

HOUSEHOLD LOCATION CHOICE AND TRAVEL BEHAVIOUR: A REVIEW OF INTERNATIONAL EVIDENCE

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ABSTRACT

Over the last three decades a growing research literature has been concerned with the relationship between urban form and travel patterns. This research has assumed a heightened importance given concerns about the environmental effects of carbon intensive transport systems, the expansion of travel to work areas and the need to provide housing for growing populations. This paper examines the international research evidence for the factors which drive residential location choice behaviour of households on the one hand, and on the other the travel behaviours of households found in different types of urban/rural contexts. Evidence from existing research clearly shows that land-use planning patterns influence mode choice and patterns of mobility but that residential location choice behaviour is also an important factor which has a long lasting effect on patterns of household travel behaviour. This paper reviews the empirical studies that have been conducted into the effects of density, land-use mix, settlement size, the role of public transport oriented development and neighbourhood facilities on travel behaviour. The paper also examines the importance of household self-selection, habit and attitude and other socio-economic factors which contribute to household mobility patterns and location choice. The paper concludes with evidence based recommendations for policy development.

Keywords: Residential location, Travel Behaviour, Urban form, Density, Mixed land-use, Neighbourhood design.

1. INTRODUCTION

Choice of residential location is a multi-dimensional decision for any household. During the last three decades, researchers are attempting to find out the exact relationship between attributes of built environment and household travel behaviour. The motivation of this interest is based on the possibility that design policies associated with land-use planning may be used to manage, control and shape individual's travel behaviour and then overall aggregate travel demand (Bohte *et al.*, 2009; Litman, 2009). There are some studies which look at urban form factors and the effect of land uses such as *smart growth*, mixed land-use and street design on the travel patterns of households. Detailed review of such studies has been conducted by leading scholars with conclusion that there is indeed a significant impact of land-use attributes on the travel behaviour. At least some link exists between the characteristics of residential locations and travel behaviour (Badoe and Miller 2000; Crane 2000; Stead and Marshall 2001; Ewing and Cervero 2001; Handy 2005; Cao *et al.*, 2008). These studies show that among others, socio-demographic characteristics of family and urban form attributes formulate the households travel behaviour.

When investigating the direction of causality between residence location choice and travel behaviour two questions are of particular importance (i) does housing location choice affect travel behaviour and/or vice versa and (ii) after the causality has been established in either direction should land-use planning policies be based on expected transport impacts? Such questions are of key interest for policy makers. For example, the Dutch government has adopted the well-known 'ABC location policy'. The reason for this policy is that spatial planning can be used to influence the amount and mode of travel. The objectives for adopting this policy are environmental and economic because good accessibility and a clean environment are vital for the economic and social functioning of the country (Schwanen *et al.* 2004). Planning Policy Guidance (PPG)¹ in the UK on transport is similar to ABC policy in spirit but less specific. The guidance deals with the reduction in the length and number of car journeys and encourages alternate means of travel which have less impact on the environment and reduce car dependency (Owens, 1995).

The interaction between land-use and transportation has been a matter of interest for many years from both theoretical and empirical perspectives among the researchers. Land-use planning as a mobility strategy is still a matter of debate. Land-use planning is a key element for achieving sustainability in an urban context and housing location is one of key component. Recent literature shows that sustainable urban development can only be achieved when transport and land-use are treated simultaneously (Banister 2008). The land-use planning stimulates the need for transportation and the supply of transport infrastructure shapes urban form. Urban planners and transport policy makers face a challenge to reduce overall mobility and as a result carbon emissions without compromising economic growth.

The relationship between urban form and travel behaviour is complex and there are many factors (variables) involved from both sides (TRB 2009). Bhat and Guo (2007) have mentioned three elements which represent the complexity of this relationship. These elements are (i) the multi-dimensional nature of the relationship between both (ii) the influence of decision maker characteristics and (iii) the spatial scale of analysis. Due to this complexity researchers do not have harmony in opinion about the intensity of causality between residential location choice and travel behaviour (Ewing and Cervero, 2001; Dieleman *et al.*, 2002). Here there is also an argument about residential self-selection concerning travel behaviour which refers to how households choose a residential location

¹ In UK Policy Planning Guidance (PPG) is a statement of Government policy and principle towards the aspects of the town planning and transport framework.

that conforms to their travel-related attitudes. It makes a significant contribution to this complexity and ignoring this can lead to wrong estimation of the impacts of urban form on travel behaviour.

Emerging research studies have addressed the relationship between urban form and travel patterns. In response, land use planners have recommended certain policy measures to reduce travel demand such as:

- (i) *Push and Pull policies:* Car user's attitudes can be changed by pull (by making the car unattractive) and push (by making public transport attractive) strategies, because attitudes are based on the weighing of the (perceived) costs and benefits of various alternatives.
- (ii) (ii) *Hard and Soft measures:* An effective way to change the behaviour of people is with 'hard measures' like doubling the fuel price or doubling the public transport frequency. For 'soft measures' (e.g. education, information and motivation) to be effective in changing the attitudes of people, a comprehensive and integrated urban form policy is required along with the transportation demand management strategies.
- (iii) (iii) *Sustainable Communities:* It means development policies that encourage dense and mixed land-use, car free developments where appropriate and establishment of home zones - strict controls on vehicles within residential areas (e.g. low speed limit such as 10 mph). The smart growth development strategies have impact on numbers and length of car trips.
- (iv) (iv) *Opportunities and constraints:* policies based on opportunities (for environmental friendly modes) and constraints (car mobility) are more effective to change the human behaviour such as safe riding paths for cyclists and pedestrians and maximum car parking standards rather than minimum.

It is considered that households make a trade-off between residential location and the cost of commuting to access the goods and services. Households make their decision about a particular transport mode and residential choice on the basis of a systematic analysis of available alternatives. The advantages and disadvantages of a particular site can encourage or discourage adoption at a specific behaviour. Local development policies therefore need to provide certain kinds of opportunities at the micro level (e.g. neighbourhood design), in order to influence behavioural change at the macro level. The impacts of these interventions can be significant for society but there is still a need for research to explore the effectiveness of these policies.

The aim of this paper is to examine the international research evidence concerning the factors which drive the residential location choice behaviour of households. It includes empirical research which discusses travel behaviour from the perspective of three main factors namely: planned behaviour (e.g. need, desire and attitude), land-use planning factors and socio-demographic characteristics. The rest of the paper has been organised as follows. Section two examines the theoretical linkage between land-use planning and travel behaviour. Section three reviews the empirical studies that have been conducted into the effects of density, land-use mix, settlement size, the role of public transport oriented development and neighbourhood facilities on travel behaviour. The role of socio-economic and demographic factors has been assessed in section four. In section five, an importance of household self-selection has been examined and a conceptual model of household travel behaviour and housing choice preferences has been developed by focusing on personal and social characteristics which contribute to household mobility patterns and location choice. Section six deals with overall discussion and in the last section conclusion and policy recommendations have been presented.

