, has however provided strong accumulated evidence that this is rarely the case.

through three different aspects of leisure: holiday/travel, literary interests, and recreational activities. The survey resulted in 136 binary variables representing lifestyle activities which, after using two order factor analyses, were reduced to five lifestyles: culture-lover; friends-and-trends; home-oriented-but-active-family; active; and home-oriented-traditional-family.

REFLECTIONS

The methodological underpinnings of studies on the relationship between urban form and activity-travel patterns vary widely. Irrespective of the method used, however, most studies are characterized by some fundamental flaws. These flaws are related to three aspects of the analyses discussed below.

Multi-level nature of the data

One of these flaws is that the unit of observation in most studies is an individual. To examine the relationship between urban form characteristics and facets of activity-travel behaviour, neighbourhood characteristics are added to the data of the individuals and serve as input to the statistical analysis. Consequently, individuals living in the same neighbourhood will share the same set of urban form characteristics. This common approach violates the assumption underling the statistical methods of independent measurements.

Using this approach, the standard errors used to test the significance of the estimated coefficients, which are a function of sample size, are underestimated. This occurs because the sample size for the neighbourhood characteristics effectively concerns the number of neighbourhoods and not the number of individuals. As the number of neighbourhoods is smaller than the number of individuals, the standard errors should be larger and therefore the t-statistics should be smaller. Thus, conclusions about the significance of effects may be falsely based. By ignoring the inherently multi-level nature of their data, most studies on the relationship between urban form and activity-travel behaviour claim to have found evidence of significant coefficients, which likely would not be significant if appropriate statistics had been calculated.

Meaning of the concept of control

Most studies examine the relationship between urban form and activity-travel behaviour by regressing socio-demographic characteristics on characteristics of urban form/function. Often, authors use phrases such as estimating the effects of urban form *after controlling for socio-demographics*. Such wording may however be misleading.

In the methodological literature on (quasi-)experimental design, the term control means that the researcher has control on manipulating the scores or values of the variables varied in the experiment and also on the assignment of subjects to the experimental conditions. In other

words, the researcher can *control* the variance and covariance of the independent variables of his statistical model.

In the context of survey research, the term control may be misleading. In fact, the wording in many papers may give the impression that by controlling for socio-demographics (i.e. including socio-demographic variables into the equation) what is left is a pure, unbiased estimate of the coefficients that expresses the strength of the relationship between urban form characteristics and the investigated facet of activity-travel behaviour. However, such interpretation would be misleading.

What is happening is that part of the variance in the dependent variable is explained by socio-demographics and part is explained by urban form. Because the researcher does not have control over the variance-covariance structure of these independent variables, socio-demographics and urban form characteristics are likely moderately to strongly (spatially) correlated and the estimated coefficients cannot be decomposed into independent contributions of the urban form indicators. Hence, if the interpretation would be that the researcher has identified the “true” relationship between urban form and travel behaviour that interpretation would very likely be wrong. Control in this context just indicates that the researcher has also included socio-demographics in the regression analysis. Deleting or adding socio-demographics will likely change the coefficients that represent the influence of the built environment on travel behaviour.

Causal relationships

Studies on the relationship between urban form and activity-travel patterns are faced with the problem of every survey: the interpretation of the estimated coefficients in terms of cause and effect. Because researchers do not have strict control, an inherent aspect of survey research is to *interpret* the statistical results in theoretical concepts and *assumed* causal relations: there is no evidence to that effect.

The distinction we made earlier between urban form and urban function is relevant here. Urban form is like the envelope for locating functions either planned or as an expression of self-organizing processes or a mixture of these. It is unlikely that urban form in its basic morphological meaning serves as a driver of human behaviour. The immediate value of urban form for organizing activities in time and space is not evident. Moreover, results from environmental psychology and behavioural geography on mental maps suggest that very few people have consistent, let alone accurate, mental representations of urban forms (see Golledge and Timmermans, 1990 for a review of the relevant literature).

