Measuring the transport patterns of those living in deprived areas in Dublin, Ireland

Brian Caulfield*
Department of Civil, Structural and Environmental Engineering
Trinity College Dublin
Dublin 2
Ireland
Tel: +353 1 8962534
Fax: +353 1 6773072
Email: brian.caulfield@tcd.ie

David McNamara
Department of Civil, Structural and Environmental Engineering
Trinity College Dublin
Dublin 2
Ireland
Tel: +353 1 8962537
Fax: +353 1 6773072
Email: mcnamadg@tcd.ie

*Corresponding Author

Submitted: 13th November 2011

Word Count: 3,935 + (250 *9) = 6,185

ABSTRACT

This paper examines the relationship between social deprivation and travel patterns. Many studies have examined the relationship between deprivation and travel patterns, but few have compared those in the most disadvantaged areas with those living in the most affluent areas. This study examines the impact that deprivation has upon individuals' trip patterns, in Dublin, using 2006 Census of Ireland data. A number of maps were created to determine the patterns of deprived areas in the city relative to a number of trip characteristics. A multinomial logistic regression model was estimated in this study to determine how the level of deprivation impacts upon a number of characteristics such as mode choice, annual emissions, cost of transport and car ownership. The main findings of this study are that those individuals living in deprived areas in Dublin are more likely to use sustainable modes of transport compared to individuals living in the more affluent areas of the city.

INTRODUCTION AND BACKGROUND

This paper examines the relationships between deprivation and the transport characteristics of individuals living in these areas. The motivation for conducting this research was to establish if those in more deprived areas have a greater dependence on unsustainable modes of transport. The research presented in this paper provides a comprehensive comparison between deprived and affluent areas to determine which area have the most sustainable travel patterns. The study area examined in this paper is Dublin city. Dublin is the capital of Ireland and in 2011 had a population of 1.27 million (*1*). Dublin is a relatively low-density city with high levels of car ownership and modest levels of commuting by public transport (*2*).

Several studies have examined the modes of transport used by individuals living deprived or social excluded areas. Mobility is a key socio-economic resource and access to means of mobility can exercise considerable influence over household social outcomes and individuals' well being (*3*). The phrase 'travel poverty' is often used to describe how individuals in deprived areas have less access to education, employment and other local amenities. This lack of access reinforces the inequalities in these sectors of the population (*4*). Scott and Horner (*5*) examined the relationship between social exclusion and urban form. The authors present a study conducted in Louisville to determine the level of social exclusion based upon different destination opportunities, the authors found that urban form did impact upon mobility and that rural households were shown to have high levels of exclusion. Hartell (*6*) reports the results of household survey that examined the barriers to community engagement. The findings of this study showed that that females, low-income households and those with longer commutes were most likely to cite poor transportation links as the main reason for poor community engagement. Poor access to transportation can cause a cycle of deprivation resulting in low education and employment levels. Thakuriah and Tang (*6*) demonstrate the economic and social benefits of government subsidies to improve transportation services in disadvantaged areas. The authors postulate that these economic benefits include a reduction in unemployment benefits and other government assistance in the long run.

Several studies have been conducted in Australia to examine how social exclusion impacts upon transportation. Australia is a country with low population density and high car ownership levels and very little public transport in rural areas (*8*). These characteristics have resulted in social exclusion due to poor transport accessibility becoming a serious problem. Currie et al (*9*) discuss the concept of forced car ownership. This concept relates to how individuals in deprived areas with low public transport accessibility are forced into multiple car ownership in Melbourne. Engels and Gang-Jun (*10*) conducted a study in Melbourne to determine how social exclusion impacts upon seniors that no longer have driving licenses. The results show that ageing populations are at risk of becoming socially excluded due to poor public transport accessibility. Ireland has several characteristics that are similar to Australia with a large rural population living in low-density areas. McDonagh (*11*) demonstrates how individuals living in rural Ireland are subject to social exclusion due to poor transport accessibility.