2. CHOICE BEHAVIOUR: THEORETICAL PERSPECTIVE

A theoretical link between land-use planning and travel behaviour is important because theories provide the basis for understanding hypotheses. Theories can also explain the relationship between variables. The choice behaviour literature shows vast disagreement about the theoretical relationship between travel behaviour and land-use planning (Handy, 2004a). After many years of research, a common understanding is still missing, how the urban development in the region stimulates the needs for transportation and the supply of transport infrastructure makes the shape of urban form. For many years, the researchers have developed travel pattern theories about travel mode choice in the context of economy, geography and social aspects. It is pragmatic to look in detail these theories to understand the travel activity of the household. Before going to the depth of land-use planning impacts on travel behaviour, it is important to look at the theoretical perspective of choice behaviour first.

2.1 Planned Behaviour Theory

Individual/household choice behaviour is mostly influenced by two factors, individual characteristics and the surrounding environment. Many studies show that individual travel choice depends on demographic factors (age, gender) and socioeconomic characteristics such as income level and education. Other internal and external factors which are also important in deciding the travel mode choice include: (i) attitudes, preferences, motivations and skills related to behaviour (ii) constraints or opportunities that have a direct impact on making the behaviour easier or more difficult in relation to a trip (iii) and the incentives and disincentives (Ajzen, 1991).

Psychological studies explain behavioural responses by searching for factors that may explain people's choices including the external and internal factors which affect travel behaviour. One of such study is *planned behaviour theory* (PBT) (Ajzen, 1985; Ajzen 1991) which provides important information about attitude measurement and the prediction of human behaviour. PBT is probably the most frequently used theory in transportation on travel behaviour (Bamberg *et al.*, 2003; Gardner and Abraham, 2008) which is derived from the expectancy-value theory (Bohte *et al.*, 2009). Expectancy-value theory says that people determine the expected value of their action by cognitive evaluation (e.g. public transport is environmentally friendly) multiplied by the affective evaluation of the attribute (e.g. using an environmentally friendly travel mode is good). Therefore, it is assumed that people choose the travel mode and residential location which they feel has the highest expectancy-value for them (Gärling and Garvill, 1993). The application of PBT to travel choice and residential choice helps in understanding how people make decisions.

According to the PBT most actions can be viewed as deliberative and planned behaviour. Behavioural intentions are influenced by people's attitudes, subjective norms and perceived behavioural control. PBT says that individuals make their decision about a particular transport mode and residential choice on the basis of systematic analysis of available alternatives. Behavioural intention comprises of three main factors namely: attitude to the behaviour (individual's positive or negative evaluation of performing a behaviour), subjective norm (perceived social pressure to perform the behaviour) and perceived behaviour control (perception of whether it is feasible to perform the behaviour).

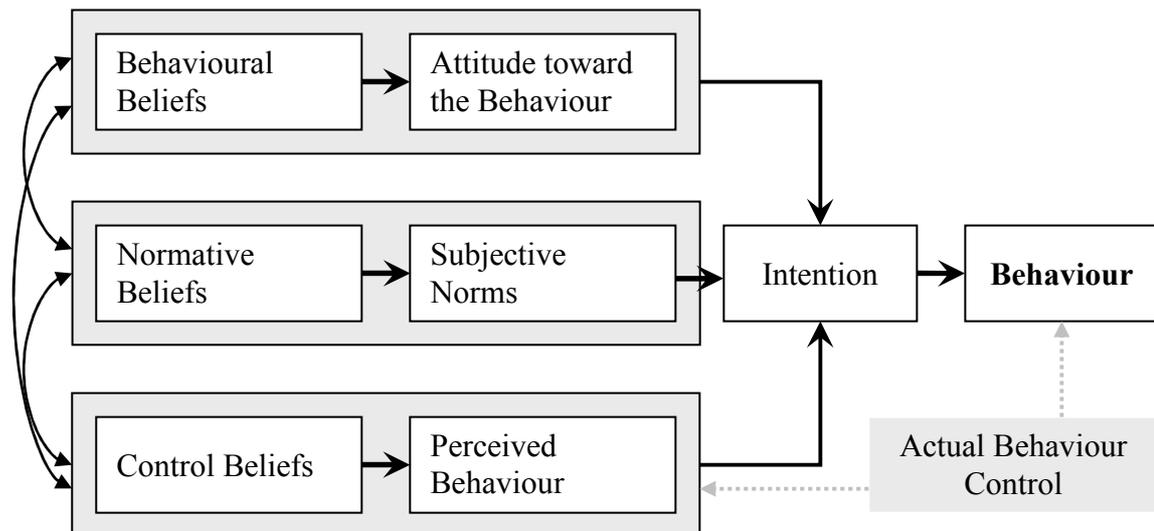


Figure 1- The Theory of Planned Behaviour (Ajzen, 1991)

Subjective norms mean an individuals' perception about expectations and opinions of other people (like family members or friends). Social norms affect people's behaviour through intentions, especially when they are not sure about appropriate behaviour. People who are sure about which behaviour to perform are less affected by social norms and they have a low possibility of changing their behaviour.

Perceived behavioural control refers to a person's perception about his/her own capability to perform an act (Forward, 1997). According to the theory, perceived behavioural control affects people's intentions, which subsequently influences behaviour. As presented in the figure 1, the broken arrow between perceived behavioural control and behaviour shows that the effect on behaviour can be both direct and indirect. There are four additional variables that are important and they include environmental concern, moral norm (internal notion whether it is right or wrong to perform the behaviour), behavioural norm (perception of other's behaviour) and habit (willingness to use a particular transport mode to travel to a variety of destinations).

2.2 Behaviour and the Physical Environment

Another psychology theory comprising individual and environmental circumstances explains that change in behaviour is based on change in personal determinants. Therefore, at micro level personal motivation and feasibility for a specific behaviour are two main factors (Vlek, 1999). The needs and opportunities can help to make the motivation whereas opportunities and abilities are important for feasibility for a certain kind of behaviour. Opportunities (social or physical) are the situation that can encourage or discourage the adoption at a specific behaviour. Abilities are associated with skills, education and experience in order to be able to execute the behaviour. Therefore certain kinds of opportunities and/or abilities must be available at micro level before any behavioural change is expected macro level (Rooij, 2005). Regional development patterns influence directly on opportunities of a specific location and the main factors can be categorized as cultural, institutional, demographic, economic and technological developments.