This situation leaves the researcher with the problem of having to *argue* the interpretation of the relationship in an indirect manner: particular urban forms co-evolve with distinct accessibilities, service provisions and configurations of land uses and facilities, which in turn affect activity-travel patterns. It seems that this approach involves some unnecessary torture: rather than focusing on these indirect relationships, why not examine the mediating variables included in the argument directly? In that sense, including urban functions, accessibility,

quality of destinations etc. should be easier to interpret. It may also be the reason why urban functions tend to be stronger related to travel behaviour than urban form.

Realising the complexity of the relationships between urban form and activity-travel patterns, structural equation models³ have become the standard in this line of research. It represents an attempt of specifying the overall relationship between urban form and a particular facet of travel behaviour into a set of direct and indirect *linear* relationships. Often, the estimated structure is viewed as evidence of causality. However, it should be realised that the limitations of standard regression analysis equally apply to structural equation modelling. The coefficients pick up covariances between the set of selected variables, and results are highly dependent upon the assumed structure. At best, it is possible to specify alternative structures and evaluate the interpretability of the estimated coefficients and/or the overall goodness-of-fit of the model. Apart from the fact that the assumed linear relationships may be questionable, one should not make the mistake of concluding, as in the early days of structural equations modelling, that each and every structural equation model has a causal meaning.

Incorporating attitudes and lifestyles has the conceptual and methodological advantage of including more behavioural terms in the analysis. Some decades ago, lifestyle segmentation has been tried rather unsuccessfully in marketing research. It has been typically operationalized as a multidimensional concept, assuming that people with certain voting behaviour share common values, read the same newspapers, watch the same television shows, and prefer the same products. It is however a broad concept, and it is not readily evident why, for example, political preferences are related to travel behaviour. Of course, including lifestyle as an additional variable will likely pick up some of the unexplained variance, but that does not necessarily mean that the understanding of the relationship between urban form and travel behaviour also improves. In part, this depends on the measurement of lifestyle. As discussed in a previous section, some studies in transportation have chosen, as in marketing research, a rather broad set of variables measuring lifestyle. When the study defines lifestyles (and/or attitudes) that are evidently related to travel, such as pro-transit, pro-bike, pro-drive alone, etc., it is realistic to assume that a person which has pro-bike attitude will bike more often (although attitudes do not necessarily show strong links with actual behaviour) than another person which has a pro-drive alone attitude. But for other chosen attitude characteristics, such as pro-alternatives or work-driven attitudes, there is only an unclear relationship between activity-travel behaviour and the attitude in question.

The same issue occurs with the analyzed lifestyle characteristics: it is readily obvious how culture-lover, homebody, calm and adventure lifestyles can cause particular activity-travel patterns. Thus, the resulting correlation is of limited use to the understanding the underlying processes that trigger activity-travel behaviour. More general, some lifestyle and attitudinal variables may be interpreted in the context of travel behaviour; they may have some

³ Although structural equation model has become a more or less standard term, its use is sloppy in the sense that most authors have used a path model. It demonstrates the relatively poor representation of the problem in most studies in terms of the lack of a measurement model. It also reflects a theoretically low level, mainly data-driven operationalization, reinforcing the main concerns and reflections voiced in this paper.

meaning in that they may influence activity generation, transport and mode choice decisions. In that sense, attitudes may be more relevant, although it would also depend on the kind of attitudes that are included. For example, an individual's attitudes with regard to the environment and/or health may influence travel choices. Including such attitudes into the analysis may thus elaborate the relationship between urban form and travel behaviour. However, this line of research has shown a tendency to use a tendency to identify segments and summarized factors, missing an opportunity to specify which activity-travel decisions are influenced.

