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Is 'Compact City' a sensible planning approach? Empirical evidence of cross perceptions of travel attitudes in British settlements

By

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TITLE: **Is 'Compact City' a sensible planning approach? Empirical evidence of cross perceptions of travel attitudes in British settlements**

ABSTRACT: 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 neighbourhood design, travel patterns, travel attitudes and socio-economic characteristics.

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, the application of a regression analysis model for different neighbourhood types reveals that 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. This finding suggests that the generic measures implied by UK land-use policy to promote sustainable mobility should be selectively targeted.

KEY WORDS: ***Neighbourhood design; land-use; travel attitudes; multi-variate analysis***

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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 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 may cause these people to drive less but their desire to drive less causes them to select a neighbourhood with those characteristics. Understanding the role of residential self-selection is the key to understanding the causal relationship between neighbourhood design and travel behaviour (Handy *et al.*, 2005). However, this self-selection issue is less clear in the UK context, *i.e.* whether it is applicable as in the US or otherwise; studies are needed to address the issue. The evidence at the macro scale 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 a 'Design Code' shows that built environment characteristics to promote sustainable travel have been less frequently included in this code confirming that in the UK, there are not yet strong synergies between the actors in the promotion of sustainable development. Experience has been repeated elsewhere in the developed countries such as in Australia (Curtis, 2007). 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 UK 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 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. The paper gives a brief overview of literature so as to identify the experimental design best able to achieve results linking urban form to travel behaviour in the next section. This is followed by an outline of the experimental methodology and the analysis of results. The final section concludes with recommendations of how to enhance the likelihood of sustainable development in neighbourhood design.

2. Built environment characteristics as an urban-form

Earlier research studies have used various kinds of urban form measures to capture the effect of the built environment on travel behaviour. The built environment is defined as consisting of three general components: land-use patterns, transportation system and design (Handy, 2005). All these characteristics affect travel behaviour as they relate to the concept, evidenced by Cervero and Kockelman (1997), that density, diversity and design are the features which influence travel demand. Though a more recent US study emerges extendable variables which include destination accessibility, distance to public transport and development scale to also impact travel behaviour (Ewing *et al*., 2009). However, the evidence is very much a reflection of the extensive American literature looking at how to reduce people's car dependency. Whilst the scale of car dependency in the US is perhaps not replicated in the UK and elsewhere, there is a significant trend in suburbanisation and car ownership is growing all over the world, generally following the trend in the US.

American case studies (for example: Boarnet and Crane 2001, Handy *et al.*, 2005) employ the concept of the traditional neighbourhood vs suburban neighbourhood to contrast differences in travel behaviour. In this context, traditional neighbourhoods have broadly rectilinear grids and the suburban neighbourhoods have broadly curvilinear layouts. In terms of a time frame, traditional neighbourhoods are usually grouped into the pre-World War II built form whereas the suburban neighbourhoods are grouped in the late modern built form or after 1960. Some other classifications have been less extreme, allowing neighbourhood types to exist in between traditional or suburban and are called hybrids or mix (See: Ewing and Cervero, 2001) or early modern neighbourhoods (Handy, 1996). From an empirical point of view, it is more appealing to use definitions which vary according to the street layout since this is more closely aligned with the emerging concern among planners of desirable street design features such as connectivity, walk-able street grids and undesirable properties such as road hierarchy (Marshall, 2005). Figure 1 shows that what has been called a traditional street layout can be represented by A or B types and the suburban street layouts by C or D types. These latter categories allow a finer level of detail to be ascribed to the nature of the neighbourhood and have been used as a way of comparing the UK and US date (Aditjandra *et al., 2007*). However, in this paper the more usual 'traditional' versus 'suburban' distinction is retained to allow comparisons with other studies.

Whilst the extended literature review on the impact of neighbourhood design on travel behaviour can be seen elsewhere (See: Aditjandra *et al.*, 2009a and 2009b - forthcoming), the issue of residential self-selection is not specifically addressed. A US based study led by Handy *et al.* (2005) addressed this issue by using quasi-longitudinal data. They found that changes in neighbourhood characteristics have the strongest association with changes in walking but only the accessibility factor[1] had a significant association with changes in driving. A more recent study by Cao *et al.* (2009) reviews more widely the methods and findings in respect of the impact of residential self-selection on travel behaviour and confirms that longitudinal studies are the most appropriate.