The following section of this paper presents the methodology used to examine the impacts of the level of deprivation and the transport characteristics. The third section of the paper presents the descriptive statistics and the maps created to illustrate the settlement patterns in Dublin. The fourth section of the paper presents the multinomial logit model that examines the relationships between a number of

variables and the location in which the individual lives. The paper concludes with a conclusions and discussions section.

METHODOLOGY

This section of the paper describes the methods used to measure the transport patterns of those living in deprived areas in Dublin.

Data

The data used in this study was taken from the 2006 Place of Work Census of Anonymised Records (POWCAR), which was provided by the Central Statistics Office of Ireland. This dataset was collected on the night of Sunday the 23rd of April 2006. The POWCAR dataset contains information on over 1.8 million trips.

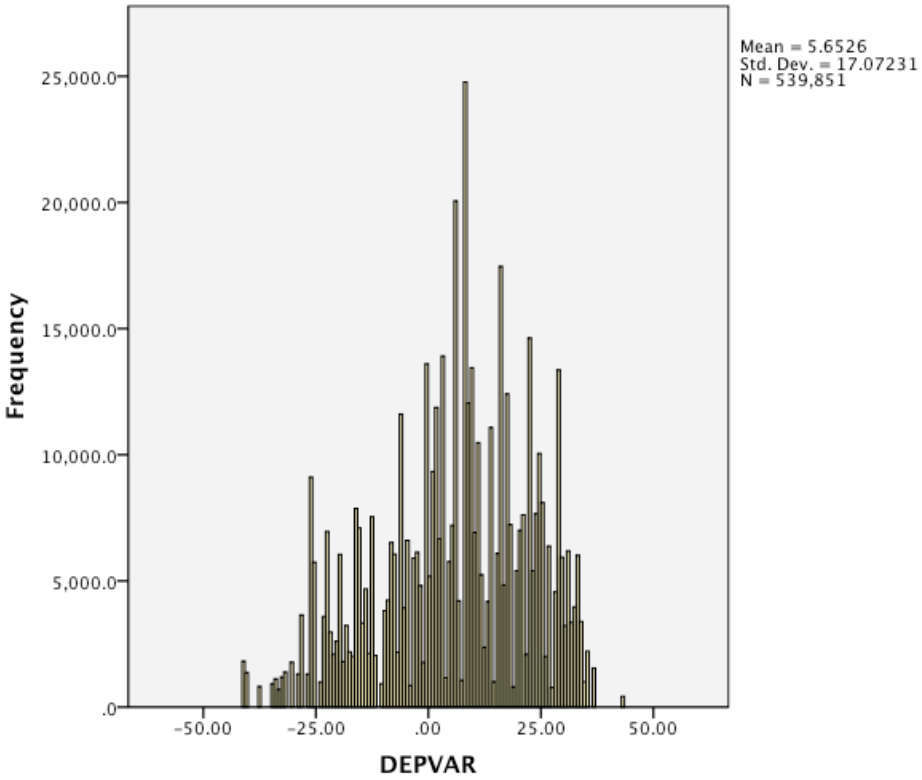
The POWCAR dataset was supplemented with a number of measures for deprivation to determine if living in these areas impacts upon transport patterns. A composite measure of deprivation is used in this study called DEPVAR, which takes into account a number of measures such as:

- Unemployment
- Number of lone parents
- Age dependency ratios
- Highest education level
- Professional classes
- Number of residences per room

The methods used to estimate this DEPVAR are presented in Haase and Pratschke (*12*). Figure 1 details the distribution of the composite deprivation measure DEPVAR in the study area. The DEPVAR varies from negative values (most deprived areas) to positive values (in the most affluent areas). The DEPVAR is categorised into four segments and used in the modelling.

