Analysis of Rural Activity Spaces and Transport Disadvantage using a Multi-Method Approach

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Abstract

Current knowledge about the relationship between transport disadvantage and activity space size is limited to urban areas, and as a result, very little is known about this link in a rural context. In addition, although research has identified transport disadvantaged groups based on their size of activity space, these studies have, however, not empirically explained such differences and the result is often a poor identification of the problems facing disadvantaged groups. Research has shown that transport disadvantage varies over time. The static nature of analysis using the activity space concept in previous research studies has lacked the ability to identify transport disadvantage in time. Activity space is a dynamic concept; and therefore possesses a great potential in capturing temporal variations in behaviour and access opportunities. This research derives measures of the size and fullness of activity spaces for 157 individuals for weekdays, weekends, and for a week using weekly activity-travel diary data from three case study areas located in rural Northern Ireland. Four focus groups were also conducted in order to triangulate quantitative findings and to explain the differences between different socio-spatial groups. The findings of this research show that despite having a smaller sized activity space, individuals were not disadvantaged because they were able to access their required activities locally. Car-ownership was found to be an important life line in rural areas. Temporal disaggregation of the data reveals that this is true only on weekends due to a lack of public transport services. In addition, despite activity spaces being at a similar size, the fullness of activity spaces of low-income individuals was found to be significantly lower compared to their high-income counterparts. Focus group data shows that financial constraint, poor connections both between public transport services and between transport routes and opportunities forced individuals to participate in activities located along the main transport corridors.

Keywords: Activity spaces; Transport disadvantage; Rural Northern Ireland; Activity-travel diary; Focus groups

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1. Introduction

Lack of participation in activities is a key outcome of the social exclusion process (Burchardt et al., 1999; 2002). Transport has been identified an important dimension in this process as it enables people to travel and to participate in activities (Church et al., 2000; Hine and Mitchell, 2001; Social Exclusion Unit, 2003). The identification and reduction of transport related social exclusion is, therefore, now a key element of transport policies in the developed world (Casas, 2007; Cebollada, 2009; Department for Transport, 2006; Stanley and Lucas, 2008). Traditionally, transport disadvantage has been identified using spatially aggregated measures including multiple deprivation based measures (Department for Communities and Local Government, 2008; NISRA, 2010; Scottish Executive, 2006; Welsh Assembly Government, 2008), area based accessibility based measures (Department for Transport, 2006), and area based mobility measures (Currie et al., 2009; Dodson et al., 2007; Wu and Hine, 2003). Although transport disadvantage is a function of both access to transport and access to opportunities (Hurni, 2006; Stanley and Stanley, 2004), these measures take into account only element of the transport disadvantage problem. For instance, area based accessibility measures count the number of opportunities available to participate in without taking into account whether transport is available to travel to these opportunities. Area based mobility measures, on the other hand, assess the availability of transport services in an area but do not evaluate whether the required opportunities are available and accessible. In addition, access to transport and access to opportunities are relative concepts and vary amongst individuals living both within and between areas (Farrington, 2007). As a result, the use of socio-economic and spatio-temporal disaggregated measures has been highlighted in the literature (Department for Transport, 2006; Kamruzzaman and Hine, in press; Preston and Rajé, 2007). In order to overcome these weaknesses researchers have used activity space size as an indicator of transport disadvantage (Casas, 2007; Casas et al., 2009; McCray and Brais, 2007; Rogalsky, 2010; Schönfelder and Axhausen, 2003). All of these studies have, however, focused on identifying transport disadvantage in an urban area, and as a result, the central question that this paper seeks to answer is: does the size of activity spaces differ significantly between different groups living in rural areas and if so how does this relate to the identification of transport disadvantage in space and time?

The activity space measure of transport disadvantage has some merits over the other measures primarily due to its ability to identify disadvantage based on socio-economic and spatio-temporal disaggregation (Buliung et al., 2008; Department for Transport, 2006). However, identifying transport disadvantage using the size of activity spaces as an indicator may be misleading if the activity space size is not explained in relation to the contexts in which individuals live. This is because transport disadvantage is a relative concept and needs to be considered in the wider context of activities of others living in the same area (Jain and Guiver, 2001; Stanley and Vella-Brodrick, 2009). This is often referred to in the literature as spatial or geographical relativity (Burchardt et al., 1999; Portnov et al., 2008). For instance, a smaller sized activity space for an individual living in an urban area does not necessarily mean that the individual is transport disadvantaged when compared to an individual living in a rural area. Similar distinctions can be made between different rural areas because research has shown that rural areas are largely heterogeneous in terms of the availability of goods and services (Cloke et al., 1994; Gray, 2000; Higgs and White, 2000; Nutley, 1985). Therefore, despite having a smaller sized activity space, individuals should not necessarily be labelled as disadvantaged if they are able to access their required activities locally (Currie et al., 2009; Kamruzzaman et al., 2011). An important requirement is, therefore, to answer the *why* question in interpreting the size of activity spaces from the perspective of the individuals identified as disadvantaged, which the previous research studies have failed to address (McCray and Brais, 2007). Røe (2000, p.102) has stated that:

> "..these types of studies [disaggregated quantitative analysis], while giving important information about statistical correlations between individual background data and social events, do not capture the nature of social systems and structures, and do not necessarily enhance the understanding of causal mechanisms. To achieve this the quantitative techniques need to be combined with qualitative research."

Activities occur at specific locations for certain time periods. Transportation resources (personal mobility and/or public transport accessibility) allow an individual to trade time for space, to travel and participate in activities at dispersed locations (Miller, 2005). Therefore, the size or spatial coverage of individuals' participation in activities (activity spaces) varies depending on their personal circumstances (e.g. disability, income), exposure to travel opportunities (e.g. owning a car, introduction of new public transport services), and exposure to opportunities (e.g. opening of a new shopping centre) (Casas, 2007; Cass et al., 2005; Gray et al., 2006; Schönfelder, 2001). Studies have shown that both access to transport and access to opportunities vary over time (e.g. peak hours vs. off-peak hours, weekdays vs. weekends) (Dodson et al., 2007; Kwan and Weber, 2008; Weber and Kwan, 2003; Wu and Hine, 2003). This means that an individual who is not disadvantaged in a certain period of time is certainly at risk of being excluded during another period of time. Miller (2006) has mentioned that transport disadvantage can best be understood from the perspective of individual dynamic life trajectories which operate within a particular socio-spatial context. Very little attempt has been made to capture these dynamics using the activity space concept in order to identify transport disadvantage (Buliung et al., 2008).

Based on the above discussion, the objective of this paper is two fold: firstly, to identify patterns of transport disadvantage in different rural settings over different time periods from Northern Ireland using the activity space concept; and thirdly, to validate and explain these quantitative findings based on the views of identified disadvantaged groups. Adoption of both quantitative and qualitative approaches would therefore offer the advantages of triangulation (Beirão and Sarsfield, 2007). Huang et al. (2005) have mentioned that each method has unique strengths and that, when combined, complement each other. Advancement in identifying transport disadvantage based on the activity space concept is reviewed in Section 2. Section 3 discusses the methods used to collect, process, and analyse the data required to investigate and validate the variations in the different indicators of activity spaces between different socio-spatial groups. Such indicators include both potential size of activity spaces and their fullness, and actual size of activity spaces. Section 4 portrays the results found from these analyses. Based on study findings, Section 5 discusses the implications of such findings in policy terms.

2. Measures of transport disadvantage based on the activity space concept

Despite conceptual differences, action spaces and activity spaces have often been used interchangeably in the literature (see for example, Dijst and Vidaković, 1997; Schönfelder and Axhausen, 2003). Action spaces are meant to describe an individual's total interaction with his/her environment and they contain all locations about which an individual is aware of or has some knowledge (Buliung et al., 2008; Golledge and Stimson, 1997). Action space has also been referred to as 'awareness space' in the literature (Jones and Zannaras, 1978; White, 1985). Jakle et al. (1976) have divided action spaces into two meaningful components: movement, and communication. Golledge and Stimson (1997) have denoted the movement component of an action space as the activity space. This movement within an activity space has been characterised as: firstly, movement within and near the home; secondly, movement to and from regular activity locations such as journeys to work, to shop, to socialize, and so on; and thirdly, movement in and around the locations where these activities occur. Therefore, activity spaces have been considered as the subset of all locations in which people have direct physical contact as a result of their day to day activities (Buliung et al., 2008; Golledge and Stimson, 1997; White, 1985). On the other hand, communication has been regarded as an indirect means (e.g. telephone, newspaper, magazines, radio, television, etc.) of expanding one's spatial knowledge (Golledge and Stimson, 1997).

