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Neighbourhood Design Perception and Travel Behaviour in Tyne and Wear, North East England, United Kingdom

This paper will present empirically based evidence from the UK in respect of the impact of neighbourhood design on travel behaviour using a case-study approach.
The case-study is based on the metropolitan area of Tyne and Wear, North East of England. Ten different neighbourhoods have been carefully selected to characterise two different types of traditional and suburban neighbourhood street layouts. A self-administered questionnaire has been delivered to 2,200 households to capture four dimensional aspects of land-use and transport characteristics: neighbourhood design, travel patterns, travel attitudes and socio-economic characteristics.
Factor analysis has been used to model the relative importance of neighbourhood design and travel attitude characteristics against respondent's perceptions and preferences. Multivariate analysis of cross-sectional data shows that some socio-economic variables as well as travel attitudes and neighbourhood design preferences can explain the differences in travel patterns. Furthermore, looking at a *regression analysis* model for different neighbourhood types, the traditional neighbourhood group has more sensitive factors that influence the differences in travel pattern than the suburban neighbourhood group, suggesting that land-use policy designed to accommodate low carbon-based travel neighbourhood characteristics will have greater impact on the traditional group than the suburban group. However, although residents of a traditional neighbourhood have more advantage of better accessibility, the causal explanation revealed that they have a bigger potential to travel further than their suburban counterparts if given the opportunity, suggesting that a persons desire to travel further is inherent even though they have better choices to other travel opportunities.

Keywords: *neighbourhood design, land-use, travel behaviour, multi-variate analysis*

1. Introduction

The expansion of cities to accommodate new development either for residential or business purposes continues to be monitored with careful attention by policy makers and researchers. Of particular concern is the observation that present development policies have yet to meet the need to accommodate sustainable development. The present growth of land development patterns can be shown to cause environmental problems by contributing to a high level of car travel and consequently high carbon emission, more land occupation for roads and further community segregation. The 'New Urbanism' (US) and 'Compact City' (Europe) movements are trying to re-assess the approach of how to build and/or re-build our cities. The campaign is to bring residents closer to destinations and provide viable alternatives to achieving lower carbon-based travel patterns. However, research

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findings about how neighbourhood design and urban form can contribute to such a change in travel behaviour are mixed. Extensive US studies show that land-use has or has only caused a small impact on travel behaviour. As yet, there is not sufficient evidence that land-use planning is an effective means to manage travel demand (Handy, 1996; Badoe and Miller, 2000; Boarnet and Crane, 2001; Cervero, 2002 and Banister, 2005) but there are other factors, such as socio-economic and attitudes/preferences, and self-residential selection, which also contribute to an apparent causality between land-use and travel behaviour change. Thus, people who prefer to walk or use public transport may choose to live where a walk or public transport use friendly environment is available (Krizek, 2003; Handy *et.al.*, 2005). Consequently, the characteristics of neighbourhood design do not appear to cause these people to drive less; rather their desire to drive less causes them to select a neighbourhood with those characteristics. Understanding the role of self residential selection is the key to understanding the causal relationship between neighbourhood design and travel behaviour (Handy *et.al.*, 2005). In the UK, the evidence has revealed that less than one third of the travel patterns can be explained by land-use characteristics (Stead, 2001).

In the UK, PPG 13 (Policy and Planning Guidance in Transport) has been sensitive to the need to promote sustainable travel but recent evidence reported by CABE (Commission for Architecture and Built Environment, UK) on the implementation of 'Design Code' shows that built environment characteristics to promote sustainable travel have been less frequently included in this code confirming that the progress towards sustainable development is not straightforward. Research funded by the UK government looking at how to develop cities in a way which can be shaped towards sustainable development is now being undertaken. This includes the City Form project, started in 2001, which aims to identify what a sustainable neighbourhood is and how to achieve it and the SOLUTIONS project, started in 2004, which aims to identify city planning scenarios that could shape future sustainable development. Whilst the results of these studies (both EPSRC funded) are now emerging, they are not yet implemented in planning guidance. The White Paper "Planning for a Sustainable Future" (2007) which reflects the findings of recent significant reports from Eddington (transport), Barker (land use planning) and Stern (climate change) was established to guide the future direction of different types of sustainable development. In anticipating climate change caused by CO_2 emissions, transport and land-use planning have to be more sensitive to the micro level of built environment characteristics which contribute to the resulting travel pattern. In this respect this study of neighbourhood design characteristics and travel behaviour has gained relevancy as it seeks to exhibit a better understanding of the dimensions involved in people's travel decisions.

This paper reports the analysis of British evidence of the relationships between urban form and transport. Relevant literature is considered first as the basis to identify the experimental design best able to achieve results linking urban form to travel behaviour, in the context of a case-study in the North East of England. The case-study examines the role of neighbourhood design in influencing people's travel and discusses the relationships revealed between dimensions involved in the transport / land-use interaction.

2. Studies to analyse neighbourhood design impact on travel – a concise literature review

The work of Newman and Kenworthy (1989) established that urban form measures such as density could have a strong relationship with travel behaviour. Their campaign which sought to overcome car dependence in favour of more environmentally sustainable travel patterns has led to many subsequent questions as to the cause and effect between urban form and travel behaviour. Literature in this study area has been developed in several different perspectives. According to Boarnet and Crane (2001), the analysis of research on the influence of urban form on travel can be classified into three different approaches: hypothetical studies, descriptive studies and multivariate statistical studies.

2.1. Hypothetical studies

In hypothetical studies the general idea is to construct situations, in a strategically and controlled environment, where different land-use patterns and other urban features can be linked to travel. Traditional transportation models are used to predict differences in total travel between typical suburban neighbourhoods and hypothetical neo-traditional neighbourhoods (Handy, 1996). These studies are not intended to explain behaviour; rather they make certain assumptions regarding behaviour and then apply those to alternative situations to see what happens. This approach usually tended to focus on the overall structure of a city or metropolitan area, in terms of distribution of employment and residential activities and/or the structure of the transportation network (Handy, 1996).

Examples of hypothetical studies can be seen from the work of Kulash *et.al.* (1990), McNally and Ryan (1993), Stone *et.al.* (1992) and Rabiega and Howe (1994), all cited by Boarnet and Crane (2001), Handy (1996) and Marshall (2005). These studies compare the vehicle miles travelled (VMT), for a fixed number of car trips, in two different kinds of fictional neighbourhood (See Figure 1. for illustration of street layout comparison). One has an open grid like street pattern and the other is a more closed and circuitous cul-de-sac neighbourhood. They compare how aggregate travel distances change as trip origins and destinations are moved nearer or farther apart, for a fixed number of trips. The research confirms that a given trip becomes shorter if the destination is nearer.