Few studies interpreted the statistical relationships between urban form and activity-travel behaviour in terms of drivers of behaviour, preferences and utilities. Measuring preferences and utilities would be a more direct approach to understanding and validating the relationship between urban form and behaviour. Especially stated preference and choice approaches allow researchers to vary attributes of the built environment and observe housing or travel behaviour choices. In addition, qualitative studies can be used to understand motives underlying particular choices. Although stated preference and choice studies and qualitative studies are also not necessarily error-free, at least in this context, they have the advantage that subjects can directly indicate which attributes they took into consideration when moving house or when choosing a particular neighbourhood.

If we do consider the extensive literature on housing choice, then the importance of accessibility and the provision of transport facilities are compared against the influence of housing attributes and properties of the built environment. Molin and Timmermans (2002) summarized a set of Dutch studies considering preference and choice. These studies, systematically varying between attributes of the house, attributes of the neighbourhood, and relative location vis-à-vis work, school, various facilities, bus stop and stations, found that on average the typical urban form characteristics only play a relatively minor role in the decision process. Their summary is not atypical: without exception professionally conducted studies have indicated the relatively weak influence of transport facilities and accessibility on housing choices.

THE LIFE TRAJECTORY APPROACH AS A LARGER CONCEPTUAL FRAMEWORK

Considering that (i) there is a lack of consensus in the literature about whether urban form characteristics affect activity-travel behaviour, and that (ii) the influence of transport facilities and accessibility is relatively weak in the decision process of housing location, we believe that previous studies have often adopted a too narrow perspective when looking for an influence of urban form on activity-travel behaviour. We argue that the relationship between urban form and activity-travel behaviour should be seen within a larger context: considering people's life trajectory.

People have certain goals in life they wish to pursue or to achieve. They may wish to have a family, make sufficient money, travel, have friends, play a role in society, entertain and be

entertained, have an inspiring job, live in a nice house, etc. They have certain needs, desires, aspirations and expectations. In trying to realise these aspirations, people will go through a life trajectory, or life course, which is composed of multiple careers individuals have in their lives and their developmental implications (Elder, 1998). Careers are the consistent paths formed by the stages or statuses people have and take over time according to different aspects of their lives (Mulder, 1993). During a lifetime, people develop various careers in different aspects of life: education, work, family, house, mobility, and others.

The realisation of these aspirations involves activities. To some extent these activities involve spatial decisions in the sense that the facilities to conduct the activities are unequally spatially distributed and this involves travel. The built environment offers opportunities and at the same time constraints. The availability of a bus stop close to one's house means that an individual can easily decide to use public transport. The non-availability of a bus stop at close range means that public transport is not a realistic option. Available budgets also represent constraints. In the beginning of careers, when individuals tend to have less money, they will face more constraints in terms of affordable housing, availability of car(s), etc. Later during the life course, they may have more to spend and thus are less constrained in where to live, choice of transport mode, activities to conduct and how much to spend on these activities.

In a life career there are major events occurring, such as marriage, birth of child, change of job location, etc. When an event happens, we assume that people enter a process of reconsideration of their current behaviour and if necessary adapt to the new life context (see also Verhoeven et al., 2005). This adjustment is a function of the relative importance of the various careers, viewed from a longitudinal perspective. For example, consider the job search process. If an individual does not truly need a new job and receives an offer that would only make a marginal difference, it is unlikely that it will be accepted. If, however, this is a dream job, probably everything else (house, social network, travel etc) will be ignored and the opportunity will be taken. Analogously, we assume that all major decisions in a life trajectory will be implicitly or explicitly evaluated in terms of the multiple careers, of the different household members and a decision, not necessarily optimal, will be made, given the constraints faced by the individual and the household. In the meantime, individuals and households will cope as best as possible with the situation and organize their daily activities accordingly. Lifting constraints may cause shifting behaviour. For example, if the office is relocated from the middle of the city to the main train station, the commute time will be reduced. Consequently, using the same budget, this may open up new opportunities for more preferred housing further away from work. If the relative importance of housing for the quality of life is higher than that of other facets, the reduced travel time will likely be used to realize housing aspirations rather than reducing travel time.