The above discussion shows the theoretical foundation of the relationship between travel behaviour and urban form which is basically based on the theory of utility theory as well as travel demand and PBT.

3. URBAN FORM AND TRAVEL BEHAVIOUR - LITERATURE REVIEW

This section summarizes the literature concerned with the connection of urban form and travel behaviour. Over the last two decades, numerous studies have been conducted that have analysed household travel behaviour in relation to land-use planning. Some renowned scholars have conducted six comprehensive reviews of this rapidly increasing literature (Badoe and Miller 2000; Crane 2000; Stead and Marshall 2001; Ewing and Cervero 2001; Handy 2005; Cao *et al.*, 2008). Three major aspects have been covered especially in these reviews namely: urban form characteristics, Socio-demographic factor and self-selection. The content analyses of these reviews have been presented in the table below.

Table 1 - Meta-analysis

	Content analysis
Badoe and Miller (2000)	Summarise the empirical evidence concerning impacts of urban form on travel, but also look at mode use and studies of transit impacts on urban form. Main conclusion included: (i) most studies suffered from methodological and/or data weakness, (ii) regional accessibility measures are important and socioeconomic characteristics are important determinants of travel behaviour.
Crane (2000)	Focuses on strengths and weaknesses of research approaches and categorises studies by type of research.
Stead and Marshall (2001)	Review evidences for the influence of land use on travel patterns from empirical studies only. The role of socio-economic factors, urban form and travel patterns has been analysed in relation with land use and travel characteristics.
Ewing and Cervero (2001)	Review a number of studies to examine the effects of the built environment, relative to socioeconomic variables, on four travel variables: trip frequency; trip length; mode choice; and VMT(vehicle miles travel). The results of review show that low elasticities of vehicle trips and VMT with respect to density and local design.
Handy (2005)	Summarises evidence for the proposition that new <i>smart growth</i> strategies will reduce car use. She also comments on importance of socio-economic as well as built environment characteristics in explaining travel behaviour and addresses issues of causality, including self-selection.
Cao <i>et al.</i> (2008)	Focuses primarily on the issue of self-selection to determine whether the built environment has a statistically significant influence on travel behaviour in those studies that control for socioeconomic characteristics and attitudes and preferences and, if so, whether the magnitude of that effect is identified.

The majority of these reviews find a statistically significant effect of land-use planning strategies after controlling socioeconomic characteristics and self-selection (Cao *et al.* 2008). However, these meta-analyses have provided limited knowledge whether particular urban form decisions have the impact to reduce the vehicle miles travelled (VMT). The authors characterize these results as 'mixed'.

Several publications (mainly originating from the US) have identified the effect of urban form on VMT. Bento *et al.* (2005) for example, examined a broad range of land-use and socioeconomic variables. In their model, they determined annual VMT by the number of cars owned as well as the number of miles each car is driven. They generated measures of urban form, population centrality, jobs-housing balance and the supply of public transit, combined

with data on the socioeconomic characteristics and automobile ownership and travel patterns of households drawn from the 1990 Nationwide Personal Transportation Survey (NPTS). The authors found that population size, jobs-housing balance, urban form, road density, and rail supply all have a significant effect on annual household VMT but the magnitude of the effect of each measure is too small to support any policy relevance. For example, a 10% change in either the urban form or the transit supply variables is associated with at most a 0.7 % change in average annual miles driven with the exception of population centrality, which is associated with a somewhat larger, 1.5 % change (Bento *et al.* 2005).

The study by Chen *et al.* (2008) also examines the impact of the built environment on mode choice, particularly transit use, which would be a substitute for car use and thereby contributed to a reduction in VMT. They assess the importance of density relative to other built environment variables (such as job accessibility with respect to the central business district (CBD) and distance to transit stops from home and work) in affecting mode choice for commuting while controlling self-selection. The authors find that indeed residential self-selection is a key factor in interpreting the importance of the built environment on travel behaviour. However, after controlling for self-selection, job accessibility via transit remains statistically significant and the most important of the built environment variables, reducing the propensity to commute by car. Density is also significant, but only employment density at work, corroborating findings of earlier studies (such as Badoe and Miller 2000 and Ewing and Cervero 2001); also significant is distance to transit stations from home and work. Chen *et al.* (2008) also test the impact of tour complexity on mode choice and find that increasing the number of stops in a tour significantly increases the propensity to commute by car.

Bhat and Guo (2007) examined the effect of the built environment on car ownership, which indirectly affects vehicle miles travel, in a model of residential location and car ownership decisions, using data for Alameda County from the 2000 San Francisco Bay Area Travel Survey and other related sources. After applying extensive controls for self-selection, the authors find that both household characteristics (primarily household income) and built environment characteristics were influential in car ownership decisions, although the former had a more dominant effect. Household and employment density, however, had a statistically significant but small effect on propensity for car ownership.

The study of Brownstone and Golob (2009) is another example. They use a rich set of socioeconomic variables to help control for self-selection and model the relationship among residential density, vehicle use, and fuel consumption for California households. The authors employ residential density alone (dwelling units per square mile at the census block group level show the strongest relationship among density measures) to describe the built environment because of consistency and availability of density data. They find that, after controlling for socioeconomic differences, a 40% increase in residential density is associated with about 5% less annual VMT. The most important exogenous influences on annual VMT and fuel consumption are the number of household drivers and the number of workers; education and income are also significant.

A study from the perspective of Southern California found no significant evidence that land use variables influence travel behaviour (Boarnet and Sarmiento, 1998) whereas Hanson (1982) found that socio-demographic variables prevail over spatial variables, while Kitamura *et al.* (1997) found that spatial factors do explain some variation in travel behaviour and travel patterns and Sun *et al.* (1998) found that land use balance and accessibility were significantly related to VMT, whilst also controlling the set of socioeconomic variables. Two studies from Scandinavian perspective (Naess, 1993 and Naess *et al.*, 1996) concluded that the effects of spatial factors compensate the effects of socioeconomic variables. Another study from Dutch perspective showed some interesting findings on the relationship between

spatial structure and travel patterns (MuConsult, 2000). It found that street type (home zone), density and the 'walk and cycle friendliness' of the neighbourhood are spatial factors influencing the number of kilometres travelled, while street type and the accessibility of shopping facilities influence the number of trips. A recent empirical study by Scheiner (in press) using structural equation models from German context confirm standard knowledge in travel studies. It shows that car availability plays a powerful role for residential location choice. Individuals with access to a car tend to locate in peripheral with lower levels of access to jobs and fewer shopping trips in the neighbourhood. The study indicates that, in general, neither lifestyles nor location preferences have a strong impact on trip distances.