[1] The accessibility factor here is the given name for a factor after factor analysis result derived in the study by Handy *et al.,* 2005). This factor has a strong association with 'easy access to a regional shopping mall' (0.854 – the factor loading) and 'easy access to downtown' (0.830).

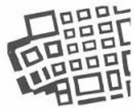
Type	Example pattern	Typical location	Frontages	Transport era
A-type *Altstadt*		Historic core	Built frontages	Era of pedestrian and horseback
B-type Bilateral		Gridiron (central, or extension, or citywide)	Built frontages	Era of horse and carriage
C-type Characteristic/ Conjoint		Anywhere; including individual villages or suburban extensions: often astride arterial routes	Built frontages or buildings set back in space ('pavilions')	Any Era of public transport; car
D-type Distributory		Peripheral development: off-line pods or superblock infill	Buildings set back in space, access only to minor roads	Era of the car

Figure 1: Urban associations of ABCD Typology

Source: Marshall (2005)

To consider the self-selection issue in the UK, it must be recognised that the transport and land-use pattern in the UK is somewhat different as compared to the US (Aditjandra *et al.*, 2009a and 2009b). Many of the suburban residential neighbourhoods of the UK are not as isolated as the suburban neighbourhoods of the US. In the US evidence, residents who live in the suburban neighbourhoods and who claim to prefer not to use private car have no alternative. In contrast, UK residents who live in suburban neighbourhoods still have access to public transport services and local facilities, especially when living in a metropolitan area such as Tyne and Wear which has an extensive public transport system. This means that residential self-selection may not be as big an issue in the UK, as compared to the US (Aditjandra *et al.*, 2009b). However, one of the aims of this paper is to demonstrate a deeper understanding of travel attitudes within the UK neighbourhood case study so as to give answers to some of these research questions.

3. Modelling micro-scale analysis of neighbourhood design and travel behaviour

Most of the studies looking at the relationship between urban form and travel behaviour use a case-study approach as the way to determine whether the 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 for the relationship under investigation. The reporting of quasi-longitudinal analysis is discussed elsewhere (Aditjandra *et al.*, 2009b - forthcoming)

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. 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.

3.1 Neighbourhood 'hotspots' methodology

For choosing appropriate case-study neighbourhood 'hotpots', a methodology has been developed with a number of sources of information, not only from discrete neighbourhood layout as in most US studies (as identified above in the literature section), but also from interviews with local authorities, the use of the latest British Census data and Google Earth aerial view. This strategy allowed a robust choice of 'hotspot' to be identified which satisfied all the criteria of the study.

The case-study potentially included all neighbourhoods of the five District authorities which make up Tyne and Wear. An early decision was to include each of the five Districts in the case-study with each District providing a traditional and a suburban area. This was important to capture the diversity of the Tyne and Wear area and to be able to link the outcome to the local authority interviews which were an important part of the methodology.

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[2] (ODPM, 2004). The importance of this element of the methodology was to ensure that neighbourhoods were selected where households might choose to live (as opposed to being directed for some other socio-economic reason).

The further criteria for choosing neighbourhood 'hotspots' included the homogeneity of street layout (based on ABCD street typology) within selected Google Earth aerial view captured LSOA[3] and the inclusion of incidence of high vs low percentage of people who travel to work by walking, public transport and cycling (based on UK Census 2001) relative to the entire criteria. The process is summarised in Figure 2 below which shows the cascading structure to select the 'hotspots' for the survey of this study.

In terms of scale, Tyne and Wear comprises 719 LSOAs out of a total of 32,482 for England as a whole. 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 Figure 3.

[2] 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.

[3] Lower Layer Super Output Area (LSOA) is the lowest administration area used in the latest British Census (2001)