Different modalities in the relevant processes also play an important role in this context. The first housing choice of many individuals is made when they do not have much money, are perhaps still single, may have a temporary job or a first job in the job career etc. Hence, the choice may be heavily constrained, may be satisfactory, and may be made considering that it is very likely that a housing move will follow (soon). In contrast, the second or third house in many cases will be more permanent. Even though the housing decision may have been made such as to maximize household utility, characteristics of the neighbourhood will

change: economies of scale may imply that certain types of stores will disappear; the social composition may change, often small design aspects are changed over time as the neighbourhood needs revitalisation and maintenance. It does imply however the existence of inertia and different generations of movers, characterised by different preferences and/or constraints. Consequently, the strength of the relationship between urban form and travel behaviour may be less than one might expect or planners would like to believe.

Due to such constraints, to exogenous change, and to events, individuals and household will experience discrepancies between aspirations and the actual situation, and they will need to cope with such discrepancies. Over time, the stress to realize their aspirations and/or to cope with organising their daily activities in time and space due to a busier agenda or increasing travel time may increase. They will try to deal with this situations, and enforce relatively easy-to-made changes (e.g. departing earlier, less free time) until some more dramatic change is required. These dynamics take place against the background of the same attributes of the built environment, especially at the level of basic urban form indicators. Thus, activity-travel patterns and housing careers are unfolding; the built environment is merely the décor.

A broader, unified conceptual framework will potentially have some advantages. First, the probability of finding spurious or confounding effects is smaller. Secondly, the choice of residence and housing moves are considered in the larger context of lifecycle and quality-of-life decisions, which give meaning to these decisions. Thirdly, the analytical capabilities of the approach will increase, including the options for more behaviourally oriented approaches and the methodologically richer set of causally-oriented analysis given the longitudinal nature of the involved data. For example, alternative Bayesian decision networks can be learned and estimated, perhaps ruling out particular causal processes underlying the data. Fourthly, by explicitly collecting data on aspirations, careers, context- and lifecycle-dependent preferences, etc. richer explanations can be provided and alternative hypothesis can be tested.

The existing literature suggests that key events in the life careers such as marriage and the birth of child (e.g., Courgeau, 1985; Deurloo et al, 1993) may trigger housing moves to a different location. The choice of the house location is also affected by the job location (e.g. Ham et al., 2001), not only of the individual concerned but also of spouses (e.g. Borgers and Timmermans, 1993; and Timmermans et al., 1992), place of birth (e.g., Feiten et al., 2007; Mulder, 2007) and the place where parents live (e.g., Mulder, 2007). Similar effects of key events have been found for first-time homeownership. Because the spatial distribution of rented versus owner housing is not uniform, spatial effects may be observed. Deurloo et al. (1993) for example concluded that main triggers for a move into homeownership are the transition from couple to family and a significant positive income change. Family-related reasons were also mentioned by Feijten and Mulder (2002) as a decisive factor for the change to a long-stay dwelling. Smits and Mulder (2008) found that the likelihood of becoming a first-time homeowner was greater for singles, cohabiters and those starting cohabitation than for married people.

Other studies have provided some evidence that activity-travel behaviour may be affected by the life trajectory. Beige and Axhausen (2006) concluded that residential mobility is

influenced by the ownership of the different mobility tools and vice-versa. Beige (2008) pointed out that spatial changes and changes in mobility tools are considerably connected to one another. Verhoeven et al. (2005; 2006; 2007) using Bayesian Belief Networks showed that life trajectories are related to changes in car availability and transport mode choice decisions.

Together, these limited results suggest that life career events affect directly and indirectly activity-travel behaviour. This may again imply that needs and constraints of individuals and households will have a bigger influence than urban form characteristics on housing choice, re-location decision, and activity-travel behaviour. Our hypothesis is that the influence of the life trajectory on activity-travel behaviour is determinant, and that urban form characteristics are only a mediator in this relationship.