Two levels of activity spaces have also been operationalised in the literature including macro-level activity spaces, and micro-level activity spaces. White (1985) has defined the macro-level activity spaces as inter-city movements. On the other hand, micro-level activity spaces refer to the local area within which most of the individuals' movements occur during a specified time (Rai et al., 2007). Micro-level activity spaces were found to have been operationalised more extensively in transport research. Researchers' efforts to conceptualise and to operationalise activity spaces has been traced back to the mid 1960s (Buliung et al., 2008). Since then two related themes have been progressed within the literature. One theme, influenced by the work of Wolpert (1965) and Horton and Reynolds (1971), looks for actual or observed movement patterns in space and time; and has been referred to as 'actual accessibility' in the literature (Becker and Gerike, 2008; Verron, 2008). Indicators such as the number of unique locations visited, number of trips made, distance travelled, activity duration, frequency of trips have all been used to identify transport disadvantage based on this concept (Farber and Páez, 2009; Kamruzzaman et al., 2011; Kawase, 1999; Nutley, 2003; Rollinson, 1991; Schönfelder and Axhausen, 2003; Wyllie and Smith, 1996). The other theme that has been progressed is based on Hägerstrand's (1970) time-geographic concept; this approach largely seeks to model potential size of individual's activity spaces subject to space-time constraints (e.g. capability constraints, coupling constraints, and authority constraints)[1]; and has been referred to as 'potential accessibility' or the 'space-time accessibility' of individuals.

Time geography considers that for an individual some activities are fixed in time and space and are referred to as 'pegs' (e.g. office) (Cullen and Godson, 1975; Parkes and Thrift, 1980). Accessibility to discretionary type activities (e.g. recreation, social, dining out) are, therefore, determined by the available time and speed of travel between two successive pegs (Cullen and Godson, 1975; Kwan, 1998). In three dimensional terms, this accessible part of a city is called the space-time prism and the projection of this prism onto a two dimensional space delimits the boundary of reachable area for an individual and is referred to as potential path area (PPA) (Burns, 1979; Lenntorp, 1976). During a day, a person can act within several sets of prisms centred on particular activity location; and therefore, the aggregation of different PPAs in a day form a daily potential path area (DPPA) and is used as a measure of the potential size of activity spaces. The general form of a PPA is an ellipse in which the two successive pegs represent the foci, and the length of its major axis is half of the product of travel speed and available travel time. The form of the PPA, however, can be a circle if the two pegs represent the same geographical location (e.g. home-shopping-home) or a line if the available time is spent only for travelling between the pegs (Dijst and Vidaković, 1997). Miller (1991) has mentioned that a large part of the PPA is useless for travel and activity participation in reality because travel occurs along streets and activities occur at specific locations. This work has discarded the geometric form of the PPA and adopted only those discrete locations where activity could take place (e.g. street, buildings) and operationalised it in GIS. After Miller (1991), the network-based approach has been widely adopted to measure individual accessibility using GIS (Kim and Kwan, 2003; Kwan, 1998, 1999; Kwan and Hong, 1998; Kwan and Weber, 2008; Weber and Kwan, 2002; Yu and Shaw, 2008).

Using the space-time accessibility measure, Kwan (1999) found that the size of the DPPA of working females was 64% smaller than their working male counterparts largely due to the difference in space-time constraints (e.g. domestic and child care responsibility) although this work did not find any relationship between commuting distance and individual accessibility level. Weber and Kwan (2002) have investigated the impact of authority constraints (e.g. facility opening hours) on accessibility and found that individuals who lived 20-35 minutes away from Portland CBD had a significantly lower level of accessibility at night. This work also found that congestion (i.e. the speed of travel) had a larger effect on accessibility for those living in suburban areas. Despite growing research in this field, the application of the space-time accessibility measure to identify transport related social exclusion is fairly limited. Miller (2006) has developed a theoretical construct and argued in favour of the DPPA measure in identifying transport related social exclusion. Casas et al. (2009) have utilised this

[1] Capability constraints are linked to the physical limitations of an individual such as eating or sleeping. Coupling constraints restrict travel by imposing where, when and for what duration individuals have to join other people in space and time. Authority constraints relate to the institutional context, and refer to laws and other regulations which imply that particular activities are only accessible at certain times.

approach and investigated transport related social exclusion amongst school children in New York. This paper, however, argues that caution must be taken to operationalise this measure in identifying transport disadvantage because certain groups (e.g. retired, unemployed) are not necessarily able to travel further away despite having free time between pegs and also owning a car (i.e. ability to drive faster). This is due to the fact that a number of other factors (e.g. income) will restrict their mobility and hence their size of activity spaces which the time-geographic concept does not take into account. This can especially be the case in rural areas where people are structurally dependent on the car (McDonagh, 2006). Currie et al. (2009) found that forced car owning households made less trips and travelled shorter distances than the average 2+ car households living in outer Melbourne. As a result, this means that the time-geographic measure will misrepresent the size of individual activity spaces and their ability to travel and participate in activities. An alternative approach in order to overcome this limitation is to delineate the size of activity spaces based on observed space-time activity locations (Newsome et al., 1998).

Different methods for deriving the boundary of activity spaces based on observed activity locations have been proposed in the literature. Buliung and Kanaroglou (2006) have generated a standard distance circle (SDC) using standard distance (SD) of activity locations as a radius centred on a mean centre. Using the SDC measure, they have shown that the size of activity spaces for suburban households are more dispersed than urban households. A similar method has been used by McCray and Brais (2007). This found that women who own cars have a larger activity space than non car owners. They have also reported that the distance of home location from a transit route influenced the size of the SDC for the non-car user. Ellipse based measures such as the standard deviational ellipse (SDE) have been used to compare the dispersion of activity spaces between travellers (Buliung et al., 2008). Using the SDE measure, Schönfelder and Axhausen (2003) found no significant differences to the size of activity spaces for those who are usually classified as socially excluded in two German cities. The SDE has also been used to measure the temporal variation of intrapersonal travel (Buliung et al., 2008). Buliung et al. (2008) have used the minimum convex polygon (MCP) measure to explore weekday-to-weekend and day-to-day variations in travel behaviour. Rogalsky (2010) has created a polygonal generalised travel area using the origins and destinations of all trips for working, poor, single mother living in Knoxville. This work found that individuals with mobility constraints had smaller sized activity spaces than other groups.

Although the size of activity spaces suggests a dispersed or clustered pattern of activity locations with a measure of areal extent, it, however, cannot be used to investigate the ability of an individual to travel and deviate from his/her main travel route. This is due to the fact that a larger sized activity space may be the result of fewer activity points located away from each other along the main transport corridor. Newsome et al. (1998) have proposed a practical alternative to overcome this problem. They have generated standard deviational ellipses and quantified their ellipse construct in two ways. Firstly, the ratio of the minor to major axis indicates the fullness of the ellipse representing the relative extent to which the traveller is willing, able, or required to deviate from the main travel route. Secondly, the area of the ellipse represents the size of the activity space. They have linked the outcomes of these measures with travellers' characteristics and have found this potentially useful in understanding travel behaviour.

3. Data and Methods

3.1 Data

An activity-travel diary survey was conducted for this research during the summer of 2009 and 2010. Throughout this survey a 7 day activity-travel diary data were collected from 157 individuals living in three contrasting case study areas (Moira, Saintfield, and Doagh) located in rural Northern Ireland (Figure 1). Moira is a self-contained village in terms of basic goods and services (e.g. shops, bank, GP, pharmacy). In addition, the M1 motorway and Moira train station are located within walking distance of the settlement. Moira is located more than 10km away from urban areas. Saintfield is also a self-contained village, located 10km away from urban areas; however, it is also located 10km away from any motorway and train stations. Doagh is located within 5km of a large urban area. However, it lacks basic goods and services within the settlement and it is also located away from motorway and train station. The case study areas are, therefore, substantially different from each other in terms of proximity to transport services as well as proximity to/availability of goods and services.

The 157 activity-travel dairies contained data for 986 diary days. Although it was expected to have a total of 1099 diary days given that 157 individuals participated in the survey for seven days (157*7 = 1099). These differences were due to the fact that 113 diary days were reported empty. This is due respondents not leaving home on these days (one day for 48 individuals, two days for 14 individuals, 3 days for 8 individual, 4 days for 2 individual, 5 days for 1 individual). Four individuals stayed at home both on Saturday and Sunday in the survey. The collected dairies contained 3057 trips and for each trip individuals reported their trip day (e.g. Monday), trip origin address, trip destination address, trip start time, trip end time, travel mode, trip purpose, and roads/routes travelled. These attributes were inserted in a database and were subsequently geo-referenced using the ArcGIS software and processed for further analysis. Table 1 summarises the characteristics of sample sizes used in previous research studies which does not provide any clear evidence on the sample sizes required for this type of analysis. Given the number of diary (157) and diary days (7), the sample sizes of this research are, therefore, representative of previous research.