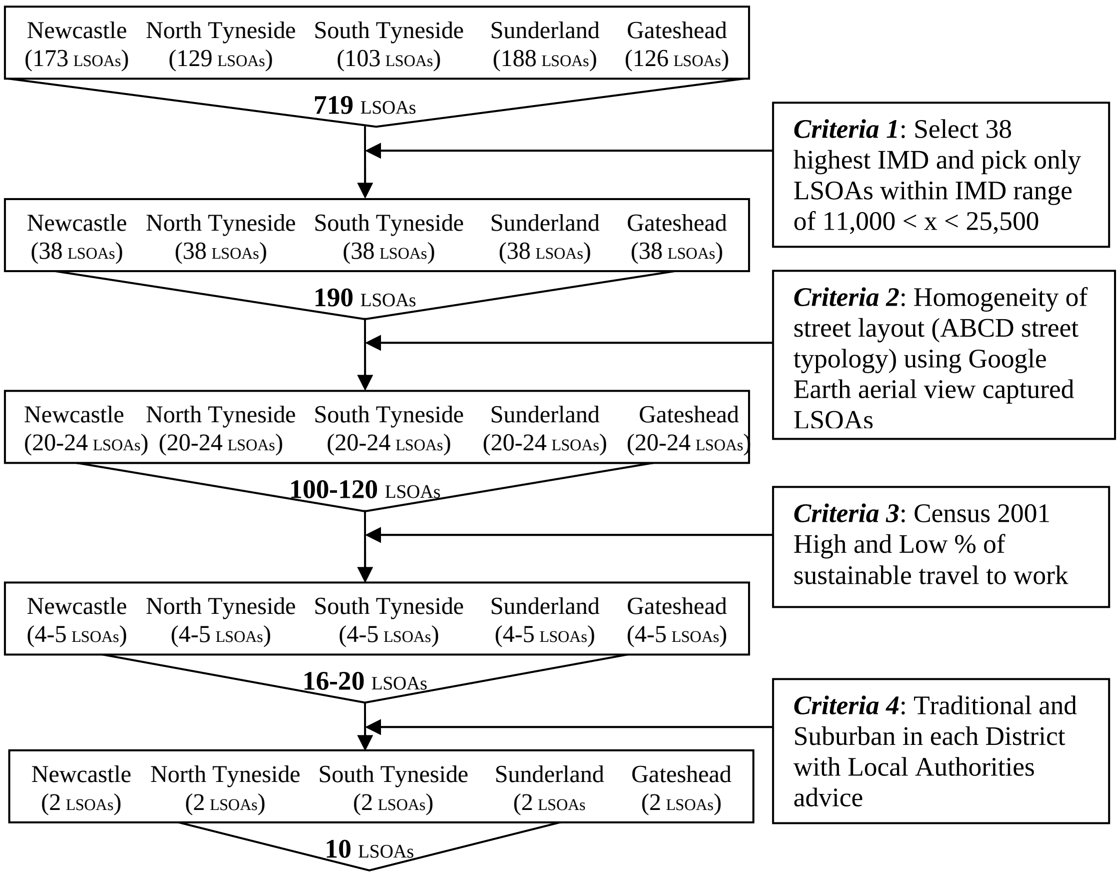


Figure 2: Structure of the 'hotspots' methodology

(Source: Aditjandra, 2008)

3.2 Survey methodology

The survey developed in this research was intended to generate 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 gave data at either individual or household level on 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 driven (VMD). 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 an 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 which was personally addressed using names and addresses from the electoral register and delivered to households in each of the 10 neighbourhoods identified in the previous section. A sample of approximately 220 households in each neighbourhood were selected to meet the number of the neighbourhood catchment represented by the Lower Super Output Area (LSOA) unit identified by National Statistics. The survey was administered using a delivered-out, mail-back approach. Surveys were delivered and 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.

TRADITIONAL (IMD)	SUBURBAN (IMD)
Tynemouth, North Tyneside (23,446) 	Preston Grange, North Tyneside (25,297) 
Lemington, Newcastle (21,291) 	Chapel Park, Newcastle (23,705) 
Low Fell, Gateshead (20,140) 	Pelaw-Wardley, Gateshead (15,726) 
South Shields, South Tyneside (11,147) 	Cleadon Park, South Tyneside (11,774) 
Fullwell, Sunderland (20,072) 	Washington, Sunderland (22,050) 

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

(Source: Google Earth)

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 from the factor analysis are presented examining the relationship between perceived versus preferred neighbourhood design characteristics and travel attitudes/preferences. These sections are followed by the multivariate analysis exploring causality.

4.1 The sample characteristics

The number of responses totalled 716, a response rate of 33%, with 32% overall providing valid data for the analysis. A comparison of sample characteristics to population characteristics (based on British Census 2001) can be seen from the Table 1. 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 by the time of the survey. These differences of the sample against the Census are not expected to affect the results as the focus of this study is on explaining the relationships of other variables to travel behaviour rather than on describing travel behaviour on its own (Handy’s *et al.*(2005) quoting Babbie (2004)).