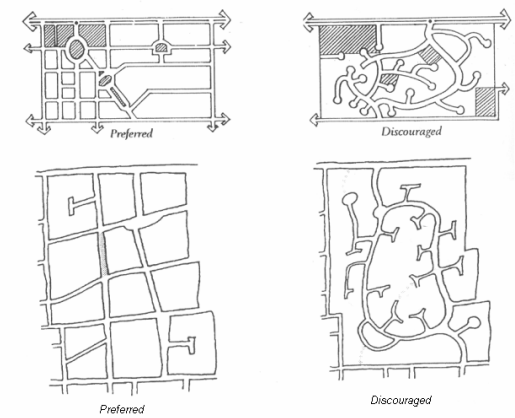

FIGURE 1 Examples of ‘preferred’ and ‘discouraged’ neighbourhood street layouts; Source: Marshall (2005)

2.2. Descriptive studies

Descriptive studies provide an account of travel experiences, individually or on average. They have the strong advantage of working from actual behaviour and form an extremely important part of the process of understanding what is going on. Descriptive studies provide a picture of observed behaviour and may contain important data and revealing insights regarding travel patterns in different settings. However, these studies also do not attempt to explain travel behaviour.

Examples of this type of study include the work of Friedman *et.al.* (1994), Dunphy and Fisher (1996), and Rutherford *et.al.*(1996), all cited by Boarnet and Crane (2001) and Handy (1996). Friedman *et.al.* (1994) revealed higher percentages of public transport use and other non-car use in traditional neighbourhoods than in standard suburban neighbourhoods and provided evidence of a difference in choices about modes in two types of neighbourhoods, but no insights as to why. Dunphy and Fischer (1996), in a descriptive examination of data from the 1990 National Personal Transportation Survey, confirmed the patterns found by other researchers of higher levels of public transport use and low car travel in higher density communities. However, the pattern is not clear cut because of the intervening relationship between density and the demographic characteristics of certain households.

Headicar and Curtis (1998) surveyed regular journeys using a one day travel diary in five suburban areas of cities and towns in Oxfordshire, South East England, which had few or no amenities within the neighbourhood. The total number of journeys was similar in all areas but a number of interesting factors emerged. Where there was public transport provision, this appeared to be associated with lower modal share for the car and a lower distance travelled by car. Residents of housing estates linked by frequent buses to Oxford city centre exhibited lower distances travelled by car and also lower car ownership than a comparable housing estate with no bus service in another town in the area.

In the Netherlands, Meurs and Haaijer (2001) described the effect of spatial characteristics which includes home, street and neighbourhood characteristics, using a cross-section analysis. These effects were particularly apparent in trips made for shopping and social or recreational purposes. The study showed that certain aspects of the planned environment have a clear impact on mobility.

2.3. Multivariate statistical studies

Multivariate statistical studies examine observed rather than hypothetical behaviour. These studies attempt to explain rather than merely describe what is going on. The studies in this category vary in several significant ways. First, they ask different questions of their data. Second, their data captures different features of the built environment and of travellers, and at different levels of detail. Third, they investigate their data by various means (Boarnet and Crane, 2001).

Cervero and Kockelman (1997) use a travel diary to examine the link between VMT per household, mode choice, and land-use near a person's residence using neighbourhoods chosen to correspond to census track (a geographic unit defined by the U.S. Census Bureau, which defines a neighbourhood and contains an average of about 3000-4000 people). VMT and mode choice were regressed on a set of

individual socio-demographic variables and variables that included population and employment densities, indices of how residential, commercial and other land-uses are mixed in close proximity and street design data for the respondent's residential neighbourhood. The analysis showed that the land-use variables had a significant effect in some of the models, but the elasticities implied by the regression coefficients were often small as compared to those of the socio-demographic variables.

Kitamura *et.al.* (1997) added data on personal attitudes to the list of explanatory variables. Travel diary data in five neighbourhoods were regressed on socio-demographic variables, land-use variables for the person's residence, and attitude variables that were drawn from survey responses designed to elicit opinions on driving, the environment, and related questions. The attitudinal variables explained the highest proportion of the variation in the data.

In the most extensive UK study, Stead (2001) used multiple regression analysis, using the data from several national travel surveys and local authority travel surveys, to identify the key socio-economic and land-use characteristics that explain the variation in travel distance per person. The study concluded that socio-economic factors explained more than 50% of the variation in the amount of travel by census wards (which are slightly larger than the US census track). The most important socio-economic factors included car ownership, socio-economic group and employment status.

Dieleman *et.al.* (2002) used the Netherlands National Travel Survey (OVG) to explore some of the relationships between trip purpose (work, shopping, and leisure), mode travel and distance. The regression models revealed that personal attributes and circumstances have an impact on modal choice and distances travelled.

Handy *et.al.* (2005) employed a multivariate analysis of cross-sectional data of 8 neighbourhoods in Northern California and revealed that differences in travel behaviour between suburban and traditional neighbourhoods are largely explained by attitudes to both urban form and travel characteristics.

2.4. Longitudinal studies

In the area of transport research, longitudinal studies are used to involve the effect of time order. Most studies examining links between neighbourhood design and travel behaviour have only paid attention to the association (or statistical association) of these variables (Handy *et.al.*, 2005). Meurs and Haaijer (2001) investigated the extent to which changes in spatial characteristics led to changes in mobility patterns using a dynamic analysis. They found that of the people who moved house; when someone moves from a flat to a different type of house, mobility increases, and in the reverse situation it declines. The study by Krizek (2003) used longitudinal data for households who relocated within the Central Puget Sound area, Washington State, to identify changes in travel behaviour when exposed to differing urban forms. The study confirmed that residents locating to areas with higher neighbourhood accessibility decrease vehicle miles travelled. Handy *et.al.* (2005) used a quasi-longitudinal analysis on their Northern California data of before and after a change thereby addressing time order. They specifically included data for residents who were identified as having just moved house in their total sample and separately analysed data of 'movers' and 'non-movers'. They found that a quasi-longitudinal analysis of changes in travel behaviour and changes in the built environment showed significant

associations, even after accounting for attitudes and thus have provided support for a causal relationship.