3.1 Land-use Planning and Travel Behaviour

The rise in transport demand is encouraged more by the increased spatial separation of homes and workplaces, shops and schools than by any rise in trip making, particularly in low density, sprawled cities (Banister, 2008; Owen, 1992). Rapid growth in car ownership has permitted more dispersed patterns of urban development; these land-use patterns in turn require longer journeys for most daily activities and have become increasingly difficult to serve by energy-efficient modes of transport (Guo and Bhat 2007; Owens, 1992).

The urban system is a dynamic entity and its spatial structure evolves overtime. There are some actors which are responsible for this evolution namely; housing, public institutions and activities centers. Location decisions of these actors can affect urban form and subsequently transport choice. Normally travel behaviour is a result of three main factors (Van Wee 2002; Stead and Marshall, 2001 and Stephen, 1993) as shown in the Fig. 2. The figure illustrates the relationships between the main determinants. All three categories are influential in all directions. Changes occurring in one of the three categories of determinants could have an impact on the complete system (Van Wee *et al.* 1997; Van Wee, 2002).

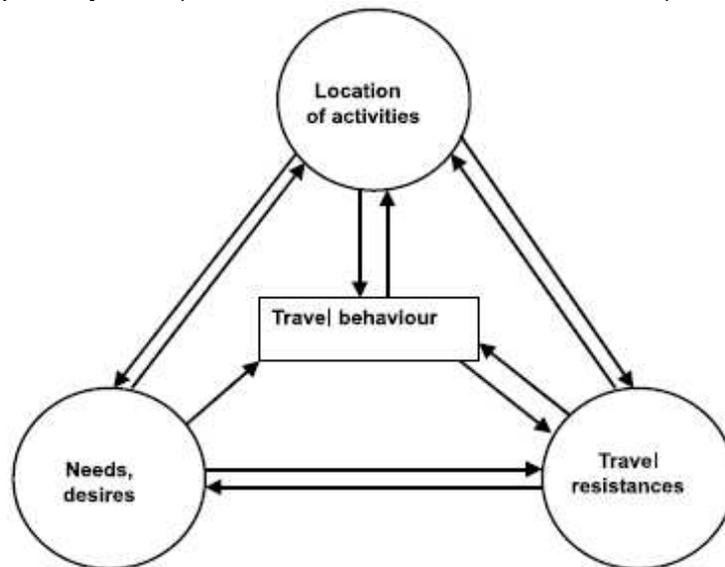


Figure 2 - Relationships between activity locations, needs and desires, transport resistances and travel behaviour (source: Van Wee *et al.* 1997)

Generally mobility can be defined as a movement of people and goods in space and time (Chapin, 1974). Activities are located in the 'space' of different land-uses and people need to spend time on these activities. Some studies show that mobility is also determined by demographic, cultural and socio-economic aspects of a region, besides the temporal and

spatial characteristics. These characteristics create the demand for travel and define how and why people travel and what modes they use for travelling.

Many studies show that *smart growth* development (also called *new urbanism* in US which is a set of sustainable planning practice based in more compact, public transport accessible and multi-modal development) can significantly reduce the need to travel (Erwing *et al.*, 2007; Litman, 2009; TRB 2009). It is believed that travel is a derived demand, people need to travel long distances because jobs, services and other activities centres are located far away from their place of residence. People rely on cars for their daily activities even for short trips because there is no other viable option available such as transit oriented development and mixed use development. The researchers have examined the land-use characteristics - from strategic to neighbourhood scale - that can affect the travel patterns. Here we will discuss some of them.

3.1.1 Density

Density is probably the most studied dimension of land-use. It means the number of people living in an area or number of jobs available in the specific area (Kuzmyak and Pratt, 2003). High density city growth is the concept of multiple and intensive land use. This concept means to intensify the use of land resources within single site through high residential densities supported by public transport and pedestrian based facilities (Lau *et al.*, 2005).

There is a considerable body of literature which discusses the relationship between urban form and travel behaviour. A highly influential and much referred study by Newman and Kenworthy (1989) was the first attempt to analyze population density at the macro level with travel pattern using the data from different cities around the world. The results stated that the need for private cars would appear to decline as cities become denser, more compact and more centralized. Later on, this concept by the Newman and Kenworthy (1989) supported by many other researchers including Kitamura *et al.* (1994), Cervero (1996), Messenger and Ewing (1996), Kokelman (1997), Holtzclaw (2000), Boarnet and Crane (2001) and Stead and Marshall (2001). The concept has also been supported by empirical studies, which have found that density and automobile travel behaviour are significantly co-related. A research study by Meurs and Haaijer (2001) conducted in the Netherlands found that the greater the urban household density the fewer the number of private car trips undertaken by household members. This research shows the strong linkage between the characteristics of land use planning, mobility and mode choice behaviour.

A research by Dunphy and Fisher (1996) has also supported this relationship, stating that household density reduces the number of private car trips. Further it adds household car ownership declines as household density increases. Another study by Holtzclaw (1994) evaluated the effect of four neighbourhood characteristics (residential density, transit accessibility and mix use development) on car usage (per household) and annual total vehicle miles travelled per household. The regression analysis in this study indicates that density is the most important explanatory variable of the four neighbourhood characteristics. Later on another study by Holtzclaw *et al.* (2002) analysed the geography, demographic structure and car ownership with results that corroborate the findings of Newman and Kenworthy. These relationships suggest strongly that low urban population density is associated with high private car ownership and use at the city level. These results, however, are subject to many of the flaws associated with aggregate analyses. The authors concluded that several of the independent variables are highly correlated like density, transit access, local shopping, centre proximity, and non-motorized travel making it difficult to identify their separate effects (Holtzclaw *et al.*, 2002). Some studies have found the role of high density development to reduce travel speed and trip distance (Manville and Shoup, 2005). Many

researchers have opinions that density itself has relatively little impact on travel but the factors associated with the density such as accessibility, mix land use as well as walking and cycling have far greater impacts on travel behaviour (Erwing, 1995; Kockelman, 1997).

According to Jenks and Demsey (2005) higher densities are one of the ways in which sustainable urban form can be achieved. High density supports the urban centralization concept which brings travel convenience and efficiency to the urban commuters by public transport and use of non-motorized modes (Lau et al., 2005; Kaido, 2005). Some studies indicate the positive impacts of density on the image of city or area. Density increases the liveable image of the city if it is implemented in coordination with pedestrian and cycling improvements, traffic calming and street design enhancements. According to Litman (2005), it can increase opportunities for neighbourhood interaction and community cohesion. Liveable communities directly benefits people who live in, work in or visit an area, and it can improve public health and safety.