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. In this sample the total average vehicle miles driven (VMD) for a typical week 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 VMD, around 60% of the vehicle miles travelled was identified as work travel for residents of both traditional and suburban neighbourhoods. The average number of years lived at the current address is 5.1 years higher for traditional neighbourhoods, with the exception of the traditional area of South Shields which is an old terraced house settlement built around 1900, where the average years lived at the current address is low at 11.5 years.

Table 1: Sample characteristics vs population characteristics

	Traditional					Suburban					TRADI-TIONAL	SUB-URBAN
	Tyne-mouth	Leming-ton	Low Fell	South Shields	Fulwell	Preston Grange	Chapel Park	Pelaw-Wardley	Cleadon Park	Wash-ington		
Districts in Tyne and Wear	North Tyneside	New-castle	Gates-head	South Tyneside	Sunder-land	North Tyneside	New-castle	Gates-head	South Tyneside	Sunder-land		
Sample Characteristics*												
Number	67	97	72	43	66	81	79	47	59	81	345	347
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

	Traditional					Suburban					TRADI-TIONAL	SUB-URBAN
	Tyne-mouth	Leming-ton	Low Fell	South Shields	Fulwell	Preston Grange	Chapel Park	Pelaw-Wardley	Cleadon Park	Wash-ington		
Districts in Tyne and Wear	North Tyneside	New-castle	Gates-head	South Tyneside	Sunder-land	North Tyneside	New-castle	Gates-head	South Tyneside	Sunder-land		
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)

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

Neighbourhood characteristics and neighbourhood preferences were measured using 27 statements which were divided into 6 aspects of neighbourhood design. The questionnaire design was loosely based on Handy *et al.* (2005) and there were a number of differences introduced. In this study the preference statements were grouped under different sub-headings of neighbourhood design aspects rather than simply listing all the statements with the sub-headings being derived from the Handy *et al.* work (2005) and the initial factor analysis of this study in its pilot phase. 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, *etc.*

Since many variables used in the questionnaire measure similar dimensions of neighbourhood design and attitude/preferences it is not surprising that many are highly correlated. The motivation for the scale used in the questionnaire is described elsewhere (See: Aditjandra *et al.*, 2009a, 2009b). Factor analysis was conducted to identify underlying constructs of perceived and preferred of neighbourhood characteristics and attitudes/preferences characteristics. Missing sample responses are always a problem in factor analysis and there is a need to treat these carefully to avoid misleading results. In this study the missing values were replaced with the 'neighbourhood specific' mean (*i.e.* the sub-sample means for the neighbourhood to which that case belongs) before factor analysis was applied.

Common Factor Analysis (CFA) was used to extract 27 statements on neighbourhood design characteristics and 28 statements of travel attitudes/preferences. Through this analysis, perceived and preferred neighbourhood characteristics were extracted into seven factors which have been identified as factors relating to safety, travel accessibility, residential spaciousness, social factors, shopping/facilities accessibility, outdoor space accessibility and neighbourhood attractiveness. The travel attitudes were reduced to eight factors including pro-public transport use, travel minimising awareness, pro-cycling, travel time sensitivity, safety of car, pro-walking, pro-travel and car dependent. The complete table of factor loadings is published elsewhere (See Aditjandra *et al.*, 2009a, 2009b).

A comparison between perceived and preferred neighbourhood design characteristics after the result drawn from the normalised factor score can be seen in Table 2. Normalised factor scores are shown in Table 2 and allow a comparison between perceived and preferred neighbourhood design characteristics and travel attitudes characteristics. According to an analysis of variance (ANOVA) as reported in Aditjandra *et al.*, (2009), respondents from the traditional neighbourhood group, score significantly higher than those from the suburban neighbourhood group on factors for perceived 'travel accessibility', 'social factors' and 'shopping/facilities accessibility', but lower on 'safety', 'residential spaciousness', 'outdoor space accessibility' and 'neighbourhood attractiveness'. The difference on travel accessibility suggests that residents of traditional neighbourhoods perceive greater opportunities for public transport use and walking than residents of suburban neighbourhoods and higher scores on the social factors. These also have a high association with a statement about their environment as having 'lots of people out and about' (one of the statements used in the questionnaire to measure social factor characteristic) and might imply a better walking environment, supporting better access to public transport. The differences on shopping and facilities accessibility suggests that residents of traditional neighbourhoods perceive greater opportunities for shopping (supermarket), town centre, local shopping, and even amenities/ facilities (health care, community/leisure centre and facilities for children) than residents of suburban neighbourhoods. However, the higher score for suburban neighbourhoods for safety, outdoor space accessibility and neighbourhood attractiveness suggests that the differences in walking environment between suburban and traditional are not simple. It is important to note that the scores across neighbourhoods do not follow the patterns for neighbourhood type; the ANOVA test which identifies significant intra-neighbourhood group differences for all the neighbourhood characteristics except for safety in suburban neighbourhoods confirms this.