2.5. Conclusions from literature review

The trend from study to study to explore relationships between transport and urban form has indicated that the understanding of behaviour change against the neighbourhood design environment is one of the ways to explain the land-use / transport relationship. Many *ad hoc* studies have revealed that particular aspects of neighbourhood design can contribute to a change in travel behaviour. However, identifying the extent to which neighbourhood design can be a powerful tool for a planning policy is not supported by sufficiently robust causal information. The literature suggests that attitude and socio-economic attributes make a difference to the transport and land-use relationship and this will be the foundation of the exploration of this research as described in the next section. Longitudinal studies give new insights since when the time order is taken into account, it shows that people can change their travel behaviour according to a change in their residential built environment form.

The aim of this study is to explore the relationship between transport and land-use and especially to focus on the British experience. The approach builds on the work of Stead (2001) but looks at more disaggregate data and focuses not only on socio-economic factors but includes the attitudinal factors that were identified as causally important by Handy *et.al.* (2005).

3. Experimental Design

The literature review of the previous section identifies several different types of study to explore relationships between land-use and transport. Most of the studies use a case-study approach as the way to determine whether the transport / land-use relationships exist and for this reason, the selection of case-study will be one of the issues to be addressed in this study. The methodology of this research uses a questionnaire approach that elicits both cross-sectional and quasi-longitudinal data from respondents and allows the employment of descriptive and multivariate statistics for analysis. These methods were chosen because of their capability for providing causal explanations as described in the previous section.

In advance of selecting areas for data collection, the identification of ‘hotspots’ of sustainable mobility practice was required. It was hoped that highlighting such practice would lead to a better understanding of the current requirements of contemporary people of their needs whilst meeting the criteria of sustainable mobility. Interviews with officers of the local authorities of Tyne and Wear were undertaken so as to gain a better knowledge of local districts and local neighbourhoods within the Tyne and Wear metropolitan area. This informed the choice of locations within the chosen case-study area. The interviews had another focus too. This was to allow local authorities who are aware of sustainable mobility issues to consider how they are meeting current needs. The results of these interviews are described later in section 3.1.

Following these local authority interviews, the use of British Census 2001 was used to identify particular neighbourhoods as a potentially good case-study. The use

of census data is important as the literature demonstrates that the investigation must control for the socio-economic background of the respondents in the 'hotspots' as the socio-economic dimension can explain more than half of the variation in the land-use / transport link (Stead, 2001). The development of a questionnaire as a chosen principal survey method was the next stage of the study so as to obtain a disaggregate dataset about people's travel behaviour at a household level. This approach was motivated by a literature review in which it was revealed that analysis using disaggregate data was better able to measure built environment and travel attitude characteristics.

3.1. Interviews with local authorities

Semi-structured interviews were held following a telephone appointment with relevant people in each of the five districts of Tyne and Wear. The interviewees were mostly a mixture of professionals, such as transport planners, town planners and district ward co-ordinators. The discussions were surprising in the sense that none of the local authorities were confident that any area within their boundary met sustainable mobility criteria. This meant that the study needed an alternative selection criteria and this is why the selection process for the case-study neighbourhoods was by reference to key neighbourhood statistics with control aspects being provided by statistics from the British Census of 2001.

Nevertheless the interviews revealed that town planners were generally more interested in the sustainable development programme as compared to other professionals. In Sunderland, a large scheme to adopt a neighbourhood centre accessibility catchment area was in progress to improve pedestrian infrastructure. Meanwhile transport planners were more concerned with finding solutions for transport problems occurring within the neighbourhoods *per se* and less sensitive to sustainability issues. One of the arguments was that different districts have different transport problems and transport planners were the ones in charge of solving the problems which appeared to be much more important in terms of the whole agenda of regional development rather than looking at sustainable travel within individual neighbourhoods. For example, in Newcastle a transport problem occurred in one traditional neighbourhood, which could be classified as a good case for a sustainable neighbourhood: this area was experiencing heavy car traffic because a school and a newly built business district were located within the neighbourhood which attracted car traffic from outside the area and this affected local residents. In South Tyneside, the transport problem, as reported from the interview, was to accommodate a heavy traffic flow going outside the district because low job opportunities within the district lead to more inter-regional car travel.

3.2. Case-study neighbourhoods

The literature identifies examples of favourable and unfavourable street layout for sustainable mobility travel. This guidance has been used by former studies in assisting the selection of different neighbourhoods and it is now accepted that some street layouts can be more prone to environmentally sustainable travel patterns than others. This approach is used in this study so that two distinct typologies were included in the case-study. One group of neighbourhoods belonged to the traditional neighbourhood typology and were built mostly before World War II, and the other

group belonged to a newer suburb neighbourhood typology of post-1960s build. To enrich the variants of neighbourhood street lay out in the selection process of neighbourhoods an ABCD typology was also considered to help select potential neighbourhoods (See Figure 2).

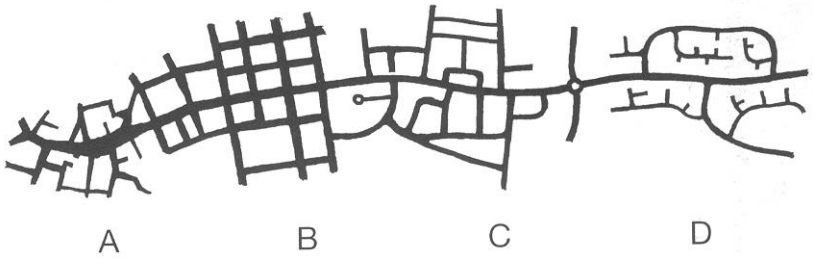

FIGURE 2 ABCD typology as transect (Marshall, 2005)

The case-study potentially included all neighbourhoods in Tyne and Wear. The first stage of screening used the Lower Layer Super Output Area (LSOA), the lowest level of administration area, to ensure that income and other characteristics were above average for the area and compared using the Index of Multiple Deprivation, 2004[*]. The purpose of this screening was to find neighbourhoods where people would choose to live rather than areas where housing might be allocated on the basis of need as it is preferences in the choice of the built environment that is being considered. To combine the census study and neighbourhood design study, Google Earth was then used to capture the aerial view of the 'hotspots' as well as to identify homogeneity of street lay out within LSOA. One constraint was the use of British Census 2001 data to provide important socio-economic characteristics and thus it was important to select areas where the most detailed Census information would map to a single type of built environment typology. A total of 190 LSOAs from the 38 highest IMD of each district were image captured and analysed studying this context. After filtering the potential 'hotspots' through controlling level of income (high IMD) and percentage of high and low of car travel to work as well as the percentage of walking, cycling and public transport use, the most representative residential neighbourhood according to traditional and suburban layout were selected as the areas for the case-study approach. This gave two areas within each of the five districts of Tyne and Wear. These are shown in Table 1.