The conceptual framework, depicted in Figure 1, captures the relationship between urban form and activity-travel patterns in this larger context, considering events that occur during people's life trajectory. These events can directly affect people's activity-travel behaviour and their choice of housing location. For example, a change in work location can lead to increasing travelling time and distance as well as a change in mode choice. With the increasing travel time, this person may consider changing the housing location closer to work. The changing house location, in turn, may trigger this person to reconsider his common travel patterns to suit the distances for their main destinations from the new place of residence. At the same time, people might choose the place they want to live according to their already established travel patterns.

The choice of the housing location can be also influenced by the urban form characteristics. People chose the place where they want to live according to the characteristics of the house, the neighbourhood and relative location vis-à-vis various kinds of facilities, family, etc. Thus, in this example, urban form has a mediating role in people's activity-travel behaviour.

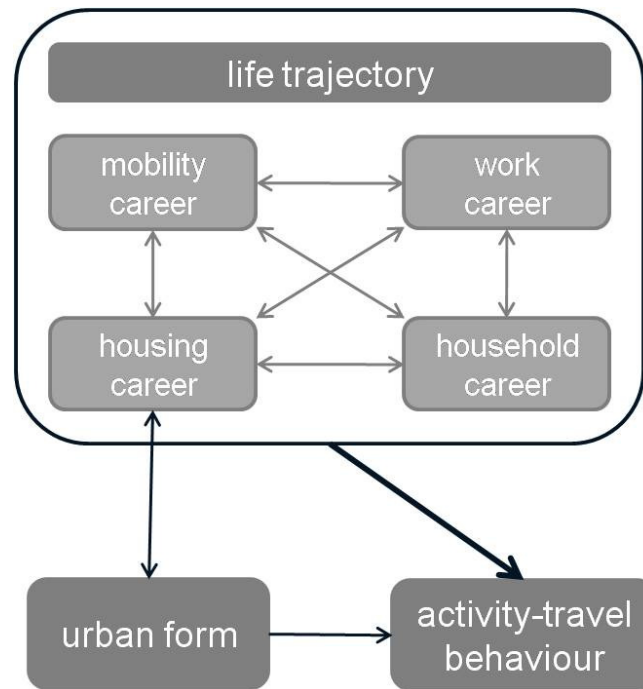


Figure 1 – Conceptual Framework

With this framework it is possible to test whether there is a direct relationship between urban form characteristics and activity-travel behaviour or that any positive relationship found may be a spurious relationship that occurs because these two variables are related to life trajectory events.

CONCLUSIONS

Academic research is fundamentally not very different from many other innovation processes. New ideas and research approaches are proposed, many are rejected, a few survive and after some time become the state-of-the-art, implying that many researchers more or less routinely adopt the same approach, and may not be aware of some fundamental underlying issues or at least will not explicitly discuss these in their motivations. This also applies to our own previous work on this and other topics. After some time, the specific approach is in need of a critical (re-)assessment to set a new research agenda or to start a new innovation and diffusion cycle and avoid that the approach becomes obsolete. In this paper, we have argued that the overwhelming literature on the relationship between urban form and travel behaviour is in need of such re-appraisal, based on a reflection of some shortcomings of the state-of-the-art.

This paper is not meant to disqualify or reduce the merits of the existing literature. Exceptions are the studies that have been poorly designed or that have drawn false or at least inaccurate conclusions, due to the lack of knowledge of some statistical principles. We cannot escape the feeling that such weak studies are more prevalent in the stream of studies which were (perhaps too) eager to provide evidence of the positive effects of land use and

design on reducing car-mobility and increasing modal shifts to environmentally friendly transport in the context of the discussion on sustainable urban development and transportation. The vast majority of studies have however done a professional job and led to justifiable or at the very least robust statistical conclusions.