Table 2: Vehicle miles driven (VMD), average normalised factor score and p-values for associated ANOVA between traditional vs suburban neighbourhood type

(Source: Aditjandra et al., 2009b)

	Average for tradition-nal	Average for subur-ban	*p*-value[b] tradition-nal only	*p*-value[b] suburban only	*p*-value[b] traditional/ suburban pooled
Weekly VMD by household	123	190	0.00	0.00	0.00
Perceived neighbourhood characteristics[a]					
Safety	-0.08	0.07	.00	.45	.00
Travel accessibility	0.14	-0.12	.00	00	.00
Residential spaciousness	-0.38	0.21	.00	.00	.00
Social factors	0.20	-0.15	.01	.01	.00
Shopping/facilities accessibility	0.23	-0.20	.00	.00	.00
Outdoor space accessibility	-0.16	0.25	.00	.00	.00
Neighbourhood attractiveness[c]	-0.14	0.12	.00	.05	.00
Preferred neighbourhood characteristics[a]					
Safety	0.05	-0.03	.42	.59	.38
Travel accessibility	0.08	-0.07	.30	.00	.01
Residential spaciousness	-0.17	0.11	.00	.40	.00
Social factors	0.10	-0.10	.06	.14	.04
Shopping/facilities accessibility	0.03	-0.01	.13	.28	.95
Outdoor space accessibility	-0.03	0.06	.43	.46	.19
Neighbourhood attractiveness[c]	-0.12	0.08	.25	.32	.01
Travel attitudes[a]					
Pro-public transport use	0.09	-0.07	.34	.00	.01
Travel minimising awareness	0.01	-0.05	.19	.48	.35
Pro-cycling[c]	-0.04	0.09	.09	.19	.06
Travel time sensitivity[c]	0.02	0.00	.37	.46	.81
Safety of car	0.00	0.02	.04	.37	.45
Pro-walking	0.13	-0.09	.00	.12	.02
Pro travel[c]	0.09	-0.10	.75	.36	.03
Car dependent	-0.12	0.07	.12	.01	.02

[a] Scores normalised to a mean value of 0 and variance of 1

[b] *p*-value for *F*-statistics from analysis of variance (ANOVA)

[c] Positive/negative signs has been adjusted against factor loadings

(shaded) Significant at 5% level

In the preferred neighbourhood design characteristics, all respondents showed similar preferences on the following factors: safety, shopping/facilities accessibility and outdoor space accessibility. But significant differences are revealed for ‘travel accessibility’ and ‘social factors’ where the traditional neighbourhood group scored higher as opposed to ‘residential spaciousness’ and ‘neighbourhood attractiveness’ where the suburban neighbourhood group gained the higher score.

The preferences of neighbourhood characteristics and travel attitudes explain the differences which may occur between different neighbourhoods and may inform the self-selection of residential area assuming the perceived and preferred neighbourhood characteristics are not independent. Preferences for neighbourhood characteristics do differ significantly by neighbourhood type as seen in Table 2 with suburban residents having higher scores on average for residential spaciousness and neighbourhood attractiveness, and residents of traditional neighbourhoods having higher scores on average for travel accessibility and social factors.

By comparing scores on preferences to scores on perceived neighbourhood characteristics it is possible to get some sense of the degree to which residents get what they want. Residents of traditional neighbourhoods have higher preferences for and perceptions of travel accessibility and social factors, but while their preference for shopping/facilities accessibility is not significantly higher, their score for perceived shopping/facilities accessibility is. Suburban residents have higher scores for their preferences for and perceptions of residential spaciousness and neighbourhood attractiveness. These results provide some evidence for the possibility that residents do live in an environment which they choose *i.e.* evidence for the concept of residential self-selection. In this sample, residents of traditional neighbourhoods want and receive two factors that might lead to a more walking and public transport conducive environment (travel accessibility and social factors) and receive one factor that they did not necessarily want that might also lead to more walking and public transport use (shopping/facilities accessibility). At the same time, residents of suburban neighbourhoods also receive two factors of which one, neighbourhood attractiveness, might lead to more walking. These findings are a little at variance of previous findings where it was argued that the residential self-selection issue is not a big issue in British neighbourhoods (Aditjandra *et al.*, (2009a, 2009b)). This analysis demonstrates some support for a degree of residential self-selection issue in the British neighbourhoods.