Respondents' socio-economic data was collected (gender, income, car-ownership, occupation, age, and home-ownership status) through a questionnaire survey in an earlier phase of this research and is used as the explanatory variables in this research[2]. The samples for the activity-travel survey were

[2] Samples for this questionnaire survey were selected via face-to-face interview in their local neighbourhoods. A total of 458 individuals participated in the questionnaire survey (153 from Moira, 152 from Saintfield, and 153 from Doagh) which was found to be greater than the minimum sample sizes required for this research considering the number of sampling population within each area (Table 2). Sampling population was determined by excluding vulnerable groups (aged below 18 years and over 74 years) from the total population due to ethical reason.

selected from those respondents who had participated in the earlier questionnaire survey and who had also provided consent for their participation in this activity-travel survey. A cross examination of the socio-economic variables between the collected activity-travel diary data and the 2001 census data shows that the respondents were representative of the population in these areas (Table 2) (NISRA, 2001). In addition, their reported activity-travel data were cross-examined with the NI Travel Survey data which also showed a close match (Department for Regional Development, 2008). Due to the differences in terms of area accessibility and area mobility options between the case study areas, a spatial explanatory variable 'area profile' was also created and used in this research. Using the collected activity-travel diary data, the activity space concept was operationalised in order to identify patterns of transport disadvantage in space and time. Both potential and actual activity space concepts were operationalised in this research. Again, both the size and fullness of potential activity spaces were derived to investigate the variations in these indicators between different socio-economic groups. On the other hand, the proportion of trips made (actual accessibility) to participate in different activity locations and at different times in a day/week were investigated in order to capture the space-time constraints faced by different groups in a quantitative way.

In order to explain the quantitative findings, subjective views were collected through four focus groups in the three case study areas. The four focus groups were found to be representative of the previous research studies both in this context (see, Mackey, 2005) and elsewhere for this type of analysis (see, Hine and Mitchell, 2001; Rajé, 2007). Two focus groups were conducted in Doagh. One focus group was conducted in Moira and Saintfield despite a number of methods being utilised to recruit participants to further focus groups in these areas. Three methods were employed to recruit the participants in the focus groups. Firstly, a list of all community organisations in each of the case study areas was prepared and these organisations were contacted to help facilitate a focus group. The two focus groups in Doagh were conducted using this method and the organisations that facilitated the focus groups included the Community Relations Forum and Burnside and District Council. However, no community organisations in the other two case study areas agreed to facilitate a focus group. As a result, community transport organisations operating in these areas were asked to recruit their transport users on to focus groups. Only Lagan Valley Rural Transport, operating in Moira, responded positively and facilitated a focus group for this research. Due to difficulties associated with organising a focus group using the above methods in Saintfield, participants for the Saintfield focus group were recruited through the local health centre. Table 3 shows the composition of each focus group.

3.2 Measuring the potential size of activity spaces

Three measures related to the potential size of activity spaces were derived including the SDE, SDC, and MCP measures. Using the reported origin and destination of each trip, an OD feature class was created based on a pointer address database covering whole of Northern Ireland. The OD feature class was dissolved to generate unique locations that were visited by each individual in a week. This feature class was then used to derive the scores of the above three measures. The directional distribution tool in ArcGIS was used to derive an individual SDE feature class based on two standard deviations. This method takes into account about 95% of the activity locations to generate the SDEs (ESRI, 2009). In a similar way, the standard distance tool in ArcGIS was used to generate an individual SDC feature class., The animal movements tool within Hawth's toolsets was used to generate an individual MCP feature class (Beyer, 2004). Figure 2 shows the weekly size of activity spaces of a car-owning, non-working individual, living in Saintfield using these three measures. A correlation analysis was conducted using the scores of these three measures which showed that the three indicators are significantly correlated to each other (Figure 3). In addition to this geometric nature of analysis, the sum area of opportunities (non-residential building footprints) located within the boundary of SDE, SDC, and MCP measures was calculated and a correlation analysis was conducted to their respective geometric measures. This also shows a significant correlation. As a result, only the SDE based score was reported as a measure of weekly size of activity spaces in this research.

In addition to the weekly measure, the sizes of activity spaces on weekdays (Monday to Friday) and weekends (Saturday and Sunday) were also derived in order to assess the dynamics of activity spaces. Two new feature classes were extracted based on the OD feature class: weekdays OD feature class, and weekends OD feature class. These two feature classes were subsequently dissolved to derive unique locations visited by each individual in these periods. These feature classes were then used to derive the size (area) of individual's activity spaces on weekdays and weekends respectively. Instead of generating the SDE or MCP based measures, the SDC based measure was used to investigate the variations between weekdays and weekends. This is due to the fact that at least 3 unique activity locations are required in order to operationalise the SDE or MCP based measures. Analysis shows that although all individuals visited 3 or more unique activity locations in a week, 16 individuals on weekdays and 34 individuals on weekends visited only 2 unique ODs (including home). Figure 2c and 2d show the size of activity spaces of an individual on weekdays and weekends respectively.

3.3 Deriving the fullness of activity spaces

The fullness of activity spaces was derived using the SDE measure. The lengths of the X-axis and Y-axis of individual SDEs were derived during the preparation of the individual SDE feature class. A new field 'fullness' was added to the attribute table of this feature class. Since the length of any of these axes can be greater than the other axis depending on the orientation of the generated SDEs, a Visual Basic Application (VBA) code as shown in Box 1 was, therefore, used in ArcGIS to calculate the ratio of minor axis over major axis.

Box 1: VBA code used to derive the fullness of activity spaces based on the individual SDE feature class

```
Dim d as Double
If X-axis > Y-axis Then
d = Y-axis / X-axis
Else
d = X-axis / Y-axis
End If
Fullness = d
```

This means that the code checked the length of both X-axis and Y-axis of an individual's SDE and identified the longer axis (major axis) between these two axes. Once the longer axis was determined, then the code divided the shorter axis length by the longer axis length and populated this value in the fullness field of the individual SDE feature class. Figure 4 shows the fullness of activity spaces of two female respondents, both living in Moira in car owning households and in employment. Each female respondent however had different levels of income; one had a higher level of income (Figure 4a) whereas the other had a lower level of income (Figure 4b). Both figures (4a and 4b) were prepared using the same geographic scale in order to exhibit the differences in fullness of activity spaces between them. As mentioned earlier, it was not possible to derive the SDE based measure separately for weekdays and weekends due to a lack of the minimum number of required unique activity locations for several individuals. As a result, a separate analysis regarding the fullness of activity spaces on weekdays and on weekends was not operationalised in this research.

3.4 Assessing the space-time constraints to participation in activities

Although the time geographic concept has traditionally been used to identify space time constraints to participation in activities, the limitation associated with this concept in identifying transport related social exclusion is indicated in Section 2. As a result, a surrogate measure to this approach was utilised in this research by operationalising an indicator representing the actual size of activity spaces (actual accessibility). This indicator includes the number (proportion) of trips made by different groups to participate in different activities both spatially and temporally and is a commonly used indicator to identify transport disadvantage (Hine et al., in press). The proportion of trips made to participate in different activities spatially (spatial distribution of trips) and the proportion of trips made to participate in different activities temporally (temporal distribution of trips) were derived to identify space and time related constraints respectively in this research.

The destinations feature class was used to derive the spatial distribution of trips from the case study areas and was classified as less than 2 km (local trips), between 2 km and 5 km, between 5 km and 10 km, and greater than 10 km away from the case study areas. These classifications were made in this way so that they matched the relative accessibility and mobility options of the case study areas (Figure 1). However, the trips that were defined as home destination i.e. 'return home trip' were excluded from this analysis. As a result, a total of 1704 individual trips were analysed which finished at locations other than homes (1353 return home trips). Three service areas were generated using the network analyst tool in ArcGIS for each case study area (break values: 2 km, 5 km, and 10 km). As a result, the generated services areas indicated a distance from 0 km to 2 km, from 2 km to 5 km, from 5 km to 10 km, and more than 10 km from the respective case study areas. The destinations of non-home based trips that were associated with a particular case study area were selected using the Select by Attribute tool in ArcGIS. The selected destinations that fell within a particular break value of the service area feature class were subsequently selected and coded accordingly using the Select by Location tool. The collected trip start time attribute was classified into morning (00:00 – 8:00), morning peak (8:00 – 10:00), mid-day (10:00 – 16:00), afternoon peak (16:00 – 18:00), and evening (18:00 – 24:00) and the proportion of trips made by different groups in these periods were investigated to identify their time related constraints in a day in addition to analysing their weekday and weekend trips.