3.1.2 Land-use Mix

Land use mix refers to the development of different type of land uses like, residential, institutional, recreational and commercial in close proximity to one another. It means development of multipurpose building at the neighbourhood level with mix housing types and price ranges to accommodate variety of income classes within the society, which is the key feature of smart growth concept. Mixed land use types of developments can affect the dwellers activities and therefore can have impact on their travel behaviour to some extent at local level at least. There are relatively few studies particularly associated with land-use mix and results from the empirical evidence are contradictory. Some show that mix land-use developments reduces the travel distance and encourage the more trips by non-motorized mode (Kuzmyak and Pratt, 2003). Mixed land-use development creates so called complete communities or urban village which is compact non-motorized neighbourhood centres and major services, activities and facilities are available at walking distance. Some research studies find a very low or minor effect associated with land-use mix characteristics on trip generation (Cervero, 1989; Ewing et al., 1996).

Location of retail shopping area and its level of connectivity with public transport has also affect the travel patterns of residents in an area. Stores located in the neighbourhood and town centre reduce the car travel and whereas out of city business parks encourage the automobile travel. More nearby accessible shopping stores result in more non-motorized traffic and public transport (Handy, 2004b). There are also some examples from the research which show that the provision of local facilities in residential developments may reduce the average trip distance but that they hardly have impact on non-motorized journeys like walking and cycling (Winter and Farthing, 1997; Farthing *et al.*, 1997).

3.1.3 Settlement size

Size of residential area is important with reference to travel patterns. Normally small settlements are unable to support a large range of services and facilities and forces local residents to travel longer distances in order to access the services and facilities that they require. On the other hand very large and centralised settlements may lead to longer travel distances because of a large separation between homes and the urban centre. Inappropriate settlement development may therefore influence the travel patterns of residents (Owen, 1986; Hadicar 1997 & 2000). Researchers recommend that a population size of at least 10,000 is required for the variety of facilities and services in the specific area (Williams, 1997a&b; Banister, 1996). Annual national travel surveys also support the idea that total

distance travelled per person is high in rural areas compared to the metropolitan areas (Breheny, 1995). Research by Williams and Banister, (1998) suggests that travel distance is often lower in large urban areas containing more than 250,000 residents, after socio-economic differences are taken into account. In summary, there has been a relatively large amount of research concerning the relationship between settlement size and travel patterns. The relationship between settlement size and travel patterns is unlikely to be simple due to the interplay of competing factors. Evidence from the ten largest urban areas in the United States however shows no easily identifiable relationship between urban population size and modal choice (Gordon *et al.*, 1989).

3.1.4 Public Transport Oriented Development

This concept refers to the development of residential and commercial areas accessible with public transport. In the literature there are several studies that show the role of transit oriented development in reduction of per capita automobile travel (Kuzmyak and Pratt, 2003; Cervero, 2004; Ewing, *et al.* 2007). Studies show that employees and residents of transit development areas have a lower attraction towards car ownership, they drive less and rely more on other alternative modes compared to automobile oriented areas (Cervero and Arrington, 2008; Evans and Pratt, 2007). Around the station, increased residential and commercial density and workability can increase the transit ridership. Another study indicates that ridership can increase from 20% to 27.6% if the residential density increases from 10 to 20 unit per gross acre and implemented with pedestrian improvement (Cervero, *et al.*, 2004).

In recent years, there has been greater recognition of the link between energy efficiency and land use planning. Transport in general and car ownership in principle has been seen as a main accommodating factor in the development of suburban housing and in redirecting development pressures away from the city centre as identified by many studies (Banister, 1998). This dynamic is reinforced by the development of out-of-town and edge-of-town growth in retail, business and leisure services at motorway intersections and along transportation corridors. However, in the 1990s, the more unified approach to urban policy and planning was realized. The literature on urban density and automobile dependency shows that population density and employment rate are the major drivers that play an important role in mode choice at region, city and neighbourhood level. The analysis of key urban form attributes and travel behaviour variables indicates that none of the measures act alone but instead interact with others. Some researchers (e.g. Dumphy and Fisher, 1996) argue that the relationship between urban density and travel behaviour is not clear because of the role of socioeconomic factors that are neglected in these studies. Dumphy and Fisher criticized Newman and Kenworthy (1989) on the accuracy of data and the study is considered controversial. Critics have asserted that the authors failed to take into consideration a host of urban and non-urban form variables, including the role of income, fuel prices, and types of land uses and their spatial distribution within a city (Steiner, 1994). Gordon and Richardson (1989) have also questioned the quality of the study's data and the validity of global comparisons to American cities.

Generally meta-analyses of the literature on the influence of urban form characteristics on travel behaviour demonstrate an ambiguity on this issue. It is therefore difficult to draw general conclusion from these studies. The results of the empirical studies reviewed vary substantially, ranging from no influence to significant influence. However, there seems to be some agreement that factors such as increased density, land use mix, transit access yield best results for decreasing VMT.

4. HOUSEHOLD'S RESIDENTIAL CHOICE FACTORS

In the previous sections of this paper our discussion formed on the human psychology and physical environment perspective of household residential choice. Other factors which influence household residential choice, are socio-demographic characteristics and the social environment such as, opportunities/constraints and incentives/disincentives (Michaelson, 1977). According to some studies, housing characteristics such as cost, size and location are main choice factors (Timmersmans, 1988). Some researchers have opinion that life cycle - rather than economic motives - is the main explanatory factors in housing moves (Clark and Van Lierop, 1987; Kijkamp et al., 1993) Residential location choice depends also on at least three other factors such as (a) attitudes, preferences, motivations, and skills related to the behaviour; (b) opportunities or constraints that make the behaviour easier or more difficult to perform; and (c) incentives or disincentives that encourage or discourage the desired behaviour relative to competing activities (Handy 2004; Brun and Fagnani 1994).

4.1 Demographics Characteristics

People move their home location because of dissatisfaction with their current location or because a new location offers benefits not available at their current location. They are encouraged to move by changes in their personal (e.g. job change) or household circumstances (e.g. marriage, birth of child) or changes in their neighbourhood (more environmental friendly, quietness). Households are pulled to new locations by their aspirations for better housing or by opportunities that more closely match their needs and preferences. A move may occur because of a socio-economic change or social desire. For those households with children of school age, there is ample evidence that perceptions about the quality of schools influence locational decisions, as well as housing prices. Some studies point out that households make a trade-off between the amount of housing they can buy and the costs of commuting to access services (Hunt *et al.*, 1994; Sermons and Koppelman, 1998).