Aerial views of Tyne and Wear with the geographical position of these 10 selected neighbourhoods is shown in Figure 3.

[*] The Index of Multiple Deprivation (IMD) 2004 is a UK measure of the deprivation of an area. This is available at the LSOA level and where the lower the number, the higher the level of deprivation. In Tyne and Wear, 32,482 is the least deprived area. The IMD is a weighted index, constructed by 7 aspects: income, employment, health, education, barriers to housing and services, crime and living environment.

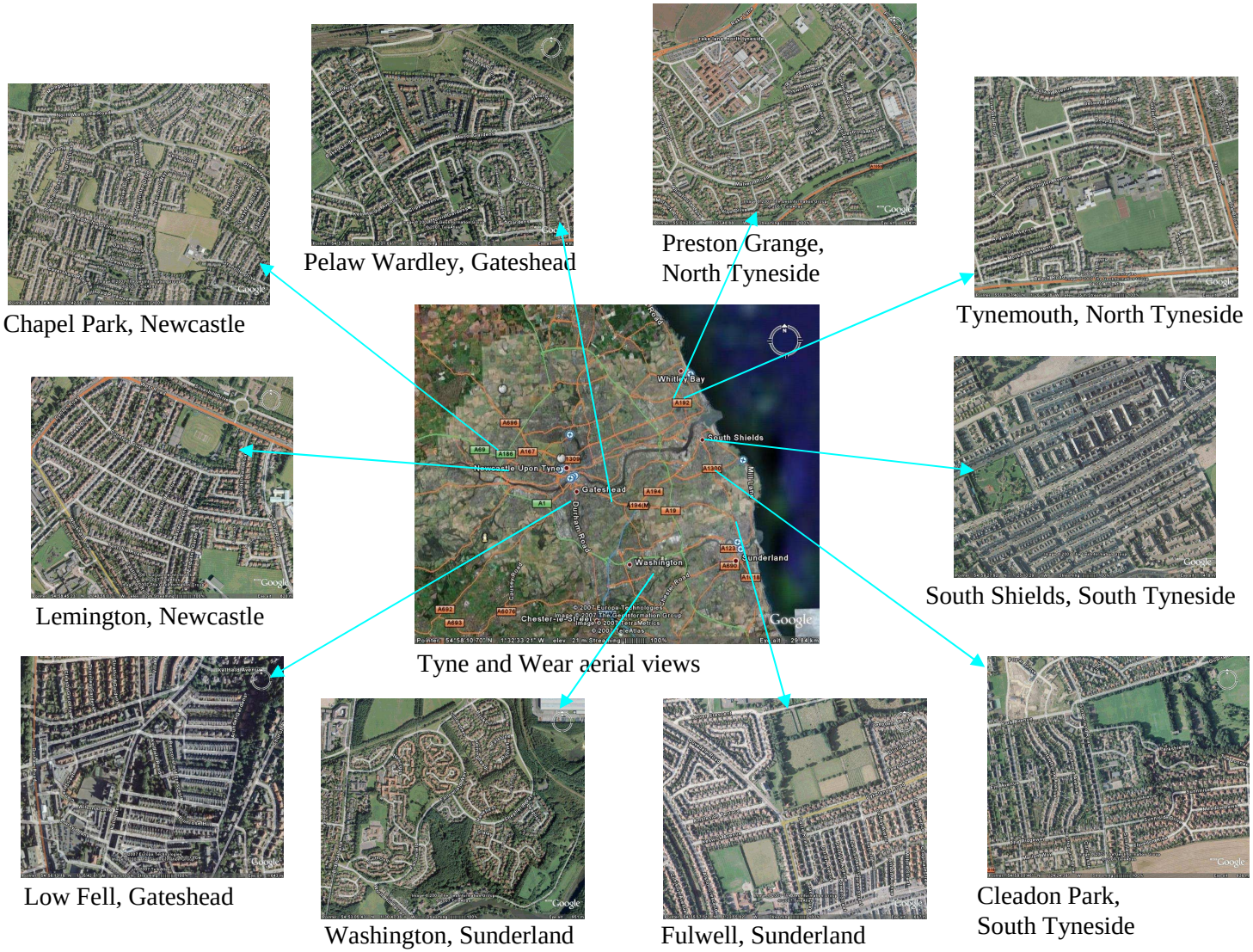

FIGURE 3 Google Earth aerial view captured on 10 selected neighbourhoods in Tyne and Wear metropolitan districts

TABLE 1 Selected Area in Tyne and Wear

Districts	*Traditional*	*IMD**	*Suburban*	*IMD**
North Tyneside	Tynemouth	23,446	Preston Grange	25,297
Newcastle	Lemington	21,291	Chapel Park	23,705
Gateshead	Low Fell	20,140	Pelaw – Wardley	15,726
South Tyneside	South Shields	11,147	Cleadon Park	11,774
Sunderland	Fulwell	20,072	Washington	22,050

Table 2 shows how the chosen areas are classified according to the ABCD typology, as well as the characteristics of high vs low percentages of sustainable travel to work attributes derived from the British Census 2001 data which includes the modes of walk, cycle, metro and bus. Within Tyne and Wear, it was not found possible to identify an 'A' type area at the LSOA level.

TABLE 2 Case-Study areas classified by ABCD Typology

ABCD typology sorting	*% Sustainable travel to work (walk, cycle, metro and bus)*	
	High	*Low*
B or B prone to C type	South Shields, South Tyneside (T)	
	Low Fell, Gateshead (T)	
C type	Lemington, Newcastle (T)	Cleadon Park, South Tyneside (S)
	Fulwell, Sunderland (T)	Tynemouth, North Tyneside (T)
D type	Pelaw - Wardley, Gateshead (S)	Chapel Park, Newcastle (S)
		Preston Grange, North Tyneside (S)
		Washington, Sunderland (S)

(T) = traditional neighbourhood
(S) = suburban neighbourhood

This paper uses the traditional vs suburban neighbourhood typology as this eases the comparison with former studies. However, the choice of 'hotspots' using the ABCD typology was the true basis for selecting the case-study areas. The choice of 'hotspots' took into account the relative deprivation (using the UK index of multiple deprivation - IMD) and the sustainable travel to work characteristics as well as relating the traditional vs suburban typology against the more recent ABCD typology. In connecting the results of this study with the US-based literature, the suburban typology as can be classified as D type and traditional as C type. In the UK, however, the inclusion of a B type allows further differentiation which may allow fuller explanation of results.