3.5 Data analysis

Using the size and fullness of activity spaces, a seven-factor ANOVA with a full factorial interaction between the explanatory factors was conducted using the general linear model (GLM) to identify patterns of transport disadvantage. The GLM test was preferred in this research over the multiple linear regression analysis because the GLM test uncovers both the main as well as the interaction effects for all of the possible combinations of categorical explanatory variables (Bojanic, 2011). In contrast, a regression model does not take into account the interactions between the explanatory variables unless explicit crossproduct interactions terms are added (Garson, 2009). In addition, the GLM was tested with and without the interaction effects of the explanatory variable and the results show that the GLM procedure explained a larger variation in the data when the interaction effects were taken into account. A GLM without interaction effects is analogous to the linear multiple regression analysis. However, a separate linear multiple regression analysis was conducted before conducting the GLM in order to check the multicollinearity amongst the explanatory variables. This analysis shows that all the models met the accepted standard that the part and partial correlations did not drop sharply from zero-order, the tolerance values were not close to zero, and that none of the explanatory variables had a variance inflation factor (VIF) greater than 2 (Xing et al., 2010). The GLM was constructed to analyse the statistical significance of the seven explanatory variables and their interactions in SPSS. The effect size of the different explanatory variables and their interactions were determined using the Partial Eta Squared and is the most common method to measure the effect size (Garson, 2009). The simple contrast method was applied in the GLM which is due to making a comparison of each category (level) of an explanatory variable to the first category (reference) of that explanatory variable. Since the responses were found to be unbalanced meaning that the number of frequencies in different cells were not equal, as a result, the Type III Sum of Square method was used in the models. Unlike other explanatory factors which are dichotomous in nature, the area profile variable had three categories (Moira, Saintfield, and Doagh); and as a result, the post-hoc analysis was conducted using the area profile variable in order to test significance between the case study areas.

The binary logistic regression analysis was conducted to analyse the spatial-temporal distribution of trip variables between different groups. Research has highlighted that individual travel behaviour is not only influenced by their socio-economic and contextual differences but is also influenced by the characteristics of the journey itself (e.g. trip purpose, travel distance, time of the day when the journey is made) (Cervero and Radisch, 1996; Greenwald, 2006; Schwanen et al., 2001). As a result, in addition to using the seven explanatory variables, journey characteristics were also included as explanatory variables in these models. A new variable was created for each of the categories (e.g. local trips) of the spatial and temporal distribution of trips variables which were then coded into a binary form. As a result, the binary logistic regression model computed the odds ratios (ORs) for each explanatory variable that indicated a measure of how much more likely one group (e.g. male) performed in one category over all other categories when compared to its counterpart (e.g. female) and controlling for other explanatory variables in the model. This means that the ORs represented the ratio-change in the odds of an event of interest for a one unit change in the predictor.

4. Key Findings

4.1 Variations in the size of activity spaces

Table 4 shows the results obtained from the GLM tests using the size of activity spaces as dependent variables. It shows that all three models associated with different time periods (e.g. weekdays, weekends, and weekly) are significant at the 0.05 level with good explanatory power. The Partial Eta Squared values for the corrected model show that all models accounted for more than 60% variance in data, a level considered good for a disaggregated analysis (Xing et al., 2010). All three models show that the area profile variable is a significant explanatory factor in the models. Table 5 shows that individuals from Doagh had a larger sized activity space in all periods than that which can be found for individuals living in Moira and Saintfield. This means that the activity locations of individuals living in Doagh are more dispersed in all time periods. This was explained by the focus groups participants who stated that due to a lack of locally available goods and services, individuals living in Doagh had to travel further to the nearby urban centres whereas these opportunities are located locally in Moira and Saintfield (self-contained village) and individuals did not need to travel further. The smaller sized activity spaces of individuals living in Moira and Saintfield therefore does not necessarily mean that they are disadvantaged when compared to individuals living in Doagh.

> "We don't have a picture house here, we don't have a restaurant here, we don't have doctor's surgeries or dentists locally. You know…so you need transport. Transport in a rural area is very important, but the thing is that it's neglected." (Non-car owning, female participant from Doagh)

> "Yes, we do shopping in Lisburn, we do shopping in Lurgan. But, you know, we have advantages…the advantages are that…we have shops, doctors, bank locally. So, therefore, we can use these…if needed." (Male participant from Moira)

> "I get everything I need in Saintfield. I don't drive and I don't need to drive, I don't have to wait for buses and still I am getting everything here." (Female participant from Saintfield)

Respondents' age was found to be a significant explanatory factor in the size of activity spaces only on weekdays (Table 4) and Table 5 shows that the activity spaces of older individuals are significantly larger than their younger counterparts on weekdays. This difference was found to be an impact of the introduction of the free bus pass for senior citizens (aged 60 and over) in Northern Ireland in 2007. Senior citizens are also eligible for free fares on public transport throughout the island of Ireland (Department for Regional Development, 2007). As public transport services are not available on a Sunday in rural Northern Ireland, older citizens were only able to utilise their free travel pass on weekdays. Consequently, no differences were identified between younger and older participants on weekends.

> "Talking about the pass…I have a pass…so my sister…sister was in Dublin…hospital in Dublin…so we were able to get on to the train and travel free to Dublin...and got on to the bus

> anywhere right there go somewhere else…you know. So, it is very good…it is really." (Older, female participant from Doagh)

> "Oh yes, as pensioners, none of us could afford transports if we didn't have free pass." (Female participant from Saintfield)

Car-ownership was found to be a significant explanatory factor in the weekly model (Table 4). Table 5 shows that the activity locations of car-owning individuals are more dispersed than their non-car counterparts. It appears that this weekly difference is due to the significant variation found on weekends because during the week both car-owning and non-car owning individuals had a similar sized activity space. This is due to the fact that public transport services are limited on weekends, and as a result, non-car owning individuals had to participate in activities locally. Therefore, their activity locations are more compact on weekends. This also signifies the importance of car-ownership in a rural setting particularly in places where goods and services are limited locally.

> "There are people that do not have a car. So, those people yes, they can't go out on Sunday. They might be able to get out to their church because sometimes the churches run a bus or something. But I can think a lot of people live down the road here and they don't have a car. So on a Sunday; they are prisoner on their own." (Male, car-owning participant from Moira)

> "If I didn't have a car, I couldn't have ever survived in rural areas. We only have limited, (laughter), no bus after, ten to six is the last bus on Monday to Friday and no bus after twenty to four on Saturday." (Car-owning, female participant from Doagh)

> "Because of the lack of flexibility within the transport system, its necessity for me and others to own cars which is an additional expense to your family, which you don't necessarily incur if you live in more urban setting. You can't get pass without having too old. In a rural area, its very much family required, a car may be not just one." (Car-owning, male participant from Doagh)

Although the activity space size of car-owning individuals were identified as significantly larger, a lack of public transport services on a Sunday was, however, found to have an adverse impact for this group in terms of the space-time organisation of activities (Cass et al., 2005; Church et al., 2000). Due to a lack of public transport services, car-owning individuals had to provide lifts to friends and family members, and as a result, they had little time to participate in their own activities on a Sunday.

> "See, I would love a bus service on Sunday…from my house because the guy can put my daughter on…they can go to picture in Glengormley…cinema…or whatever…whereas I have to take her there and then pick her back up again…you know…for friends...I have to make sure that I am about to take her down to Glengormley and make sure back home again. Her other friends are going to cinema in Glengormley by bus whereas you cannot do that...Your children would really have a life…It has to be…be around to think you be available rather than the bus be available." (Female, car-owning participant from Doagh)

No differences were found to exist between males and females, between high-income and low-income groups, between working and non-working individuals, and between those in home-ownership and individuals living in the rented housing sector in any of the temporal models.

4.2 Variations in the fullness of activity spaces

Table 6 shows that a significant model emerged from the GLM test using the weekly fullness of activity spaces as a dependent variable. None of the explanatory variables was found to have a significant effect in this model. However, the interaction between the explanatory variables income and age was found to have a significant impact. Analysis shows that despite being young in age, low-income individuals had a lower level of fullness in their activity spaces (0.29) than their high-income counterparts (0.40). Three reasons were identified for this difference in this research. Firstly, that participants in all focus groups were found to be concerned about the higher rate of public transport fare in rural Northern Ireland. This was found to be true for all modes of public transport services.

> "Another way to put things to is if you had your buses going to Glengormley, could a family afford to do because they going to get from you about £4 each way?" (Female participant from Doagh)

> "It [taxi] is very expensive if you are going on a taxi, at night especially, if you are pensioner. You know, I used to use taxi three times a week when the rural transport did not exist three years ago and I paid £10 each way." (Female participant from Moira).

> "Taxi is a phenomenal. I pay £144 a month to get a taxi to my work. That's an awful lot of money. It really is." (Female participant from Doagh)

Secondly, a higher number of low-income individuals were identified as non-car owners. These individuals, therefore, had to rely on public transport services which follow a specific route. Thirdly, according to the focus group participants, a major drawback of public transport services in rural areas is the poor connections between transport services and transport and activity locations. This poor connectivity when coupled with the higher rate of public transport fare has forced low-income individuals to consume their activities along the main transport corridor.