Because most households have budgetary constraints, housing costs and housing attributes (parking facility, number of rooms, lawn) are a primary factor in the locational choices they make. Housing costs vary with diverse factors of current location including size, quality, type, and age of the unit and the characteristics of the neighbourhood where it is located. Studies find that housing affordability is a primary determinant of the location of households, and people make trade-offs between housing cost and travel cost of access the different destinations (Kaysi and Abed, 2001; Cooper *et al.*, 2001). Some studies addressed the residential choice issue by comparing housing attributes, residential environment and accessibility. The results of six case studies from the Netherlands suggest that accessibility considerations are significantly less important than housing attributes and attributes related to neighborhood environment (Molin and Timmermans, 2002). These findings however represent a discrepancy from the results of other residential location choice studies (Gayda, 1998; Cooper *et al.*, 2001; Walker *et al.*, 2002).

4.2 Socio-economic Characteristics

The socio-economic differences between different types of settlement also play an important role in transport choice (Headicar, 2000). Being a relatively prosperous society; it is easy to buy private car in most developed countries therefore the result is newer, expanding urban areas and in dormitory rural areas. This is reflected in much higher rates of household car ownership overall in developed countries including UK (Headicar, 2000; DfT, 2009). In the

UK, two factors which are especially important in influencing the amount of car travel are the current lifestyle of younger generations and land-use planning (Headicar, 2000). A proportion of the difference in travel behaviour between settlement size categories will be attributable to such socio-economic differences rather than to settlement size in itself. This behavior is clearer when research conducted within two English counties is considered which suggests that socio-economic rather than land use characteristics account statistically for more of the variation in travel patterns (Stead *et al.*, 2000).

There are also large numbers of research studies available in literature, which deal with variety of socio-economic factors and their influence on travel pattern and residential location choice. After comprehensive review of studies, Stead and Marshall (2001) identify among others eleven types of socio-economic factors which impact on travel patterns. These socio-economic factors are interconnected with each other, and it is often difficult to separate the effect of one from another (Stead and Marshall, 2001). For example household income is linked to employment and this may influence car ownership and use. Car ownership and use is also further influenced by age and gender. Several studies have examined the impacts of socio-economic factors on travel pattern by using different methods and scales (Dunphy and Fisher, 1996; Kockelman, 1997). Socioeconomic characteristics such as income, age, gender, occupation have a significant impact on travel behaviour and must be adequately represented at a disaggregate level in models that attempt to estimate the impact of the built environment on travel behaviour (Stead and Marshall, 2001). Ewing and Cervero (2001) note further that socioeconomic factors are dominant in trip frequency decisions, whereas the built environment appears to be more influential with respect to trip length, while mode choice depends on both factors.

Overall, a combination of household socio-demographic characteristics, such as income levels, age of household members, and family size, interact with the housing opportunities available in a region to determine whether a household will move. Housing opportunities are a product of the type and quality of housing stock, the characteristics of neighbourhoods, and desired quality as well cost of public services.

5. RESIDENTIAL SELF-SELECTION

Households may not only align their travel behaviour to the possibilities and constraints of their residential location, but also self-select themselves by choosing to live in residential locations that correspond with their travel related attitudes. For example, residents who prefer driving over using public transport may choose remote and spacious neighbourhoods, while households with a preference for public transport may opt for more urban residential locations within walking or cycling distance of a railway station. Residential self-selection significantly contributes to the complexity of travel behaviour and links with housing location choice. Ignoring residential self-selection leads to an overestimation of the impact of the built environment. This is evidenced by several studies on residential choice which, using different research methods, have indicated that travel-related attitudes and preferences do indeed influence residential choice (e.g. Molin and Timmermans, 2003; Schwanen and Mokhtarian, 2007; Naess, 2009). Therefore it is essential that the issue of self-selection is discussed in some detail.

Residential self-selection (also called the Sorting effect) is related to travel behaviour and means how households choose a residential location that suits to their travel-related attitudes. In other words, self-selection refers to the '*tendency of people to choose locations based on their travel abilities, needs and preferences*' (Litman, 2005, p.6). Residential location choice is an important a long term decision for a family which affects the travel

patterns in the long run. On the other hand, travel behaviour of households may be affected by the opportunities and constraints of a location. Research studies show that, for residential self-selection, people take decisions under the influence of two sources: socio-demographic circumstances and personal attitudes (Mokhtarian and Cao, 2008). For example, a location decision under certain financial limitations (job, budget to buy/rent the house) and a residential choice without any internal or external limitation.

Under the first assumption people (households and individuals) select an area and locate themselves accordingly and then based on a range of neighbourhood attributes, develop their travel behaviours. This means people choose the location under financial or time constrained reasons but not necessarily because of car ownership. Built environment attributes can play an important role in shaping the travel behaviour, but the problem with the above assumption is that it does not take a comprehensive view of how individuals and households make residential choice and travel decisions. In real life, it is clear that high density and mixed land-use developments with public transit are more attractive for the car neutral households and individuals. These types of households will use walking and cycling to pursue their daily activities if neighbourhood facilities are available.

The second assumption is based the strong personal preferences related to travel pattern. Travel behaviour of people and consequently residential location selection comes under personal attitude and then people fulfil their daily requirement accordingly, like visiting jobs, services and activities. For example, people with high car ownership prefer less crowded residential location and remote neighbourhood. These assumptions have been confirmed by many studies with different research methods, although disagreement exists about impact intensity of built environment attributes and household variables. Some recent studies show that travel related habits and preferences have a significant influence on residential self-selection (Molin and Timmermans, 2003; Schwanen and Mokhtarian, 2007; Mokhtarian and Cao, 2008; Naess, 2009).

The correlation of housing choice and travel mode choice is an understudied area and researchers are divided about the exact causal effect of both. Numerous recent studies have found a significant association between the residential environment and travel behaviour (Scheiner J. 2009; Pinjari et al., 2009; Cao et al., 2009; Naess 2009). However, most of these studies confirm only the associative relationship between them and the disagreement exists in knowing whether the neighbourhood environment influences travel behaviour or travel pattern preferences affects residential choice. The above mentioned large amount of literature from US and Europe covers the impacts of residential location choice (neighbourhood facilities) on travel behaviour but the reverse effect has not been well documented in the literature. Accessibility is a dominant factor when selecting a residential location. Policies related to transportation and land-use planning can impact on the lifestyle of households in the specific area. The residential location preference is one of many variables thought to affect travel behaviour. The conceptual model for this study (Fig. 3) recognizes the complex relationships travel behaviour and housing location. The impact of many variables in particular context are still unknown, however some decisive factors are included: household's socio-demographic characteristics, personal attitude and habits and physical environment as shown in the conceptual model below.