3.3. Questionnaire methodology

The survey was intended to provide descriptive case studies which would facilitate the investigation of the differences in travel behaviour associated with neighbourhood design and the extent to which neighbourhood design makes an impact on travel. The questionnaire was divided into five sections which represent either individual or household data, namely: travel patterns, built environment characteristics, attitudes and preferences to travel, change in travel patterns and residential move issues and socio-economic characteristics. Travel patterns were measured using average weekly vehicle miles travelled (VMT). Built environment characteristics were measured using 27 statements of perceived/preferred

neighbourhood design characteristics. Attitudes and preferences were measured using 28 statements of travel behaviour related issues. Socio-economic variables included gender, age, economic status, educational background, household income, household size and number of children. The built environment and attitude and preference statements were developed from the adaptation of the work of Handy *et.al.* (2005).

The survey was carried out in Spring 2007 in the form of a self-administered 8 page survey delivered to personally addressed households in each of the 10 neighbourhoods identified in the previous section. A sample of approximately 220 households in each neighbourhood were selected at every two or three houses proportionally to meet the number of the neighbourhood catchment represented by the Lower Super Output Area (LSOA) unit identified by National Statistics. Names and addresses were taken from the electoral register. The survey was administered using a delivered-out, mail-back approach. Surveys were delivered to the addresses with individual names on each envelope in the selected neighbourhoods. A pre-paid self-addressed envelope was enclosed inside each questionnaire delivered. One week later, a reminder postcard with individual names stated on the postcard was delivered to the respondents.

4. Empirical Findings

This section considers the results of this survey. In the first section, information about the sample and how representative it is of the population is presented. Then, more detailed results are presented in the following section of the relationship between perceived versus preferred neighbourhood design characteristics and travel attitudes/preferences. The final section is the result of the Ordinary Least Square Regression Analysis.

4.1. The sample characteristics

The number of responses totalled 685, a response rate of 32%. A comparison of sample characteristics to population characteristics (based on British Census 2001) can be seen from the Table 3. Overall, the socio-economic variables of the sample characteristics are quite similar to the population characteristics with the exception of age and the number of households with dependent children. In terms of age, the percentage of people aged over 45 are over-represented in comparison to the census population characteristics data and the number of households with dependent children are under-represented. However, the number of years lived at the current address is high for the respondents (over 20 years for the traditional neighbourhood and over 15 years for the suburban neighbourhood) and thus a proportion of households which would have dependent children in 2001 would have moved out of this category.

The average suburban neighbourhood is characterised by cul-de-sac branches along the circular arterial roads. This road characteristic causes longer travel by car as compared to the neighbourhood area which has a grid and permeable road characteristics as seen in most of the traditional neighbourhoods. The average typical weekly vehicle miles travelled (VMT) shows this difference as, on average, respondents from the traditional neighbourhoods drove 36% less miles than those in suburban neighbourhoods. In terms of the components of VMT, around 60% of the vehicle miles travelled was identified as work travel for both traditional or suburban neighbourhoods. The average of the number of years lived at the current address is

TABLE 3 Sample characteristics vs population characteristics

	Traditional					Suburban					TRADIT-IONAL	SUB-URBAN
Districts in Tyne and Wear	Tyne-mouth North Tyneside	Leming-ton New-castle	Low Fell Gates-head	South Shields South Tyneside	Fulwell Sunder-land	Preston Grange North Tyneside	Chapel Park New-castle	Pelaw-Wardley Gates-head	Cleadon Park South Tyneside	Wash-ington Sunder-land		
Sample Characteristics*												
Number	66	97	69	43	64	81	79	47	59	80	339	346
Percent female (%)	40.9	46.4	58	51.2	57.8	37	46.8	44.7	44.1	45	50.86	43.52
Percent age 25 – 44 (%)	21.2	24.7	33.3	39.5	20.4	18.5	26.6	61.7	23.7	15.1	27.82	29.12
Percent age 45 – 64 (%)	40.9	44.3	42	39.5	31.3	48.2	30.4	23.4	50.8	67.5	39.6	44.06
Percent age 65 above (%)	34.8	27.8	21.7	16.3	48.4	27.2	39.2	8.5	20.3	13.8	29.8	21.8
Average H/H Size	2.3	2.28	2.12	1.69	2.19	2.51	2.44	2.69	2.55	2.65	2.12	2.57
H/H with dependent children (%)	21.2	19.5	17.3	14	17.3	22.2	27.9	53.1	18.7	21.3	17.86	28.64
No car available to H/H (%)	13.6	14.4	18.8	32.6	17.2	7.4	15.2	8.5	20.3	6.3	19.32	11.54
One car available to H/H (%)	47	53.6	44.9	55.8	62.5	43.2	48.1	53.2	42.4	45	52.76	46.38
Two cars available to H/H (%)	28.8	26.8	31.9	11.6	15.6	43.2	27.8	34	28.8	37.5	22.94	34.26
Home owner (%)	84.8	92.8	88.4	76.7	93.8	90.1	92.4	93.6	83.1	93.8	87.3	90.6
Average years lived at current address	21.57	22.7	17.33	11.53	24.76	14.57	18.14	10.13	17.39	14.51	20.36	15.27
Average typical week mileage (work)	100.33	81.84	71.87	45.66	72.62	112.85	84.37	90.16	94.43	198.09	77.14	120.06
Average typical week mileage (local)	55.08	53.76	39.7	18.4	47.38	80.62	70.22	51.31	47.89	86.1	45.46	70.11
Average typical week mileage (total)	155.41	135.6	111.57	64.06	120	193.46	154.59	141.47	142.32	284.19	122.59	190.18
Percent of units built after 1960s (%)	30.2	0.0	1.4	0.0	19.7	97.4	93.5	89.1	29.1	98.8		
Population characteristics**												
Population	1511	1349	1498	1500	1502	1739	1493	1388	1832	1644	7360	8096
Household number	644	553	650	781	653	622	622	569	751	561	3281	3125
Percent female (%)	52.28	51.37	51.53	49.53	53.06	50.54	51.57	51.87	51.15	48.3	51.55	50.69
Percent age 25 – 44 (%)	22.17	31.14	34.45	39.53	30.23	28.43	25.32	42.87	23.19	26.46	31.50	29.25
Percent age 45 – 64 (%)	28.19	25.21	24.3	18.2	23.64	29.64	29.81	14.7	29.64	33.27	23.91	27.41
Percent age 65 above (%)	22.17	16.75	12.55	16.47	22.77	10.22	18.62	10.09	19.54	4.81	18.14	12.66
Average H/H Size	2.35	2.44	2.3	1.92	2.3	2.8	2.4	2.44	2.44	2.93	2.26	2.60
H/H with dependent children (%)	28.26	30.38	29.23	21.9	26.19	40.68	27.01	37.96	29.03	44.39	27.19	35.81
Percent no car available to H/H	24.22	24.05	26.15	45.58	27.57	5.95	17.85	27.77	24.37	10.16	29.51	17.22
Percent one car available to H/H	46.58	54.97	49.23	46.22	52.99	46.62	55.47	52.37	47.27	30.84	50.00	46.51
Percent two cars available to H/H	25.93	18.26	20.77	7.43	17.3	39.39	22.67	18.1	21.84	46.52	17.94	29.70
Percent home owner (%)	80.56	93.84	86.16	71.06	90.96	96.79	95.64	75.97	81.23	85.26	84.52	86.98