> "Even to get from here (Glengormley) to Whiteabbey hospital which is about what mmm...five, five minutes with the car with taking…you know…I will have to go from here…and I have done this...I had to do this…go walk to the Carmoney road to catch the express bus…which comes down through Carmoney…to get to Whiteabbey hospital…and that is a five minute journey and it takes at least half an hour... the time you get from this bus where the bus going into Carmoney and wait and catch the express coming through... going to Newtownabbey hospital...and I have no idea whether I get the Antrim Bus (express service)." (Non-working, car-owning, female participant from Doagh)

> "Bus service from Moira to Lisburn or Belfast is reasonable. But there is no bus service to Banbridge (from Moira). No bus service to Craigavon Hospital (from Moira). There is a bus service to Lisburn hospital (from Moira)." (Older, male participant from Moira)

4.3 Spatio-temporal distribution of trips

This section examines the space-time constraints that the different groups faced in order to participate in different activities. Table 7 clearly shows that the location of available opportunities, as shown in Figure 1, dictated travel behaviour for individuals living in different case study areas. It shows that individuals from Doagh were around twenty times less likely to make a trip locally whereas they were found to be about seven times more likely to make trips within a range of 2 km – 5 km from their home. These findings are, therefore, consistent with the findings reported in the size of activity spaces in these areas. This means that individuals living in Doagh not only have a dispersed activity location but that they also visit these locations frequently. In a similar way, the activity locations of individuals living in Moira and Saintfield are not only condensed, these are also located close to their neighbourhoods and they tended to visit these locations more frequently compared to the activity locations of individuals living in Doagh. This means that none of these groups are transport disadvantaged in terms of participation in activities spatially.

Similar sizes of activity spaces were identified for both males and females. However, Table 7 shows that females are less likely to make trips further away from their living areas. This suggests that although their activity locations were located further away from their local area, their rate of participation in these distant activities were significantly lower. This result may be due to lower levels of time flexibility as a result of additional family responsibilities (e.g. childcare). This situation was exacerbated with physical inaccessibility of existing transport services in rural areas.

> "The buses we have here, don't compare to any of the buses in Europe [where] you can use and align prams and wheelchairs for ambulant people and old people in the city, but when we come out towards Ballyclare, I have never ever able to get on a bus to my area with a pram, you hold the kids beside, out of the pram, fold the pram down, get on the bus and hold the panel with you, so there is no sitting for prams and wheelchairs." (Female participant from Doagh)

Non-car owning and low-income individuals participated in local activities more frequently than their respective car-owning and high-income counterparts which signify the need for local opportunities in order to enhance participation (or reducing transport related social exclusion) in activities for these transport disadvantaged groups. Table 7 shows that individuals were more likely to make trips to destinations closer to their living areas for social, shopping, recreational, health purposes and other types of activities than undertaking work. This suggests a spatial mismatch of work related opportunities in rural areas and also indicates that despite having a long distance commute, working individuals had a lower size of activity space on weekdays highlighting their time based constraints for to participation in discretionary activities.

The odds of making walk trips decreased as the location of activities moves further away from the community whereas the free bus pass policy has created the ability for senior citizens to participate in distant activities more easily (Table 7).

> "What do you may notice when you go round this area? May be three or four shops… You find there is ten or eleven cars park. Those are not customers to the shops, those are people parking their cars there and taking the (free) bus into town." (Older, female participant from Saintfield)

Individuals were found to be more likely to use local goods and services during the morning peak period compared to mid-day and on weekends compared to weekdays. Lack of transport on weekends was found to force some individuals to change their normal travel behaviour (Table 7).

> “I do some local things like go to the park and walk (on Sunday), I readjusted my life setup. It would be helpful for young people to be able to get a bus to swimming pool or something on Sunday.” (Female, non-car owning participant from Moira)

The propensity to engage in activities was reduced significantly at locations that are located more than 10 km away from the case study areas during the morning peak period and in the evening compared to mid-day (Table 7). This means that individuals undertook activities at mid-day that were located further away from their home. However, individuals living in Doagh were found to be more likely to make trips at mid-day and were less likely to make trips in the evening compared to individuals living in other areas (Table 8). These differences were explained by the focus group participants in terms of availability of public transport services and local opportunities. No bus service is available in all the three areas after 6:00 pm. As a result, the non-car owning group from Doagh had to finish their trips before this time whereas the non-car owning groups from Moira and Saintfield perhaps were able to participate in activities late at night. This is due to the fact that opportunities are located within walking distance in these areas. Table 8 shows that female activity-travel behaviour was also constrained in time as they were less likely to make trips at weekends and in the evening compared to their male counterparts due to perceptions of safety that stemmed from a lack of transport in these periods.

> “That is one of the roads where you do need rural transport, not I like to saying for an old person, for every body…I wouldn’t feel safe a youngster walking on the road.” (Older, female participant from Saintfield)

Table 8 also shows that the odds of making trips in the morning peak period were increased for car owning individuals compared to their non-car counterparts. On the other hand, non-car owning individuals were found to be more likely to make trips in the early morning than their car-owning counterparts. These differences were due to the fact that non-car owning individuals had to travel by bus which takes longer to reach their destinations; as a result, they had to leave home earlier to be present at the activity locations in time (impact of coupling constraint on capability constraint). In addition, due to work commitments, working individuals were found to make significantly fewer numbers of trips on weekdays and in the morning peak periods.

> “…get a lot more people on the bus as long as the journey went down. It could have an extra ten minutes…because stopping and starting, stopping and starting to the whole way down. So, if the lot more people use the buses, they need to put more bus on because people will get fade up and say it takes too long…shouldn't take forty minutes to go down the main road into Belfast.” (Female participant from Saintfield)

5. Conclusion

This paper has investigated the link between the size of activity spaces and transport disadvantage in a rural context. The main objective of this research was to test whether the size of activity spaces corresponds with those who are usually classified as transport disadvantaged in rural areas. The findings of this research both support and reject this relationship. This research found that despite having a smaller sized activity space, individuals living in an area with the availability of goods and services were able to participate in their required activities. This finding therefore rejects the link and highlights the need for qualitative investigation in combination with quantitative analysis (McCray and Brais, 2007; Røe, 2000). Older individuals have frequently been identified as transport disadvantaged in previous research studies in this context (Department for Regional Development, 2001, 2002; Department of Agriculture and Rural Development, 2003), and as a result, concessionary fare policy intervention was undertaken for this group (Department for Regional Development, 2007). The finding of this research is clear evidence of the positive impact of such intervention which shows that the size of activity spaces of older individuals are now more dispersed which is reflection of their travel capabilities. This research supports the link made in previous research studies that car-ownership is important in shaping lifestyle in rural areas (Gray et al., 2001; Nutley, 2005). However, temporal disaggregation of the data reveals that this is true only on weekends due to a lack of public transport services. On weekdays, non-car individuals were found to be able to travel and participate in activities equally like their car-owning counterparts. The findings of this research also show that the size of activity spaces alone does not capture the complexity associated with accessing public transport services and consequently lacks the ability to identify a complete picture of transport disadvantage. The utilisation of the fullness of activity spaces measure clearly complements this research. Although the size of activity spaces of low-income and high-income individuals were found to be similar, low-income individuals lack the ability to deviate from the main public transport route due to financial constraints and also due to poor connectivity of services. As a result, they are less capable of finding opportunities like education, access to jobs etc and certainly are at a higher risk of being excluded from society (Cass et al., 2005).

> "Likewise going down to the....the college...and in the evenings…you could have got a bus to Whiteabbey hospital...then you have to walk from Whiteabbey hospital down on to the main road get to the college and then you have finished your course at nine...going back home…you either got a taxi or relied on someone giving you lift." (Female, non-car owning participant from Doagh)

> "You can't have bus to go to Newtownards directly (from Saintfield). Most people just have to own a car, it's a necessity in rural area…hmm…really to get to work." (Working, female participant from Saintfield)

This research also shows that there is a need for a separate analysis to identify the space-time constraints associated with travelling and participation in activities in rural areas which the traditional activity space size and fullness measures are not capable of capturing. Although a number of groups were identified with a similar size and fullness of activity space (e.g. male and female), their participation in activities were found to be significantly different both spatially and temporally. For instance, the activity-travel behaviour of females was found to be skewed both in space (fewer trips to distant activities) and time (fewer trips in the evening and weekends) due to coupling and authority constraints (Kwan, 1999). On the other hand, this research shows that working individuals not only have smaller sized activity spaces despite long commute distances, but that they were also unable to make more trips on weekdays due to work commitments (coupling constraint) (Weber and Kwan, 2002). This research also shows that certain disadvantaged groups (e.g. non-car) in rural areas had to negotiate their personal time (capability constraint) to meet the demand of the coupling constraint (office) due to the problems associated with rural transport (e.g. delay). Therefore, the utilisation of actual activity space measures (e.g. the proportion of trips made to participate in activities spatially and temporally in this research) enhanced our understanding of the space-time constraints faced by rural travellers.