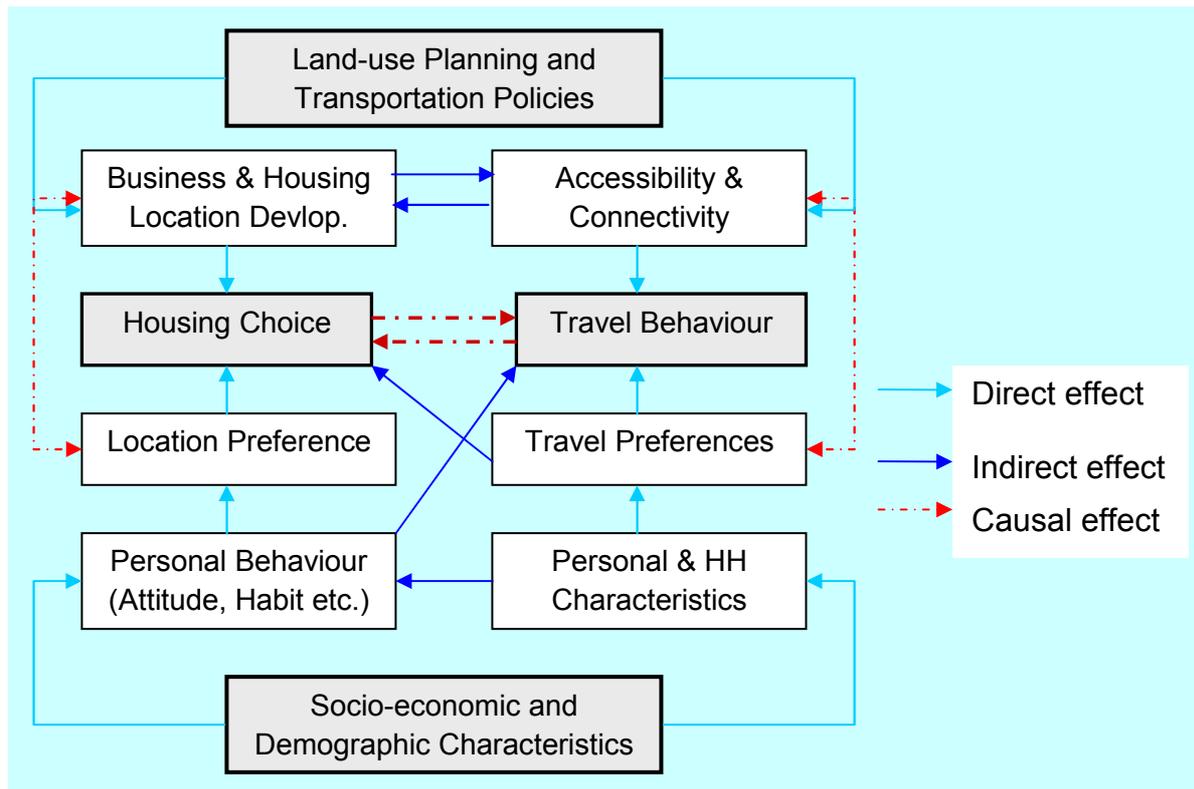


Figure 3 - Conceptual Model: Travel behaviour and Housing choice Preferences

As mentioned above, numerous studies have found a significant association between the built environment and travel behaviour. However, most of these studies confirm only the associative relationship between them and the disagreement exists in knowing whether the built environment influences travel behaviour or travel behaviour preferences and land-use patterns affects residential choice. If the later assumption is more dominant then the ability to use the built environment characteristics to change traveller's mobility patterns may be limited because the majority of people like suburban types of development and who prefer walking, may consciously choose to live in walkable neighbourhoods (Morrow-Jones *et al.*, 2004).

6. DISCUSSION

With a high number of variables and attributes from both sides make the relationship complex and it is not easy to get the answer to the question: which dimension of urban form has impact on which aspect of travel. Within the empirical studies it is hard to identify, which urban form characteristics have implicit and explicit impacts on selected travel dimensions. For example a denser land-use mix may reduce the travel for services and activities but on the other hand, may increase leisure travel activities (Bhat and Srinivasan, 2005). Within the growing literature it is important to differentiate the studies on the base of scale (aggregate verses disaggregate) methodologies and the role of socio-demographic characteristics.

6.1 Aggregate versus Disaggregate Analysis

Research studies are conducted at different scales with variety of data about urban form attribute and household variables. Generally there are no predefined criteria for the boundaries of neighbourhood, zone, local and regional level. Therefore, it is important to

distinguish the scale of study for a better understanding of the complexity of relationship. In the literature there are two types of qualitative and quantitative studies dealing with urban form and travel behaviour. Firstly, the studies which indicate the significant impacts of urban form attributes on travel behaviour. In this category most studies are included which were conducted at a disaggregate scale, for example the impact of neighbourhood on walking and cycling. The detailed review of many studies can be mentioned in this category (see Erwing and Cervero, 2001; Rajamani *et al.*, 2003; Krizek, 2003; Shay and Khattak, 2005; Bhat *et al.*, 2005; Bhat and Singh, 2000; and Rodriguez *et al.*, 2005). Secondly, some studies show very little or no impact at all of land-use planning measures of mobility. Generally these studies were conducted at an aggregate level with the variety of urban form attributes and travel variables. Such studies were reviewed by Crane (2000) and this phenomenon is supported by many other studies (Boarnet and Sarmiento, 1998; Boarnet and Crane, 2001; Bhat and Lockwood, 2004; Bhat *et al.*, 2005; and Bhat and Zhao, 2002). Contrasting results is not surprising given the complex nature of relationship between urban form and travel behaviour and as well as of the nature of different estimation techniques, scale of analysis, empirical contexts and dimensions of travel behaviour. Moreover urban form characteristics and the scale used across studies are also different and as a result it is almost impossible to get the same result. Mostly, the studies mentioned above that are carried out in different countries with the aim of defining the impacts of residential choice have mixed results. Some studies found that urban form attributes had a significant impact on travel behaviour, whereas other studies have found built environment partly (e.g. one or more dimensions in travel behaviour).

6.2 Socio-demographic Characteristics

Most studies show that socio-economic circumstances and life style aspects of individuals have a greater role in influencing travel behaviour. Higher household income means more attraction towards private car ownership and use (Schwanen and Mokhtarian, 2005; Kitamura *et al.*, 1997; Handy *et al.*, 2005; Lund, 2003). Some studies show that mobility is also determined by demographic, cultural and socio-economic aspects of region, besides the temporal and spatial characteristics. These characteristics create the demand for travel and define how and why people travel and what modes they use for travelling. Human behaviour itself is very complex and therefore, many researchers believe that many unobserved variables exist which describe an individual's characteristics and which have direct or indirect role on decision making.