Our concerns and reflections, expressed in this paper, are meant to be *methodological* in nature in the true, strict meaning of the word as opposed to its sloppy use, equating it to research methods. Limitations relate to the *interpretation* of the statistical findings, their attribution to characteristics of the built environment, the lack of rigour ruling out alternative explanations and the relative inability of cross-sectional survey research to infer causality from statistical relationships, especially if the approach is largely data-driven and narrow in scope.⁴ Most of our arguments are not new. Already in the seminal work by Kitamura et al. (1997), the authors argued that “Is the observed association between travel and land use real, or is it an artefact of the association between land use and the multitude of demographic, socio-economic, and transportation supply characteristics, which also are associated with travel?”. Ever since, the research community concerned with the relationship between urban form and travel behaviour has been aware of alternative explanations for obtained associations, self-selection being the typical disclaimer. Our point however is that very few substantive solutions seem to have been proposed, disregarding the theoretically limited, econometric treatment suggested in for instance Bhat and Guo (2006), who assume that a covariance term represents self-selection. If, as we have argued in this paper, decisively providing evidence that the coefficients of the utility function based on cross-sectional survey data on observed activity-travel behaviour represent causal relationships between urban form and travel behaviour may already be problematic, the justification of interpreting estimated covariance terms uniquely in terms of self-selection may methodologically be even considerably more problematic. Alternative explanations cannot be given to the same covariance terms.

As an alternative, potential theoretically richer approach, in this study we have advocated the use of a life trajectory approach to analyse the relationship between urban form characteristics and activity-travel behaviour. We have also proposed a conceptual framework with which it is possible to capture the two factors we consider are influencing activity-travel patterns. Furthermore, we have discussed three methodological limitations existent in previous studies: the ignorance of multi-level nature of the data, interpretation of the concept of control and interpretation of causal relationships. These issues should be considered in future research.

We hope that our reflections will induce new impetus to exploring alternative, broader, behaviourally-oriented, and methodologically more rigorous approaches in studies

⁴ We realize that this discussion is heavily dependent on one’s position in the discussion on the concept of causality in the methodological and even philosophical literature. In fact, this paper could have contained an additional layer of discussion and articulation linking philosophical, methodological, research design and statistical stances and decisions. However, in light of the target audience, the main goal of the paper and the kind of meeting, we decided not to include this more detailed articulation of arguments and reflection. Suffice it to say that our arguments are inspired by the writings of Wright, Lazarsfeld, Blalock, etc. (or for that matter, Hume or Mill)

concerning the important topic of the influence of the built environment on travel behaviour. Our personal research agenda is to collect data of the kind discussed in this paper and analyze the relationship between urban form and travel behaviour from this larger, quasi-dynamic unified perspective.

We should emphasize that the proposed perspective will not necessarily lead to different conclusions regarding the influence of the built environment on travel behaviour. In fact, because the current narrow approaches may be more sensitive to confounding, it is more likely that this broader approach will find even less evidence of a strong impact. Results will also depend on the area under investigation. In countries and cities with more uneven spatial distributions (less equity) and more heterogeneous travel behaviour, due to constraints and/or higher cultural diversity, stronger relationships may be expected. In contrast, less variability in antecedent conditions is expected to lead to weaker relationships.

It should also be articulated that the relative lack of evidence that the built environment exerts a strong influence on travel behaviour does not mean that we should not try to plan, design and develop our cities and transportation systems in a sustainable manner. The reason is that the discussed relationships are non-symmetrical. The availability of public transport services or mixed land uses does not necessarily imply that individuals and households will use them. However, the lack of or non-availability of such services and mixed land use does imply that individual and household cannot choose them, implying that if for whatever reason constraints become to over-rule preferences, for example due to increasing fuel prices or scarce resources, we have created urban systems that will eventually breakdown or that will lead to relatively high social exclusion levels.