Haase and Pratschke (*12*) conducted a detailed study on levels of deprivation in Ireland over the past twenty years. The clear conclusion from this research is that of an urban-rural divide in terms of deprivation and affluence levels. Indicators of deprivation used included unemployment levels, age dependency rates (number of individuals under 16 and over 65), the lone parent ratio, the proportion of population with only a primary education and the rates of population decline. These measures were combined to provide a simple scale of deprivation ranging from extremely deprived to extremely affluent. While this data loosely follows a normal distribution, outliers representing the most deprived areas were found to occur mainly in isolated rural regions. To date it is the most comprehensive study of deprivation available in Ireland and the only study, which breaks down the measures of deprivation to a localised DED level.

FIGURE 1 Distribution of the DEPVAR in Dublin



The model estimated in this paper examines the impact that the costs of transport and annual emissions have upon those living in deprived areas. The cost variables are estimated using a generalised cost of travel approach. McNamara and Caulfield (*13*) details the methods used to estimate the costs of transport in the Dublin area. An annual emissions variable was also estimated and used in the model presented in this paper. The annual emissions were calculated using modal emissions factors and the methods to calculate these values are detailed in McNamara and Caulfield (*14*) and McNamara and Caulfield (*15*).

Models estimated

To measure the impact that transport characteristics have upon individuals living in deprived areas a multinomial logistic regression model was estimated. The DEPVAR is segmented into four groups as shown in Table 1, ranging from the most deprived areas to the more affluent areas. This segmentation into four groups was conducted by dividing the variable into quartiles. The model takes the following functional form:

Equation 1

$$\text{log it (p)} = \log \frac{p}{1-p} \equiv a + \beta I + \gamma T + e$$

where:

p = probability that event Y (living in the area) occurs,

a = specified option

βI = set of individual specific characteristics

γT = set of trip specific characteristics

e = random error term

The individual specific characteristics include socio-economic grouping and the trip characteristics include distance, emissions, cost and mode of transport. Table 1 defines each of the variables used in the MNL models presented in Table 3.

TABLE 1 Details of variables examined

Variable	Definition
DEPVAR: -12.7 - 1.4	= 1 if DEPVAR: -12.7 - 1.4
DEPVAR: 1.5 - 13.9	= 1 if DEPVAR: 1.5 - 13.9
DEPVAR: 13.9 - 23	= 1 if DEPVAR: 13.9 - 23
DEPVAR: 23+	Reference category = if DEPVAR: 23+
Means of travel: Walk	= 1 if means of travel: Walk
Means of travel: Cycle	= 1 if means of travel: Cycle
Means of travel: Bus	= 1 if means of travel: Bus
Means of travel: Rail	= 1 if means of travel: Rail
Means of travel: Motorcycle	= 1 if means of travel: Motorcycle
Means of travel: Drive – alone	= 1 if means of travel: Drive – alone
Means of travel: Drive – passenger	= 1 if means of travel: Drive – passenger
Means of travel: Lorry or van	Reference category = if means of travel: Lorry or van
Socio-economic group: Employers and managers	= 1 if socio-economic group: Employers and managers
Socio-economic group: Higher professional	= 1 if socio-economic group: Higher professional
Socio-economic group: Lower professional	= 1 if socio-economic group: Lower professional
Socio-economic group: Non-manual	= 1 if socio-economic group: Non-manual
Socio-economic group: Manual skilled	= 1 if socio-economic group: Manual skilled
Socio-economic group: Semi-skilled	= 1 if socio-economic group: Semi-skilled
Socio-economic group: Unskilled	= 1 if socio-economic group: Unskilled
Socio-economic group: Self-employed	= 1 if socio-economic group: Self-employed
Socio-economic group: Farmers	= 1 if socio-economic group: Farmers
Socio-economic group: Agricultural workers	= 1 if socio-economic group: Agricultural workers
Socio-economic group: Other	Reference category = if socio-economic group: Other
Distance travelled: Less than 2KM	= 1 if distance travelled: Less than 2KM
Distance travelled: 3-5 KM	= 1 if distance travelled: 3-5 KM
Distance travelled: 6-10 KM	= 1 if distance travelled: 6-10 KM
Distance travelled: 11-15 KM	= 1 if distance travelled: 11-15 KM
Distance travelled: 16-20KM	= 1 if distance travelled: 16-20KM
Distance travelled: 21KM +	Reference category = if distance travelled: 21KM +
Cost per-trip: Less than €4.30	= 1 if cost per-trip: Less than €4.30
Cost per-trip: €4.40 - €6.80	= 1 if cost per-trip: €4.40 - €6.80
Cost per-trip: €6.90 - €10.00	= 1 if cost per-trip: €6.90 - €10.00
Cost per-trip: €10.10 +	Reference category = cost per-trip: €10.10 +
Annual Emissions: Less than 34.4kg	= 1 if annual Emissions: Less than 34.4kg
Annual Emissions: 34.5kg – 220kg	= 1 if annual Emissions: 34.5kg – 220kg
Annual Emissions: 221kg – 516kg	= 1 if annual Emissions: 221kg – 516kg
Annual Emissions: 517kg +	Reference category = annual Emissions: 517kg +
No. cars per household: No car	= 1 if No. cars per household: No car
No. cars per household: 1 car	= 1 if No. cars per household: 1 car