Comparing travel attitudes, Table 2 shows the traditional neighbourhood group scores significantly higher on the factors of ‘pro-public transport use’, ‘pro-walking’ and ‘pro-travel’ but lower on ‘pro-cycling’ (significant at 10%) and ‘car dependent attitude’ and that there are less significant intra-group differences between respondents from different sample areas although the differences between traditional and suburban residents for these attitudes are significant. However, differences between traditional and suburban groups on the factors of travel minimising awareness and travel time sensitivity were not significant. This suggests a link in neighbourhood choice between attitudes to travel modes but not about attitudes to travel itself. It should be noted that the results from the traditional and suburban neighbourhood groups are not uniform. This is confirmed by the significant intra-neighbourhood group differences for pro-public transport and car dependent attitude factors within suburban neighbourhoods and for pro-walking within traditional neighbourhoods.

4.3 Multivariate analysis

The previous section looked at descriptive differences between respondents from different neighbourhoods within the study area. Whilst significant differences are noted, ANOVA analysis does not explain why these differences might exist. The next step of the analysis is to examine whether differences in VMD[4] in the different neighbourhoods can be causally related to factors which have been described above. Thus a cross-sectional model of travel distance to examine the causation relationship between neighbourhood characteristics and travel attitudes as explanatory variables was used.

An Ordinary Least Square model was constructed using log weekly total VMD household (ln VMD) as the dependent variable and the factors identified as explanatory variables. As some respondents reported zero VMD, a value of one was added to all the zero reported VMD so the true dependent variable in this model is ln(VMD+1). The model initially included variables identified as important in US work before testing a wider variety of variables and these results are presented in Table 3.

[4] The dependent variable used here is the total (work + local) weekly household (H/H)VMD. The reason for this is it is thought that the neighbourhood characteristics influence all type of travel for each H/H.

The cross-sectional analysis identifies that holding a driving license and access to a car were significant at the 5% level and explained the major part of the variance in VMD. 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 a car by respondents. The negative coefficient results of pro-public transport attitudes show that public transport availability will significantly reduce average VMD.

Table 3: Ordinary Least Square Regression: model result for ln (VMD+1)
(Source: Aditjandra *et al.* 2009b)

Model	Unstandardized Coefficients	Standardized Coefficients	*t-statistics*	Sig.
Predictors	B	Beta		*p*-value
(Constant)	.370		2.140	.033
Female (dummy, Female=1, Male=0)	-.263	-.066	-2.789	.005
Employed (dummy, Employed=1, Not emp.=0)	.599	.146	5.464	.000
Driving license to H/H	.953	.403	14.337	.000
Cars per adult	1.421	.289	10.753	.000
Pro-walking	-.078	-.039	-1.663	.097
Pro-public transport	-.280	-.141	-5.494	.000
Safety of car	.132	.066	2.827	.005
Car dependent	.266	.135	5.444	.000
Shopping / facilities accessibility preference	-.128	-.064	-2.708	.007
Suburban (dummy, suburban=1, traditional=0)	.217	.054	2.283	.023

N = 659, R-square = 0.651, Adjusted R-square = 0.645 (significant with *p*-value of 0.000)

Dependent Variable: LnVMDplus1

The shopping/facilities accessibility preference variable is also significant at 5% level, suggesting that the presence of a shopping district locally will significantly reduce VMD. The dummy variable categorising the suburban and traditional observations was significant at the 5% level, and with a positive coefficient, shows that VMD in the suburban neighbourhood group are statistically significantly 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. The result of these separate regressions is described in the next section. However, further analysis looking at the British data, which was initially guided by variables that were important in the US study, shows a number of differences. This was explored in more detail to identify a model with the maximum number of significant explanatory variables from the set of preferred and perceived factors. This process was undertaken sequentially by first entering the set of preferred neighbourhood characteristics into the existing model, removing insignificant variables and the model re-estimated before the set of perceived neighbourhood characteristics was entered. Table 4 demonstrates the best model with additional significant predictors at the 5% and 10% levels.