6.2.1 Attitude

Mostly all human being make mind towards or against something after the careful evaluation of situation. These evaluations can be affective evaluations, cognitive evaluations as well as behavioural responses. When it comes to the selection of residential location, it usually is impossible to identify the exact role of travel related attitudes because with housing alternatives plenty of built environment attributes are also involved. As Lindberg *et al.*, (1998) indicated the complexity of residential choice by mentioning that, '*different dimensions of housing attributes may not be evaluated independently of one another and therefore the evaluation of housing attributes in isolation from one another does not seem reasonable*'. On the issue of residential choice, most empirical studies have also measured current travel related attitudes rather than attitudes at the time of the residential choice to account for residential self-selection. Therefore, the whole interaction between attitudes, built environment characteristics and travel behaviour is important for sustainable transport policy.

6.2.2 Habit and Desire

Some other factors like *habit* and *desire* have been added into many other studies. Infact, habit is considered one of the most significant factors and several studies have demonstrated the role played by habits in travel behaviour (Naess, 2005; Gardner and Abraham, 2008). Some scientists have criticised TPB for neglecting the role of *habit* and *desire* in human behaviour (Perugini and Conner, 2000; Perugini and Bagozzi, 2004; Dijst *et al.*, 2008). It is considered that when any particular behaviour is performed repeatedly, it becomes habit, consequently individuals are guided by an automatic cognitive process and therefore decisions are influenced.

Several studies have looked the effects of contextual changes (residential parking policy, financial incentives) on habits, intentions and attitudes related to travel patterns and have found a mix of results. According to some researchers land-use policies may be helpful with 'pull and push' strategies to change attitude, as well as the habit of car use (Bamberg 2002; Fujii and Kitamura, 2003). But other studies show that it is hard to change the strong habit and as a result this habitual behaviour is a key barrier to reducing the car use (Bamberg *et al.*, 2003; Bamberg, Rolle, and Weber, 2003; Matthies, Klockner, and Preissner, 2006). Some social behaviour experts have the opinion that objective advantages of car use like, higher speed, comfort, and flexibility are the main determinants of individual travel mode choice and consequently residential choice.

6.2.3 Lifestyle

Lifestyle is defined as individual pattern of behaviour towards the resources available (Salomon and Ben-Akeva, 1983, Ge and Hokao, 2002 & 2006). Individual have developed a particular lifestyle for self satisfaction. Lifestyle determines the travel patterns for all kind of activities like; work, education, social and recreational. Travel patterns of individuals are influenced by lifestyle which is considered a very stable characteristic that is very hard to change and is a prominent determinant for residential location choice (Ettena and Timmermans; 1997). Thus, in the long-term lifestyle choice is an important factor in determining mobility behaviour. Choice of life-style is long term decision while the daily travel choice is short term. Decisions about family formation, job and free time activities all mostly depend on life-style.

6.2.4 Opportunities versus Constraints

The role of opportunities and constraints at neighbourhood level has been discussed in detail in the health and physical activity literature (Handy 2004a&b; TRB 2002). Sustainable development of built environment can provide equal movement opportunities for motorized and non-motorized transport. For example, concerns about personal safety can reduce the modal share of non-motorized on the roads. Research studies have shown that cyclists perceive unsafe with car speed increases in urban region (TRB.2009 & 2002). Just providing opportunities for walking and cycling may not be sufficient to change behaviour unless the constraints related to use the opportunities cannot be omitted. Segregated land-use development and therefore long travel distances between destinations makes the personal car only viable option.

6.2.5 Incentives versus Disincentive

In a review article, Kearney and DeYoung (1996) summarize the results of 29 empirical studies evaluating the effects of different intervention strategies on commuter car use. The results indicate that material incentives and disincentives are successful strategies which can initiate rapid changes in travel behaviour. It is hot debate among the researchers how to change the household travel behaviour using financial instruments. 'Pull and push' policies (e.g. parking policy, congestion charges and subsidized public transport) have been introduced to encourage more sustainable patterns of transport. Incentives and disincentives policies can be introduced from a neighbourhood to a regional scale by lowering the cost of a desired behaviour and raising the price of an undesired behaviour. For example, walking and cycling can be encouraged by providing the safe designated paths and restricting the vehicle speed limit. If people perceive that the behavioural changes are impossible (reflecting little personal control), then push and pull policies will not be effective. Individual's behaviour also depends on the opportunities to perform the behaviour. Besides the actual opportunities, the perceived opportunities are also important in deciding whether to perform an action. For example, if people consider the public transport as unsafe then it cannot be perceived as a reasonable option, even though it might be a feasible alternative. Often pricing policies are considered to be able to change the opportunities that people have (Ubbels and Verhoef, 2003). Though the PBT claims that major source of behaviour determinants are attitude, subjective norms and perceived behaviour control, the empirical research (DfT, 2003) shows that they are hardly sufficient to provide a complete account for decision making process.

7. CONCLUSION AND RECOMMENDATIONS

Several empirical studies and comprehensive reviews of the literature have been investigated from the perspective of connection between urban form and travel behaviour. This paper has examined the literature related to household travel behaviour and the relationship with urban form. It investigates empirical evidence about the claims that land-use planning factors, household socio-demographic factors and social as well as personal preferences (attitude, habit) are the main determinants in the selection of household travel patterns and residential location choice. The analysis of the literature indicates that urban form factors (density, land-use mix, transit development) have impacts on household's travel behaviour but that the role of socio-demographic factors and personal preferences are also significant which need to be quantified precisely. Another issue is self-selection; in the literature we find still limited number of studies which address the issue of self-selection principally. Households choose their residential locations based, among other things, on their preferences for modal split and/or preference for residential location. There are enough evidences from US and Europe to conclude that urban form (smart growth initiatives) can influence the travel behaviour albeit researchers have little agreement on what aspects of the built environment are important determinants of vehicle miles travel. From critical perspective these studies have several weaknesses related to methodology, the spatial scale of the studies and accuracy of data.

The research implies that the relationship between urban form and travel behaviour is promising. Further research on this relationship can provide significant insight on the understanding of residential self-selection and any land-use policy aiming to encourage sustainable travel behaviour. In order to achieve sustainable travel behaviours, spatial planners need to design neighbourhoods (either constructing new or modifying the existing) that have sustainable patterns with houses that consider households various housing, travel and locality preferences. In case of less sustainable households, sustainable travel patterns can be induced by addressing their residential and neighbourhood preferences while

providing for sustainable travel alternatives. As travel attitudes and existing transport infrastructure are strongly related, residential areas with poor public transport infrastructure will attract household with higher car usage and increase their positive attitude towards private transportation systems. There is another argument that, if car use is valued higher than public transport use in an area, increase investment in the latter can have little effect on changing preferences. Thus, there is little empirical evidence which suggests that a change in spatial structure can affect travel behaviour.

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