* Source: this study ** Source: British Census 2001 (http://neighbourhood.statistics.gov.uk)

5.1 years higher for traditional neighbourhoods with the exception of the traditional area of South Shields, an old terraced house settlement built around 1900, where the average years lived at the current address is low at 11.5 years.

4.2. Comparison of perceived vs preferred neighbourhood design characteristics and travel attitudes/preferences

The idea behind capturing data on people's opinion about their surroundings is to measure how the current built environment characteristics influence people's travel pattern in their everyday activities. In this survey, the data captured on people's opinion about the importance of built environment characteristics in selecting their residence was developed to be compared to people's perceived built environment characteristics to indicate how well their current neighbourhoods meet their preference.

Neighbourhood characteristics and neighbourhood preferences were measured using 27 statements which were divided into 6 aspects of neighbourhood design. The paper by Handy *et.al.* (2005) which reported a study in Northern California, US was used as a basis but in this study a number of differences were introduced. In this study the preference statements were grouped under different sub-headings of neighbourhood design aspects rather than simply listing all the statements. These sub-headings were derived from the Handy *et.al.* work (2005) and the initial factor analysis of this study. The motivation for this was to make it easier for the respondents to become familiar with the questions asked and their context. In addition, all questions were translated from American experience to the British experience so that, for example, sidewalk was replaced with pavement; big street trees with tree lined street; transit with public transport use.

These statements were measured using a 4 point scale from 'not at all true' until 'entirely true' to obtain a series of answers for opinions of the respondents on the perceived built environment characteristics. In identifying the residents' opinion of the preference of the same neighbourhood characteristics in selecting residence a 4 point scale from 'not at all important' until 'extremely important' was used for measuring.

Since many variables used in the questionnaire measure similar dimensions of the neighbourhood design and attitude/preferences and are highly correlated, factor analysis was conducted to identify underlying constructs of perceived and preferences for neighbourhood characteristics and attitude/preferences characteristics.

Common factor analysis was employed to extract 27 statements on neighbourhood design characteristics and 28 statements of attitudes/travel preferences. Through this analysis, perceived and preferred neighbourhood design were extracted into 7 factors which include safety, neighbourhood attractiveness and parking space; travel accessibility; residential spaciousness; shopping/facilities accessibility; social factors; neighbourhood attractiveness; and outdoor space accessibility (Table 4).

TABLE 4 Factor Loadings from CFA on Perceived and Preferred Built Environment Characteristics (left) and Attitudes/Travel Preferences Characteristics (right) (Source: this study)

Factors (a)	Statements – variables on perceived and preferred built environment characteristics	Loadings (b)
Safety, attractiveness and parking space	Safe neighbourhood for walking	0.822
	Low crime rate	0.799
	Safe neighbourhood for children outdoor	0.713
	Low level of car traffic	0.701
	Quiet Neighbourhood	0.683
	High level of neighbourhood's upkeep	0.512
	Attractive appearance of neighbourhood	0.481
	Good street lighting	0.436
	Adequate parking space	0.348
Travel accessibility	Easy access to a good P.T. service	0.860
	Good P.T. service	0.784
	Easy access to highway network	0.489
	Local shops within walking distance	0.457
	Pavements - easy walking routes	0.436
	Easy access to town centre	0.268
	Parks and open spaces nearby	0.263
Residential spaciousness	Adequate space of garden at the front	0.855
	Adequate space of garden at the back	0.796
	Adequate parking space	0.560
	Attractive appearance of neighbourhood	0.271
Shopping/ facilities accessibility	Easy access to a district shopping centre	0.837
	Easy access to town centre	0.679
	Other amenities/facilities nearby	0.494
	Local shops within walking distance	0.374
	Easy access to highway network	0.280
Social factors	Lots of people out and about	0.764
	Lots of interaction among neighbours	0.644
	Diverse neighbours	0.453
	Economic situation of neighbours similar	0.410
Neighbourhood attractiveness	Attractive appearance of neighbourhood	0.702
	High level of neighbourhood's upkeep	0.658
	Variety in housing style	0.421
	Tree lined street	0.259
Outdoor spaciousness accessibility	Parks and open spaces nearby	0.578
	Extension of cycle routes	0.544
	Other amenities/facilities nearby	0.356
	Pavements - easy walking routes	0.296

Factors (a)	Statements – variables on attitudes/travel preferences characteristics	Loadings (b)
Pro-public transport use	Prefer travel by public transport than drive	0.845
	Like travel by public transport	0.815
	Travel by public transport easier than drive	0.743
	Walk easier than drive	0.297
Travel minimizing awareness	Prefer to organise errands for fewer trips	0.626
	Limit driving for improved air quality	0.620
	Fuel efficiency factor in choosing a car	0.595
	Fuel price effects choice of daily travel	0.567
	Buying something from closet store possible	0.414
	Often use phone/internet to avoid travel	0.405
	Vehicle taxed for pollution they produce	0.381
Pro-cycling	Prefer cycle rather than drive	0.907
	Like cycling	0.755
	Cycle easier than drive	0.751
Safety of car	Car safer than public transport travel	0.774
	Car safer than walk	0.753
	Car safer than cycling	0.498
	Build more roads to reduce traffic congestion	0.315
	Need a car to do many things	0.315
	Like driving	0.252
Pro-walking	Prefer walk than drive	0.734
	Like walking	0.703
	Walk easier than drive	0.597
Car dependent	Need a car to do many things	0.654
	Work without car is a hassle	0.537
	Like driving	0.325
Pro-travel	Importance of journey	0.671
	Use time productively	0.613
	Manage well with fewer car	0.236
Travel time sensitivity	Destination oriented	0.631
	Travel time is wasted time	0.622