Table 4: OLS Model after sequential preferred and perceived neighbourhood characteristics included (Source: this study)

Model	Unstandardized Coefficients	Standardized Coefficients	*t-statistics*	Sig.
	B	Beta		*p*-value
(Constant)	1.396		10.801	.000
Female	-.260	-.065	-2.760	.006
Employed	.638	.155	5.692	.000
Driving license to H/H	.955	.404	14.282	.000
Cars per adult	1.433	.292	10.812	.000
Pro-walking	-.078	-.039	-1.677	.094
Pro-public transport	-.289	-.145	-5.657	.000
Safety of car	.144	.072	3.082	.002
Car dependent	.276	.140	5.650	.000
Shopping / facilities accessibility preference	-.133	-.066	-2.806	.005
Social factors preference	.087	.043	1.747	.081
Social factors perception	-104	-.052	-2.096	.036
Residential spaciousness perception	.088	.044	1.835	.067

N = 659, R-square = 0.653, Adjusted R-square = 0.647 (significant with *p*-value of 0.000)

Dependent Variable: LnVMDplus1

Table 4 shows that despite socio-economic and travel attitude variables remaining unaffected in both size and significance, additional preferred and perceived neighbourhood characteristics can be good predictors of VMD. Social factors perception is significant (at 5% level) and has a negative relationship with VMD. This suggests that a neighbourhood which has 'good' social factors (implying an environment with lots of people out and about and with much interaction among neighbours) significantly reduces the need for people to travel by car. The positive relationship between social factors preference and VMD at the 10% level suggests that the need for social interaction could drive VMD upwards. This evidence confirms the importance of community interaction and proximity within a neighbourhood in supporting the reduction of private car travel.

The presence of residential spaciousness perception at 10% significance confirms that another neighbourhood characteristic, apart from the neighbourhood type (suburban), can also be a predictor of VMD generation.

4.4 Traditional and suburban model

The significance of the dummy variable for the suburban neighbourhood type in the model shown in Table 3 suggests that further potential insights might be observed from separate regressions for the suburban and traditional neighbourhood groups. This section describes the result of these regressions.

The result for the best regression is reported in Table 5 below. These models were the result of an iterative process, first by adding preferred neighbourhood characteristics and then the perceived neighbourhood characteristics. Insignificant variables were removed at each step. It can be seen that some variables which were previously significant in less disaggregated regressions are not significant in these separate regressions. For example the 'pro-walking' attitude factor is significant at 10% level to predict differences in VMD for the whole sample (Table 3 and Table 4) but appears to be non-significant in these separate samples.

Table 5: OLS Regression for ln (VMD+1) in the separate traditional and suburban areas
(Source: this study)

Model	Traditional[1]		Suburban[2]	
	Standardized Coefficients	Sig.	Standardized Coefficients	Sig.
Predictors	Beta	*p*-value	Beta	*p*-value
(Constant)		.000		.000
Female	-.064	.063	-.045	.194
Employed	.192	.000	.124	.001
Driving license to H/H	.383	.000	.422	.000
Cars per adult	.304	.000	.284	.000
Pro-public transport use	-.101	.007	-.190	.000
Car dependent	.150	.000	.139	.000
Shopping/facilities accessibility preference	-.104	.003	-.051	.150
Residential spaciousness perception	.076	.029	-.032	.365
Safety preference	-.068	.050	.000	.999
Safety perception	.082	.016	-.028	.418
Shopping/facilities accessibility perception	.053	.123	.061	.088

[1]N=328, R Square=0.651, Adjusted R-square=0.639 (significant with *p*-value of 0.000)

[2]N=331, R Square=0.641, Adjusted R-square=0.629 (significant with *p*-value of 0.000)

Dependent Variable: lnVMDplus1

Perception and preference of 'Safety of car', 'social factors' have also been excluded since they are insignificant in these separate regressions. Perhaps one of the reasons for this is because neighbourhood characteristics were found to have only marginally significant effects on VMT/D, as reported in the literature (See: Ewing and Cervero, 2001). However, insights as to which neighbourhood characteristics influence VMD are the aim of these latter studies and also the motivation for this analysis in this paper.