The findings of this research, therefore, clearly suggest that group specific policy interventions need to be developed more fully for those identified as transport disadvantaged (e.g. low-income, non-car, female, working) in order to increase their accessibility to goods and services. The different methods used in this research in order to identify transport disadvantage complemented each other. For instance, only using the qualitative data in this research, would have made it difficult to conclude which group lacked the ability to travel and participate in activities with confidence (e.g. does it matter much for not having the public transport services on weekends?). Whilst quantitative measures make it difficult to identify the causes of disadvantage (e.g. why did the non-car group have a smaller sized activity space on weekends?). Therefore, the elements of the methodology used in this research have sought to explain both the causes and their effects. However, despite the representativeness of the different samples sizes in this research compared to other research studies, a larger sample sizes would clearly enhance the robustness of this study in terms of statistical significance.

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8. Tables

Table 1: Sample sizes of several travel diary surveys

Citation	Context	Sample population	Number of diaries	Diary days
Hine and Mitchell (2001)	Scotland	Non-car owning households	19	1 day
Rajé et al. (2003)	Bristol, England	General travellers	66	1 day
Rajé et al. (2003)	Nottingham, England	General travellers	71	1 day
Kenyon (2006)	South West of England	General travellers	100	7 days
Casas (2007)	New York, USA	Disabled and non-disabled	111 (each group)	1 day
Casas et al. (2009)	Erie and Niagara, USA	Children	674	1 day
Kamruzzaman et al. (2011)	Northern Ireland	Student	130	2 days
Rogalsky (In Press)	Knoxville, USA	Single mother	19	1-5 days
Schönfelder and Axhausen (2003)	Halle and Karlsruhe, Germany	General travellers	317	6 weeks
Weber and Kwan (2002)	Portland, Oregon	Car owner	200	2 days
Kwan (1999)	Franklin, Ohio	Full time employed European American	56	2 days
Kwan and Weber (2008) Weber and Kwan (2003)	Portland, Oregon	General travellers	755	2 days

Table 2: Socio-economic status of the respondents participated in the activity-travel diary surveys

Variables	Code and classification [a]	Survey data (% of area total)				Census data (% of area total) [b]		
		Moira	Saintfield	Doagh	Overall	Moira	Saintfield	Doagh
Gender	1. Male	40	47	48	45.2	48	48	49
	2. Female	60	53	52	54.8	52	52	51
Age	1. Young	53	73	52	60.5	85	83	75
	2. Older	47	27	48	39.5	15	17	25
Occupation	1. Working	62	57	56	58.0	-	-	-
	2. Non-working	38	43	44	42.0	-	-	-
Car-ownership	1. Non-car in household (HH)	16	18	12	15.3	10	12	21
	2. One or more cars in HH	84	82	88	84.7	90	88	79
Home-ownership	1. HH owning a house	71	73	84	75.8	87	84	78
	2. Otherwise	29	27	16	24.2	13	16	22
Income	1. Low income	67	48	56	56.1	-	-	-
	2. High income	33	52	44	43.9	-	-	-
		n=45	n=62	n=50	n=157	N=220	N=247	N=183

[a] Young – age between 18 and 59 years, older – age between 60 and 74 years; working – full/part time employed and self-employed, non-working – retired, unemployed, household management, and student; low-income – income level below the average income level of rural NI, high-income - income level above the average income level of rural NI

[b] Unmatched categories are not reported.

Table 3: Composition of the participants in different focus groups

Variables	Focus groups			
	Moira	Saintfield	Doagh (Community Relations Forum)	Doagh (Burnside and District Council)
Number of participants	7	5	6	10
Transport used [a]				
Car driver	2	1	2	7
Car passenger	1	-	2	3
Public transport user	3	5	2	5
Community transport user	3	-	-	-
Gender				
Male	3	3	2	6
Female	4	2	4	4
Age				
Young (< 60 years)	1	1	3	5
Older (Between 60 and 74 years)	6	4	3	5
Occupation				
Employed	1	2	2	5
Retired/non-working	6	3	4	5
Home-ownership				
Owner	6	4	3	7
Other	1	1	3	3

[a] The sum of different values within the transport used variable may not be equal to the number of participants. This is due to the fact that some participants indicated that they used different types of modes.

Table 4: GLM test results showing the socio-economic and spatio-temporal variations in the dispersion of activity spaces

Source	Dependent variables: Area of activity spaces					
	Weekly SDE area (km^2)		Weekdays SDC area (km^2)		Weekends SDC area (km^2)	
	F	Partial Eta Squared	F	Partial Eta Squared	F	Partial Eta Squared
Corrected model	2.478[a]	0.645	3.568[a]	0.723	2.055[a]	0.612
Intercept	33.393[a]	0.271	52.003[a]	0.366	21.503[a]	0.200
Area profile	6.766[a]	0.131	9.687[a]	0.177	5.016[a]	0.104
Gender	0.151	0.002	0.000	0.000	0.084	0.001
Car-ownership	5.812[a]	0.061	0.626	0.007	8.565[a]	0.091
Income	1.620	0.018	1.158	0.013	1.955	0.022
Age	3.259	0.035	4.139[a]	0.044	1.787	0.020
Occupation	2.768	0.030	0.394	0.004	1.272	0.058
Home-ownership	0.031	0.000	0.566	0.006	0.420	0.005

[a] Coefficients are significant at the 0.05 level

Table 5: Descriptive statistics of the dispersion of activity space

Explanatory variables	Categories	Weekly SDE area (km^2)	Weekdays SDC area (km^2)	Weekends SDC area (km^2)
Area profile	Moira	1271.9075	1691.9283	1797.8990
	Saintfield	665.1634	918.0637	722.2814
	Doagh	2212.9752	2235.3300	4268.1326
Gender	Male	1695.0971	1793.6032	2939.5391
	Female	1032.2423	1366.0162	1460.1654
Car-ownership	Non-car owning	398.1428	979.7381	328.3695
	Car-owning	1500.5211	1663.9813	2440.7431
Income	Low-income	1113.7091	1541.4672	1785.5988
	High income	1610.4106	1582.2334	2576.2584
Age	Young	1268.6151	1440.1518	1811.6407
	Older	1429.1338	1742.0774	2614.5511
Occupation	Working	1295.7101	1339.0220	2161.6497
	Non-working	1382.0471	1863.2154	2104.5143
Home-ownership	Owner	1388.2978	1748.3962	1983.9398
	Rented	1155.7183	967.4756	2600.2207
Average		1332.0047	1559.3836	2137.0031
n		157	157	153

Table 6: GLM test results showing the socio-spatial differences in the fullness of activity spaces

Source	Dependent variable: Fullness of activity spaces	
	F	Partial Eta Squared
Corrected model	1.842[a]	0.575
Intercept	181.074[a]	0.668
Area profile	0.037	0.001
Gender	3.173	0.034
Car-ownership	2.101	0.023
Income	2.770	0.030
Age	0.024	0.000
Occupation	0.768	0.008
Home-ownership	0.057	0.001
Interactions		
Income * Age	6.931[a]	0.072

[a] Coefficients are significant at the 0.05 level

Table 7: Binary logistic regression results showing the ORs associated with spatial distribution of trips

Explanatory variables	Dependent variables (versus all other destinations)			
	Less than 2 km	2 km – 5 km	5 km – 10 km	More than 10 km
Area profile				
Moira (reference)				
Saintfield	1.412	0.019	1.598[a]	0.945
Doagh	0.065[a]	7.222[a]	0.870	0.570[a]
Gender (ref: male vs. female)	1.184	1.331	1.712	0.634[a]
Car-ownership (ref: no vs. yes)	0.197[a]	0.655	2.187	1.297
Income (ref: low vs. high)	0.564[a]	1.375	0.775	1.138
Age (ref: young vs. older)	1.222	0.314[a]	1.276	1.043
Occupation (ref: working vs. non-working)	0.597	4.673[a]	1.242	0.629[a]
Home-ownership (Ref: owner vs. other)	0.336[a]	1.328	1.577[a]	0.845
Trip purpose				
Work (reference)				
Social	11.513[a]	2.813[a]	1.196	0.353[a]
Recreational	3.899[a]	2.681[a]	2.465[a]	0.304[a]
Shopping	10.256[a]	2.938[a]	0.831	0.428[a]
Food	0.833	1.608	3.146[a]	0.418[a]
Other	19.628[a]	4.527[a]	0.837	0.263[a]
Health	17.881[a]	0.000	0.500	0.848
Transport mode				
Car (reference)				
Bus	0.116[a]	0.551	0.527	3.351[a]
Lift	0.829	0.631	0.973	1.268
Walk	551.537[a]	0.109[a]	.026[a]	0.020[a]
Taxi	0.244	0.000	3.957[a]	1.094
Bicycle	31.627[a]	1.129	0.241	0.237[a]
Trip time in a day				
Mid-day (10:00 – 16:00) (reference)				
Morning peak (8:00 – 10:00)	2.877[a]	1.396	1.558[a]	0.460[a]
Morning (00:00 – 8:00)	1.202	0.000	0.933	1.398
Afternoon peak (16:00 – 18:00)	1.266	1.062	1.126	0.884
Evening (18:00 – 24:00)	1.806	2.586[a]	0.720	0.600[a]
Trip day (ref: weekday vs. weekends)	2.103[a]	1.014	0.902	0.797
Omnibus test coefficient (Chi-Square)	1302.485[a]	447.906[a]	165.849[a]	652.760[a]
Nagelkerke R Square	0.802	0.458	0.172	0.425