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
(a) Rotation converged in 6 iterations.
(b) Degree of association between the factors and the statement

Travel attitude/preference were measured using a series of 28 statements on a 5-point scale from 1 ‘strongly disagree’ to 5 ‘strongly agree’ against the respondents. Factor analysis was then used to extract these 28 statements, for similar reasons to those for neighbourhood characteristics. As shown in Table 5, eight underlying dimensions were identified: pro-public transport use; travel minimising awareness; pro-cycling; safety of car; pro-walking; car dependent; pro-travel; and travel time wise. A comparison between perceived and preferred neighbourhood design characteristics after the result drawn from the normalised factor score can be seen in Table 5.

TABLE 5 Vehicle miles travelled (VMT) and explanatory variables by neighbourhood design characteristics (Source: this study)

	Average tradition-nal	Average subur-ban	*p*-value[b] traditional / suburban	*p*-value[b] traditional only	*p*-value[b] suburban only
Weekly vehicle miles travelled (VMT)	122.59	190.18	0.00	0.09	0.00
Perceived neighbourhood characteristics[a]					
Safety, attractiveness and parking space	-0.12	0.09	0.00	0.00	0.18
Travel accessibility	0.15	-0.12	0.00	0.00	0.00
Residential spaciousness	-0.37	0.19	0.00	0.00	0.00
Shopping/facilities accessibility	0.23	-0.20	0.00	0.00	0.00
Social factors	0.20	-0.15	0.00	0.02	0.01
Neighbourhood attractiveness	-0.13	0.11	0.00	0.00	0.03
Outdoor space accessibility	-0.17	0.25	0.00	0.00	0.00
Preferred neighbourhood characteristics[a]					
Safety, attractiveness and parking space	0.02	-0.01	0.81	0.66	0.51
Travel accessibility	0.08	-0.06	0.01	0.33	0.00
Residential spaciousness	-0.18	0.11	0.00	0.00	0.48
Shopping/facilities accessibility	0.03	-0.01	0.96	0.15	0.34
Social factors	0.09	-0.09	0.05	0.07	0.16
Neighbourhood attractiveness	-0.12	0.09	0.01	0.36	0.45
Outdoor space accessibility	-0.03	0.06	0.20	0.39	0.38
Travel attitudes[a]					
Pro-public transport use	0.06	-0.05	0.06	0.34	0.00
Travel minimising awareness	0.01	-0.05	0.30	0.28	0.52
Pro-cycling	-0.06	0.11	0.02	0.08	0.14
Safety of car	-0.01	0.02	0.33	0.03	0.38
Pro-walking	0.13	-0.08	0.04	0.00	0.13
Car dependent	-0.13	0.07	0.01	0.14	0.00
Pro-travel	0.09	-0.09	0.04	0.67	0.37
Travel time sensitivity	0.01	0.00	0.90	0.46	0.49

[a] Scores normalised to a mean value of 0 and variance of 1
[b] *p*-value for *F*-statistics from analysis of variance (ANOVA)

According to an analysis of variance (ANOVA), respondents from the traditional neighbourhood group, score significantly higher than those from the suburban neighbourhood group on factors for perceived travel accessibility, shopping/facilities accessibility and social factors, but lower on safety, attractiveness and parking space, residential spaciousness, neighbourhood attractiveness and outdoor space accessibility. In the preferred neighbourhood design characteristics, all respondents showed similar preferences on the following factors: safety, neighbourhood attractiveness and parking space, shopping/facilities accessibility and outdoor space accessibility. In the attitudes/travel preferences analysis, the traditional

neighbourhood group also scored significantly higher on factors for pro-walking and pro-travel but lower on pro-cycling and car dependent attitude.

Looking at the pooled data results it can be seen that there are significant differences between all the perceived neighbourhood characteristics and that this is also true of many of the preferred neighbourhood characteristics too. This confirms that perceived and preferred characteristics are different between respondents from traditional and suburban neighbourhoods. In terms of travel attitudes, there is a significant difference between the neighbourhoods on pro-cycling, pro-walking, pro-travel and car dependent attitudes.

Considering the within area variation, there is clearly less significant variation between the preferred neighbourhood characteristics than the perceived neighbourhood characteristics. In terms of travel attitudes, there is significant variation between the traditional areas for pro-walking and safety of the car and for the suburban areas for pro-public transport use and car dependency.

4.3. Multivariate analysis

Further analysis to exhibit the relative importance of neighbourhood design characteristics and attitudes/travel preferences, was completed by ordinary least square regression using log weekly vehicle miles travel (ln VMT) as the dependent variable. When taking the natural logarithm (ln) of VMT, the analysis needed to take account of the way in which there is no value for ln VMT when the value of VMT is zero. In order to use most of the data (no answer and zero mileage are differentiated in the study) a value of one was added to ln VMT so the true dependent variable is ln (VMT+1). The model regression initially includes variables identified by previous work as important (Handy *et.al.*, 2005) and then more variables from the travel attitudes and neighbourhood design preferences and perceptions were included. The results are presented in Table 6.

The cross-sectional analysis identifies that holding a driving license and the number of cars available to household were significant at the 5% level and explained the major part of the variance in VMT. However, attitudinal aspects were also significant at the 5% level with car dependent and pro-public transport attitudes also contributing to explaining a large amount of variation. The positive coefficient result of car dependent attitude explains the perceived need of car by respondents. The negative coefficient results of pro-public transport attitudes show that public transport availability will significantly reduce average VMT. The shopping / facilities accessibility preference variable is also significant at 5% level, suggesting that the presence of a shopping district locally will significantly reduce VMT. The dummy variable categorising the suburban and traditional observations was significant at the 5% level, and with a positive coefficient, shows that VMT in the suburban neighbourhood group are higher relative to the traditional neighbourhood group, thus confirming the earlier ANOVA result. This result suggested that separate regressions for the suburban and traditional neighbourhood groups might give more insights into the differences of travel behaviour relative to different neighbourhood types. Table 7 presents two regression analyses based on type of neighbourhood.