Table 5 shows that the traditional regression model exhibits more significant variables of neighbourhood design preferences than the suburban model. Interestingly, the shopping/facilities accessibility preference and the residential spaciousness perception variables appear insignificant in the suburban model when conducted separately and this contrasts with the regression presented in Table 4. This also confirms findings from a comparison study on groups of neighbourhoods with high percentage of car travel to work as opposed to non-car travel to work as reported in Aditjandra *et al.* (2009a). The safety perception and preference variables are significant at the 5% level in the traditional model although the causal relationship is positive for safety preference and negative for safety perception. This finding is interesting because the model suggests that a preferred safe neighbourhood significantly reduces VMD but at the same time the perceived safe neighbourhood significantly contributes to VMD generation. The only significant neighbourhood characteristics in the suburban model is the shopping/facilities accessibility perception and only then at the 10% level. However the positive relationship of this model suggests that good access to a shopping district or just a local shop can attract more travel by car as well as reducing it as the traditional neighbourhood model has explained.

In both the traditional and suburban model, the coefficients for the car dependency attitude factor are both significantly different from zero at the 5% level. However, the impact of this variable on the VMD 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 force of change on VMD could be such that the VMD for the traditional group could exceed that of the suburban group. Furthermore, the pro-public transport attitudes factor which is significant at the 5% level in both regressions can also explain the relative difference in preference of respondents within different urban forms. This finding also confirms previous finding as reported in Aditjandra *et al.* (2009a) that the high coefficient for pro-public transport attitudes on the suburban model – the neighbourhood group with high percentage of travel to work by car per census 2001 as reported in Aditjandra *et al.* (2009a) – as compared to the traditional model – the neighbourhood group with low percentage of travel to work by car per census 2001. This suggests that if the suburban respondents are given the opportunity to have public transport provision then this will have a relatively greater impact.

5. Conclusion and recommendation

In the Planning White Paper "Planning for a Sustainable Future" (2007) it was clear that future development has to be 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 should look like in a low carbon – in terms of both the residential layout and their supporting facilities – 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 planning proposals to make future developments more sustainable and less carbon intensive in their transport activities.

Travel attitudes and neighbourhood design preferences clearly play a role in explaining differences in VMD suggesting that future 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 VMD and the separate model for the traditional area identifies a number of significant neighbourhood design perceptions and preferences when compared to suburban neighbourhoods. 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 car dependency variable in the causal explanation revealed that they have a higher potential to travel further than their suburban counterparts, given the opportunity supporting the idea that the desire for travel is inherent and will grow even if they have better choices for other travel opportunities. The cross analysis of different neighbourhood groups also shows that the traditional neighbourhoods group is more sensitive to perceived and preferred neighbourhood characteristics. This is especially true when more perceived and preferred neighbourhood characteristics variables are significant in terms of their contribution to differences in VMD. This finding suggests that land-use policy to promote sustainable mobility in traditional neighbourhood group would be more effective. This also suggests that generic measures, as contained in UK PPG 13 (transport) and PPS 3 (housing) may be less effective than selective targeted measures.

This paper also offers new evidence on the issue of residential self-selection. In the US, studies have found that suburban residents are more car dependent, whatever their preferences. In contrast, in the UK, those residents living in the suburban areas of a metropolitan area have a transport choice and this has unsurprisingly led to less sensitive results in the issue of residential self-selection. Schwanen and Mokhtarian (2005) describe travel behaviour as being dissonant (poorly matched in the sense of having a preference for non-car travel but travelling by car or vice versa) or consonant (well matched having a preference for non-car travel and having the ability not to use the car or vice versa). Using this terminology, it could be said of both suburban and traditional neighbourhoods in the UK that the residents can show dissonant and consonant behaviour whereas in the US, residents show consonant behaviour in the suburbs because of the lack of alternative forms of travel. This is the reason why the US experience is much more sensitive to the issue of self-selection. However, it should also be noted that this does not mean that residential self-selection issue is in absent in British neighbourhoods. From the descriptive analysis reported in this paper it was found that residential self-selection issue does play some role for different neighbourhood's residents.

The preferences examined in this paper have important implications for planning. Although there are doubts about its feasibility (Breheny (1997), the introduction of a 'Compact City' policy in the UK (targeting the reduction of private car travel supported with various soft measure or hard measure packages) would build on consonant behaviour in traditional areas and dissonant behaviour in suburban areas. This is in contrast to a similar policy being implemented in the US which would not be able to build on similar dissonant behaviour in the suburbs. For the UK, moving closer to the 'Compact City' concept would seem to be a sensible approach for future settlements, not only because it addresses the environmental issue that comes from excessive car use but also it meets the public desire of better access, not only by private car.

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