[a] Associated B coefficients are significant at the 0.05 level

Table 8: Binary logistic regression analyses results showing the ORs associated with temporal distribution of trips

Explanatory variables	Dependent variables (versus all other periods)						
	Trip time in a day					Trip day in a week	
	Mid-day	Morning peak	Early morning	Afternoon peak	Evening	Weekdays	Weekends
Area profile							
Moira							
Saintfield	1.112	1.318	0.011[a]	0.815	1.059	0.703[a]	1.422[a]
Doagh	1.434[a]	1.100	0.798	0.668[a]	0.769[a]	0.836	1.196
Gender (ref: male vs. female)	1.099	1.363	0.566	1.274	0.614[a]	1.386[a]	0.722[a]
Car-ownership (ref: no vs. yes)	0.776	2.090[a]	0.074[a]	1.101	0.896	0.744	1.344
Income (ref: low vs. high)	1.081[a]	0.919	1.081	0.655[a]	1.376[a]	0.997	1.003
Age (ref: young vs. older)	1.349[a]	0.707[a]	1.200	0.611[a]	1.243	0.993	1.007
Occupation (ref: working vs. non-working)	2.296	2.547[a]	0.108[a]	0.424[a]	0.421[a]	1.935[a]	0.517[a]
Home-ownership (ref: owner vs. other)	1.022	0.886	1.101	0.862	1.205	1.058	0.945
Trip purpose							
Work (reference)							
Social	3.607[a]	0.033[a]	0.000	51.642[a]	11.690[a]	0.019[a]	52.718[a]
Recreational	2.124[a]	0.052[a]	0.070[a]	71.598[a]	13.198[a]	0.035[a]	28.839[a]
Shopping	5.225[a]	0.055	0.000	45.237[a]	4.396[a]	0.036[a]	27.540[a]
Food	2.873[a]	0.000	0.000	100.791[a]	15.833[a]	0.028[a]	35.786[a]
Other	2.390	0.133[a]	0.237[a]	45.599[a]	2.516[a]	0.105[a]	9.506[a]
Health	5.442[a]	0.087[a]	0.000	53.564[a]	0.938	0.711	1.406
Transport mode							
Car (reference)							
Bus	0.873	1.851[a]	0.050[a]	1.131	0.735	1.040	0.961
Lift	1.090	0.213[a]	0.000	1.014	1.452	0.364[a]	2.749[a]
Walk	0.778[a]	1.579[a]	2.433	0.523[a]	1.564[a]	0.663[a]	1.509[a]
Taxi	0.517	0.000	0.000	2.952[a]	1.097	1.176	0.850
Bicycle	0.347	0.497	26.254[a]	1.785	1.529	0.214[a]	4.672[a]
Trip time in a day							
Mid-day (10:00 – 16:00) (reference)							
Morning peak (8:00 – 10:00)						2.039[a]	0.490[a]
Morning (00:00 – 8:00)						1.136	0.881
Afternoon peak (16:00 – 18:00)						3.008[a]	0.332[a]
Evening (18:00 – 24:00)						2.762[a]	0.362[a]
Trip day (ref: weekday vs. weekends)	2.582[a]	0.711[a]	3.123[a]	0.506[a]	0.565[a]		
Omnibus test coefficient (Chi-Square)	538.246[a]	1052.673[a]	262.401[a]	434.984[a]	428.020[a]	563.853[a]	563.853
Nagelkerke R Square	0.219	0.455	0.457	0.218	0.206	0.251	0.251

[a] Associated B coefficients are significant at the 0.05 level

9. Figures

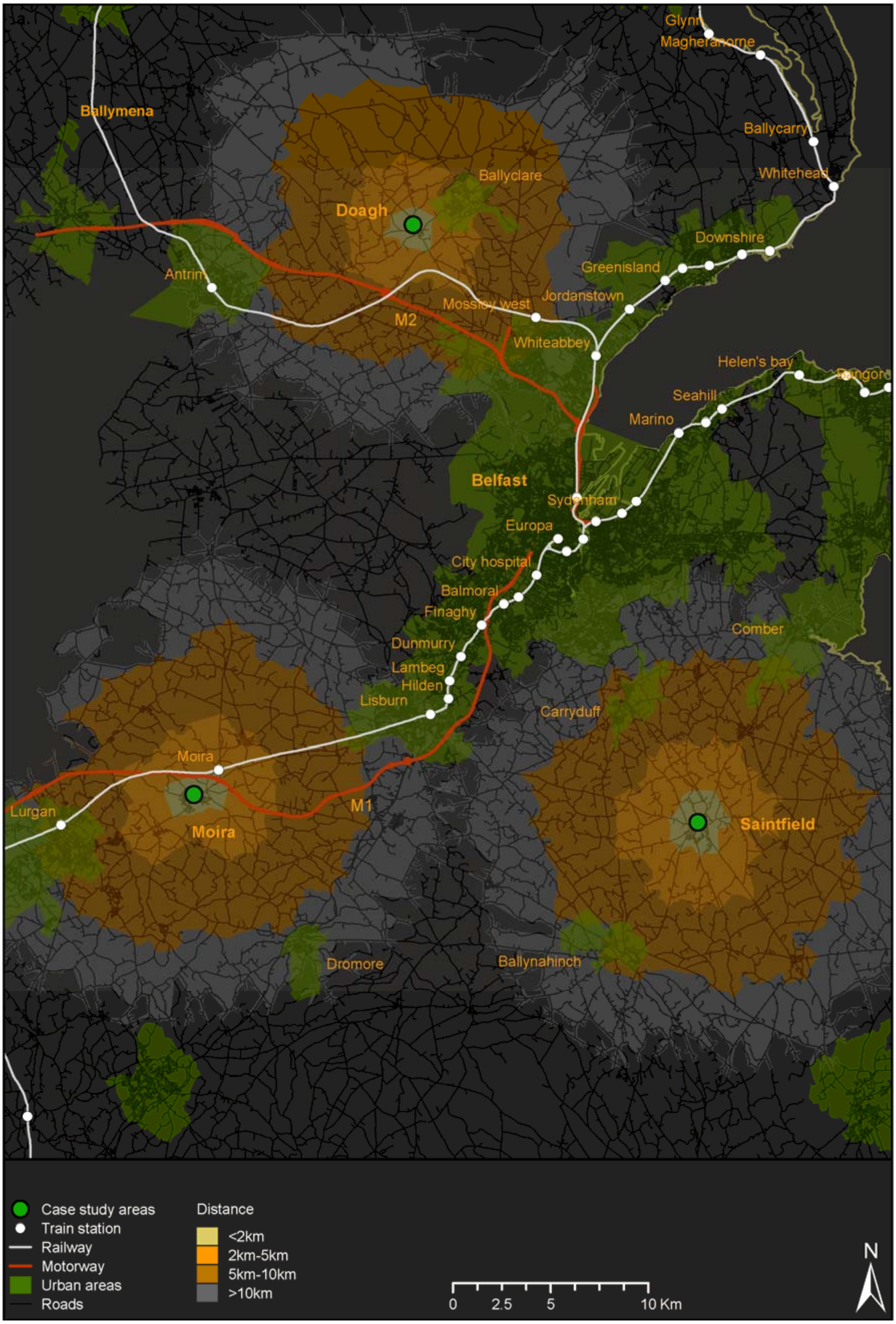

Figure 1: Location of the case study areas in terms of differential access to transport and opportunities.