TABLE 6 Ordinary Least Square Regression: model results for ln(VMT +1)
(Source: This Study)

Model		Standardized Coefficients	Sig.
		β	*ρ-value*
1	(Constant)		.011
	Female	-.033	.150
	Employed	.095	.000
	Driving license	.401	.000
	Cars available to H/H	.350	.000
	Pro-walking	-.032	.164
	Pro-public transport	-.134	.000
	Safety of car	.052	.022
	Car dependent	.169	.000
	Residential spaciousness preference	-.027	.237
	Shopping/facilities accessibility preference	-.058	.013
	Safety, neighbourhood attractiveness and parking space preference	-.034	.135
	Suburban	.057	.014

N=553; R-square = 0.725, adjusted R-square = 0.720 (significant with p-value of 0.000)
Dependent Variable: LnVMTplus1;
Predictors: (Constant), Residential spaciousness preference, Shopping/facilities accessibility preference, Safety, neighbourhood attractiveness and parking space preference, Safety of car, Pro-walking, Pro-public transport, Car dependent, Female, Driving license, Employed, Cars available to H/H, Suburban

Significant at 5% level

Table 7 shows that the traditional regression model exhibits more significant variables of neighbourhood design preferences than the suburban model. Interestingly, the shopping/facilities accessibility preference variable appears insignificant in the suburban model when conducted separately and this contrasts with the regression presented in Table 6. The safety, neighbourhood attractiveness and parking space preference variables are significant at 10% level within the traditional model. The residential spaciousness preference variable is significant at 5% level within the suburban model. It is interesting to note that the suburban neighbourhood group appears to have similar characteristics to residents in the US-based literature studies confirming the similarity in car culture between this group and the US.

In both the traditional and suburban model, the coefficient for the car dependency attitude are both significantly different from zero at the 5% level. However, the impact of this variable on the VMT is clearly different. A unit change in this attitude will have a bigger effect for the traditional group as compared to the suburban group as the coefficient is larger. The impact of change on VMT could be such that the VMT for the traditional group could exceed that of the suburban group. However, pro-public transport attitudes which are significant at the 5% level in both regressions can also explain the relative difference in preference of respondents within different urban forms. The high coefficient for pro-public transport attitudes on the suburban model as compared to the traditional model suggests that if the suburban respondents are given the opportunity to have public transport provision then this will have a relatively greater impact.

TABLE 7 Ordinary Least Square Regression for ln(VMT+1) in the separate traditional and suburban areas (Source: this study)

Model	Traditional[1]		Suburban[2]	
	Standardized Coefficients	Sig.	Standardized Coefficients	Sig.
Predictors	β	ρ-value	β	ρ-value
(Constant)		.059		.390
Female	-.025	.457	-.039	.253
Employed	.081	.033	.128	.001
Driving license	.442	.000	.337	.000
Cars available to H/H	.322	.000	.374	.000
Pro-walking attitude	-.058	.072	.000	.994
Pro-public transport attitude	-.097	.006	-.183	.000
Safety of car attitude	.053	.096	.060	.087
Car dependent attitude	.191	.000	.152	.000
Residential spaciousness Preference	.009	.774	-.079	.022
Shopping/facilities accessibility Preference	-.083	.011	-.024	.502
Safety, neighbourhood attractiveness and parking space Preference	-.065	.051	-.006	.859

[1]N=276, R Square=0.737, Adjusted R-square=0.726 (significant with ρ-value of 0.000)
[2]N=277, R Square=0.709, Adjusted R-square=0.697 (significant with ρ-value of 0.000)
Dependent Variable: lnVMTplus1
Predictors: (Constant), Residential spaciousness preference, Shopping/facilities accessibility preference, Safety, neighbourhood attractiveness and parking space preference, Safety of car, Pro-walking, Pro-public transport, Car dependent, Female, Driving license, Employed, Cars available to H/H

Significant at 5% level Significant at 10% level

5. Conclusion and recommendation

In the Planning White Paper "Planning for a Sustainable Future" (2007) it was clear that future development has to be more low carbon-based, and in the transportation context this means that promoting sustainable travel must be high on the agenda. However, what the specific layout of towns and cities – in terms of both the residential layout and their supporting facilities - ought to look like in a low carbon future remains unclear. This study gives evidence of micro-scale analysis of travel behaviour between existing different urban forms to try and identify the current drivers of travel behaviour. It is hoped that this provides an understanding that can be used in the proposals to make future developments more sustainable and be more low carbon-based in their transport activities.

The interviews with local authorities not only provided background knowledge of how the current sustainable mobility practice takes place in the case-study area but also identifies how difficult this practice can be. The comparison between two different types of neighbourhoods in this paper gives good insights as to how residents perceived neighbourhood design attributes as well as travel attitudes differently within their built environment. Descriptive evidence of differences between neighbourhood groups is supporting the contention that neighbourhood

design influences different travel behaviour. Different accessibility issues captured by factor analysis have been shown to explain differences in travel patterns between different neighbourhoods. The traditional neighbourhood group has better travel and shopping accessibility than the suburban neighbourhood group.

Travel attitudes and neighbourhood design preferences clearly play a role in explaining differences in VMT suggesting that policies that work on attitudes may have an impact in changing travel behaviour. However, the significant explanatory variables are different when traditional and suburban neighbourhood groups are separated into two models. The traditional neighbourhood area respondents exhibit a lower average VMT and the separate model for the traditional area identifies a number of significant neighbourhood design preferences. This suggests that future land-use policy must be sensitive to the different drivers identified in the different neighbourhoods.

Although residents of traditional neighbourhoods have better accessibility, the causal explanation revealed that they have a higher potential to travel further than their suburban counterparts given the opportunity as shown by the car dependency coefficient. This suggests that a persons desire to travel further is inherent even if they have better choices for other travel opportunities.

Future work will extend the multivariate analysis demonstrated in this paper to that of examining causality between neighbourhood design and travel using a quasi-longitudinal approach to establish an even stronger explanation of how neighbourhood design can change travel behaviour and to isolate the effect of residential choice self-selection.

It is also hoped that future follow-up studies will include the measurement of physical built environment characteristics in the model (*e.g.* distance to local shops, facilities, district shopping centres, *etc*.; density of housing and population within the neighbourhoods; pedestrian accessibility by means of footpath width or length), since this study has only captured the perceptions and preferences of the built environment characteristics.

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