REFERENCES

- Bagley, M.N. and Mokhtarian, P.L. (2001). The impact of residential neighbourhood type on travel behaviour: A structural equations modelling approach, *The Annals of Regional Science*, 36:279–297.
- Beige, S. (2008). Long-term and mid-term mobility decisions during the life course, Dissertation, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich.
- Beige, S. and Axhausen, K.W. (2006). Long-term mobility decisions in the life course. Proceedings 6th Swiss Transport Research Conference (STRC), Monte Verità, Ascona, Switzerland.
- Bhat, C.R. and Guo, J. (2006), A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels, Paper presented at the 85th Annual Meeting of the Transportation Research Board.
- Borgers, A.W.J. and Timmermans, H.J.P. (1993). Transport facilities and residential choice behavior: A model of multi-person choice processes. *Papers in Regional Science*, 72, pp. 45-61.

- Cao, X. and Mokhtarian, P.L. (2005). How do individuals adapt their personal travel? Objective and subjective influences on the consideration of travel-related strategies for San Francisco Bay Area commuters, *Transportation Policy*, 12, 391-302.
- Cao, X.; Mokhtarian, P L. and Handy, S. (2006). Neighborhood design and vehicle type choice: Evidence from Northern California, *Transportation Research Part D*, 11, 133-145.
- Cao, X.; Mokhtarian, P.L. and Handy, S. (2009). The relationship between the built environment and nonwork travel: A case study of Northern California, *Transportation Research part A*, doi:10.1016/j.tra.2009.02.001.
- Cervero, R. (1995). Mixed land-uses and commuting: evidence from the American Housing Survey, *Transportation Research Part A*, Vol. 30, 5, 361-377.
- Cervero, R. and Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design, *Transportation Research Part D*, Vol. 2, 3, 199-219.
- Cervero, R. and Radisch, C. (1996). Travel choices in pedestrian versus automobile oriented neighborhoods, *Transport Policy*, Vol. 3, 13, 127-141.
- Courgeau, D. (1985). Interaction between spatial mobility, family and career life-cycle: A French survey, *European Sociological Review*, Vol. 1, 2, 139-162.
- Crane, R. and Crepeau, R. (1998). Does neighbourhood design influence travel? A behavioural analysis of travel diary and GIS data, *Transportation Research Part D*, Vol. 3, 4, 225-238.
- Deurloo, M.C.; Clark, W.A.V. and Dieleman, F. M. (1993). The move to housing ownership in temporal and regional contexts, *Environment and Planning A*, Vol. 26, 1659-1670.
- Elder, G. H. (1998). The life course as developmental theory, *Child Development*, Vol. 69, 1, 1-12.
- Frank, L.D. and G. Pivo (1994). Impacts of mixed use and density on utilization of three modes of travel: single occupant vehicle, transit and walking, *Transportation Research Record* 1466, 37-43.
- Feijten, P. and Mulder, C.H. (2002). The timing of household events and housing events in the Netherlands: A longitudinal perspective, *Housing Studies*, vol. 17, 5, 773-792.
- Feiten, P.; Hooimeijer, P. and Mulder, C.H. (2007). Residential experience and residential environment choice over the life-course, *Urban Studies*, 45, 141-162.
- Golledge, R.G. and Timmermans, H.J.P. (1990). Applications of behavioural research on spatial problems I: cognition, *Progress in Human Geography*, vol. 14, 1, 57-99.
- Ham, M.v.; Hooimeijer, P. and Mulder, C.H. (2001). Urban form and job access: Disparate realities in the Randstad, *Tijdschrift voor Economische en Sociale Geografie*, Vol. 92, 2, 231-246.
- Handy, S. (1996a). Urban form and pedestrian choices: Study of Austin neighborhoods, *Journal of the Transportation Research Board*, 1552, 135-144.
- Handy, S. (1996b), Understanding the link between urban form and nonwork travel, *Journal of Planning Education and Research*, 15, 183-198.
- Handy, S.; Cao, X. and Mokhtarian, P.L. (2005). Correlation or causality between the built environment and travel behavior? Evidence from Northern California, *Transportation Research Part D*, 10, 427-444.
- Kitamura, R., Mokhtarian, P.L. and Laidet, L. (1997). A micro-analysis of land use and travel in five neighbourhoods in the San Francisco Bay Area, *Transportation*, 24, 125-148.