No. cars per household: 2 cars	= 1 if No. cars per household: 2 cars
No. cars per household: 3+ cars	Reference category = No. cars per household: 3+ cars

DESCRIPTIVE DATA

This section of the paper details the descriptive statistics that define the study area. Table 2 presents a breakdown of the variables used in the MNL models. The total number of observations examined in the results presented in this paper is 333,877. An income variable is not included in this list of variables as this variable is not included in the Census dataset. The first variable described in Table 2 is the DEPVAR. The results show that there is a good distribution between the four categories of the DEPVAR variable. The results for the mode of transport show that 'drive-alone' has the largest mode share in the study area. The results show low modal shares for walk and cycle.

The results for the socio-economic grouping demonstrate a good distribution between each of the groups with the largest percentage of individuals in the non-manual grouping. The results for the distance travelled by the individuals in the sample shows that a third of the sample travel 6-10KM (3.7 – 6.2 miles) to work on a regular basis. The results also show that 35% of the sample travel more than 11KM (6.8 miles) on a daily basis to work. The cost variable was created and split into quartiles. A quarter of the sample pay over €10.10 ($14.55) per trip. The results show that 10% of the sample had no cars per household. 55% of the sample indicated they were in a household with two or more cars available. The results for the emissions variable shows that 60% of the sample emits more than 221kg per-annum.

TABLE 2 Descriptive statistics

Variable		N	%
DEPVAR	-12.7 - 1.4	99,451	30
	1.5 - 13.9	104,186	31
	14 - 23	64,607	19
	24+	65,633	20
	Total	333,877	100
Means of travel	Walk	14,726	4
	Cycle	6,676	2
	Bus	54,724	16
	Rail	31,833	10
	Motorcycle	5,321	2
	Drive - alone	203,086	61
	Drive - passengers	8,799	3
	Lorry or van	8,712	3
	Total	333,877	100
Socio-economic group	Employers and managers	68,964	21
	Higher professional	36,628	11
	Lower professional	53,072	16
	Non-manual	87,495	26
	Manual skilled	31,905	10
	Semi-skilled	25,213	8
	Unskilled	9,985	3
	Self-employed	9,213	3
	Farmers	408	0
	Agricultural workers	375	0
	Other	10,619	3
	Total	333,877	100
Distance travelled	Less than 2 KM	34,755	10
	3-5KM	73,327	22
	6-10KM	111,426	33
	11-15KM	50,866	15
	16-20KM	31,739	10
	21KM+	31,764	10
	Total	333,877	100
Cost per-trip	Less than €4.30	81,018	25
	€4.40 - €6.80	83,314	25
	€6.90 - €10.00	85,037	25
	€10.10 +	84,508	25
	Total	333,877	100
Annual emissions	Less than 34.4kg	39,573	12
	34.5kg – 220kg	93,581	28
	221kg – 516kg	107,923	32
	517kg +	92,800	28
	Total	333,877	100
Number of vehicles per-household	No car	34,842	10
	1 car	115,401	35
	2 cars	140,298	42
	3+ cars	43,336	13
	Total	333,877	100