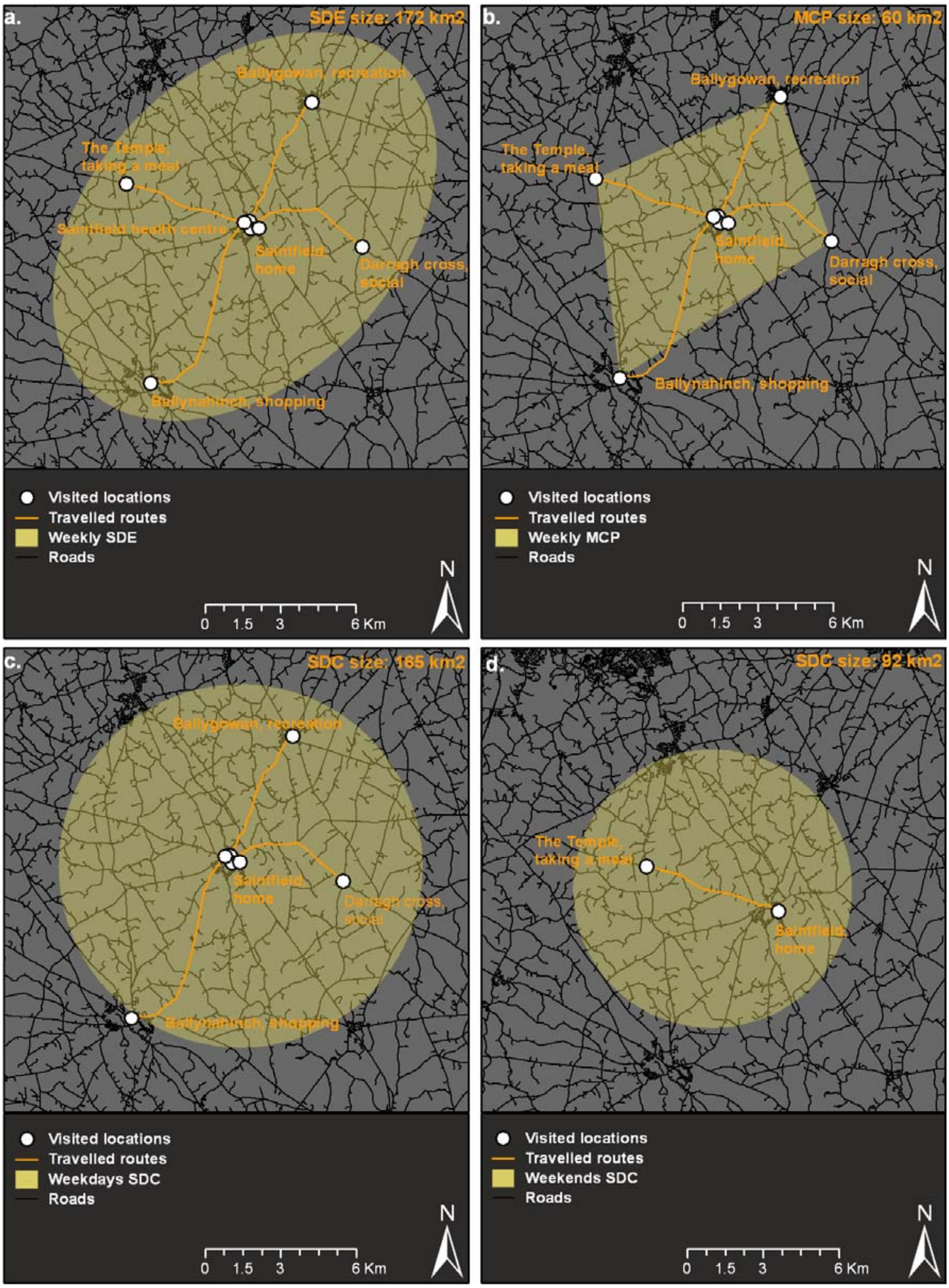

Figure 2: Deriving the sizes of activity spaces using the a) weekly SDE, b) weekly MCP, c) weekdays SDC, and d) weekends SDC measures.

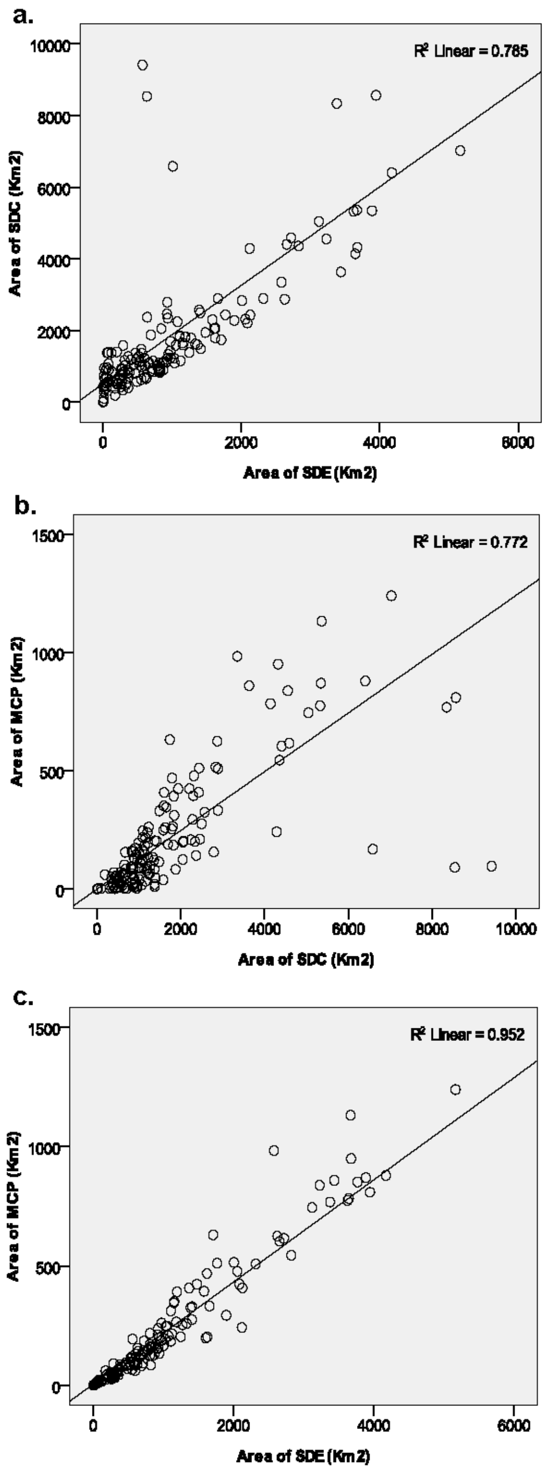

Figure 3: Correlations between the different measures of activity space size.

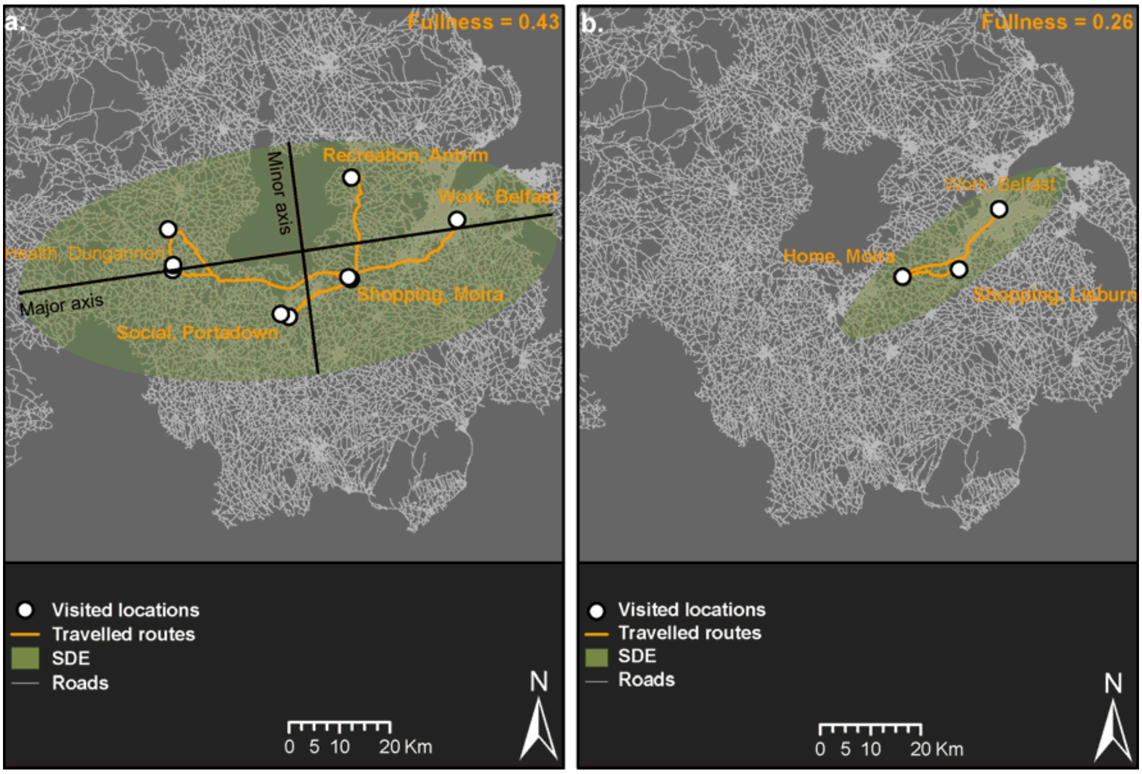

Figure 4: Fullness of activity spaces of a high-income (a), and a low-income individual (b).