- Krizek, K.J. (2003). Residential relocation and changes in urban travel: Does neighbourhood-scale urban form matter?, *American Planning Association, Journal of the American Planning Association*; 69, 3.
- Maat, K. and Timmermans, H.J.P. (2009). Influence of the residential and work environment on car use in dual-earner households, *Transportation Research Part A*, 43, 654-664.
- Maat, K.; van Wee, B. and Stead, D. (2005). Land use and travel behaviour: expected effects from the perspective of utility theory and activity-based theories, *Environment and Planning B: Planning and Design*, 32, 33-46.
- Molin, E. and Timmermans, H.J.P. (2002). Accessibility considerations in residential choice decisions: Accumulated evidence from the Benelux, Paper presented at the 82th Annual Meeting of the Transportation Research Board.
- Mulder, C.H. (1993). Migration dynamics: A life course approach, Dissertation, Amsterdam, Thesis Publishers.
- Mulder, C H. (2007). The family context and residential choice: A challenge for new research, *Population, Space and Place*, 13, 265-278.
- Næss, P. and Sandberg, S.L. (1996). Workplace location, modal split and energy use for commuting trips, *Urban Studies*, 33, 557-580.
- Pan, H.; Shen, Q. and Zhang, M. (2007). Influence of urban form on travel behaviour in four neighbourhoods of Shanghai, *Urban Studies*, Vol. 46, 2, 275-294.
- Salomon, I. and Ben-Akiva, M. (1983). The use of the life-style concept in travel demand models, *Environment and Planning A*, Vol 15, 5, 623-638.
- Schwanen, T. and Mokhtarian, P.L. (2005). What affects commute mode choice: neighbourhood physical structure or preferences toward neighborhoods?, *Journal of Transport Geography*, 13, 83-99.
- Smits, A. and Mulder, C.H. (2008). Family dynamics and first-time homeownership, *Housing Studies*, Vol. 23, 6, 917-933.
- Snellen, D.; Arentze, T.; Borgers, A. and Timmermans, H. (2001). The impact of urban setting on activity-travel patterns: a comparison of performance indicators using quasi-experimental design data, 80th Annual Meeting of the Transportation Research Board, Washington, D.C., January 2001, Committee A1D02 on Transportation and Land Development.
- Snellen, D.; Borgers, A. and Timmermans, H. (2002). Urban form, road network type, and mode choice for frequently conducted activities: multilevel analysis using quasi-experimental design data, *Environment and Planning*, 34, 1207-1220.
- Timmermans, H.J.P., Borgers, A.W.J., Dijk, J. van and Oppewal, H. (1992), Residential choice behaviour of dual earner households: A decompositional joint choice model, *Environment and Planning A*, 24, pp. 517-533.
- Van Acker, V.; Mokhtarian, P.L. and Witlox, F. (2010) Refining the lifestyle concept in travel behaviour research, in: *Spatial and social variations in travel behaviour - Incorporating lifestyles and attitudes into travel behaviour-land use interaction research*, Dissertation, Ghent, University Press.
- Verhoeven, M; Arentze, T.; Timmermans, H. and van der Waerden, P. (2005). Modelling the impact of key events on long-term transport mode choice decisions: A decision network approach using event history data, Paper submitted for presentation at the 84th Annual Meeting of the Transportation Research Board, Washington, DC.

- Verhoeven, M.; Arentze, T.A.; Timmermans, H.J.P. and van der Waerden, P.J.H.J. (2006). Modeling the influence of structural lifecycle events on activity-travel decisions using a structure learning algorithm, Proceedings of the 11th International Conference on Travel Behaviour Research (IATBR) Conference, Kyoto, Japan 16-20 august 2006.
- Verhoeven, M; Arentze, T.; Timmermans, H. and van der Waerden, P. (2007). Examining temporal effects of lifecycle events on transport mode choice decision, The International Journal of Urban Sciences, 11, 1-14.