A number of the variables examined in the multinomial logistic regression model have been presented in a map of the study area. Figure 2 presents the DEPVAR mapped in Dublin in six categories. The results show that the most deprived areas are in the centre of the map (this is the city centre) and the north side of the city. The most affluent areas were shown to be towards the south east of the city. Figure 3

details the average emissions per electoral ward categorised into six categories. The results show, as one would expect, that the lowest annual emissions be in the city centre with the levels of emissions increasing as the distance from the centre increases. The final map presented in the paper details the costs from each of the electoral wards split into six categories (see Figure 4). The results show that, as one would expect due to shorter trip lengths those living in the city centre have the lowest commuting costs. Those living on the north side of the city were shown to have the highest commuting costs.

FIGURE 2 Total deprivation levels in Dublin

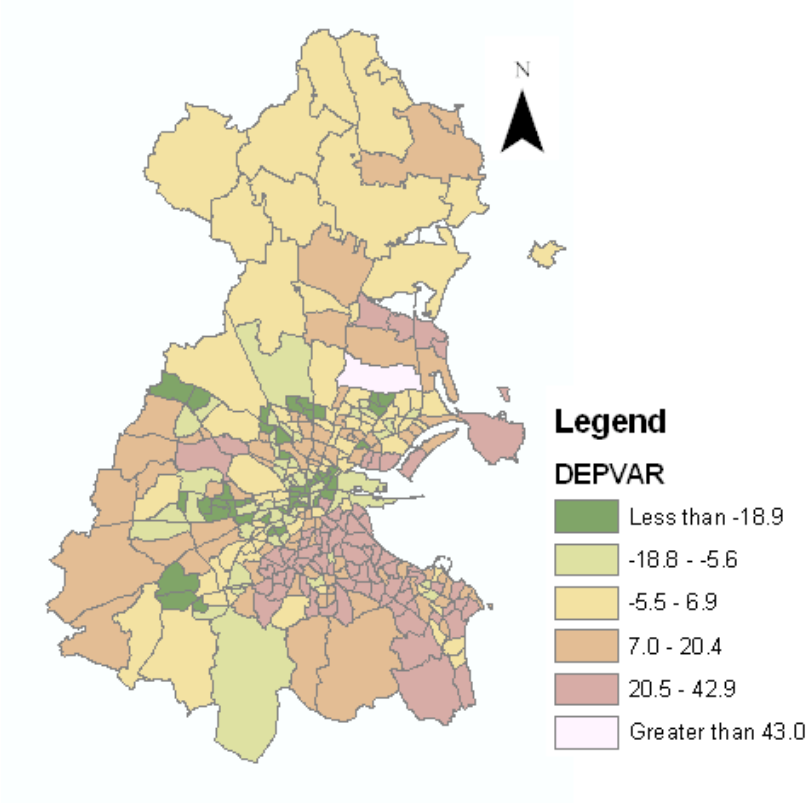


FIGURE 3 Annual emissions in Dublin

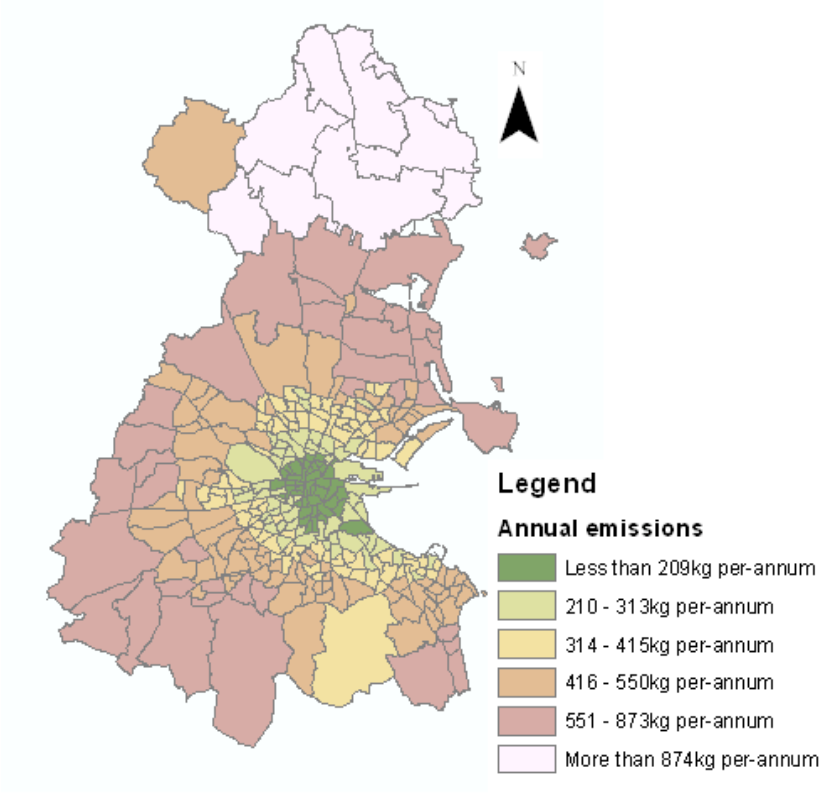
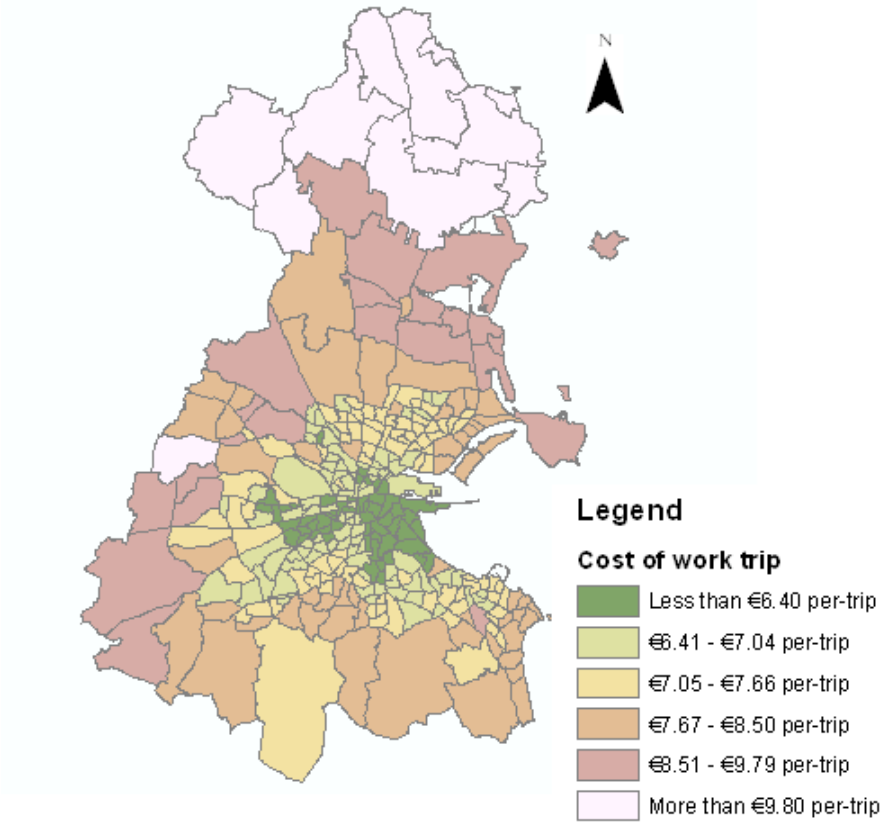
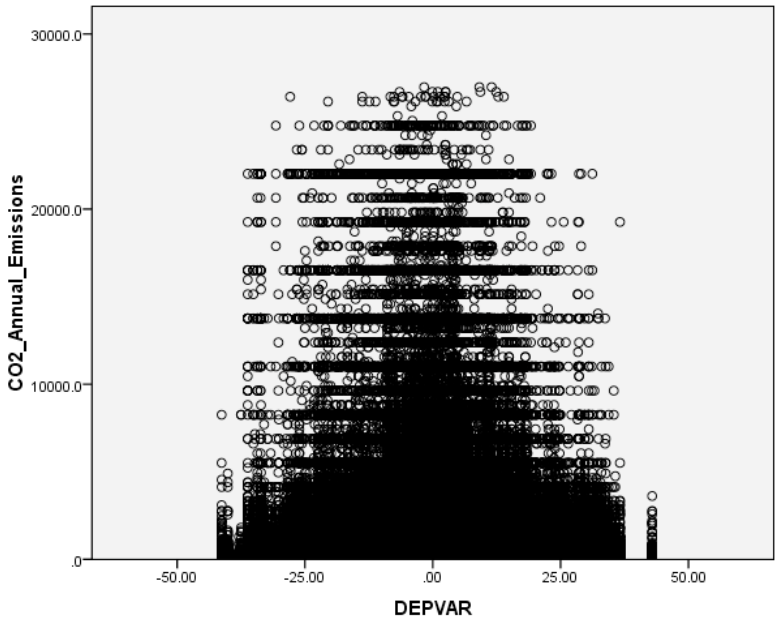


FIGURE 4 Per-trip costs in Dublin



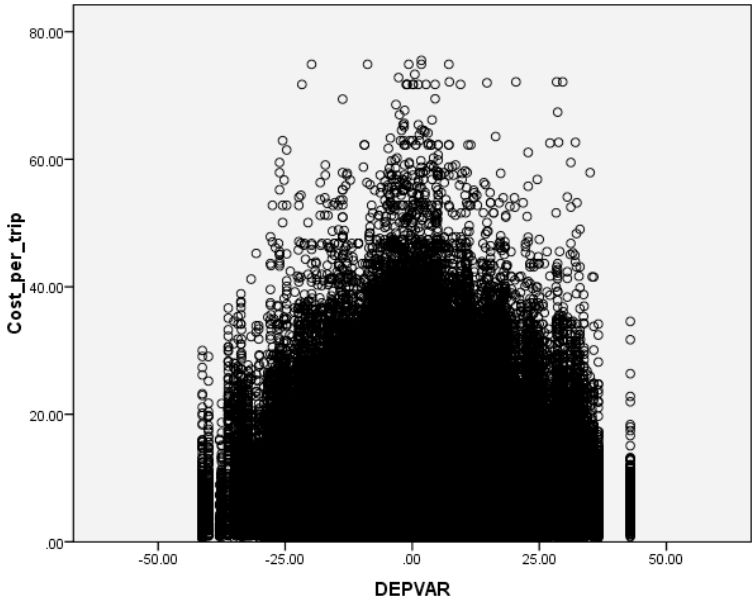
Figures 5 and 6 graph the relationships between the DEPVAR and annual emissions and cost of transport respectively. Figure 5 demonstrates the relationship between the level of deprivation and annual emissions. This result indicates that the relationship between the two variables follows a normal distribution. Figure 6 graphs the relationship between the cost of transport and the DEPVAR. The distribution also follows a normal distribution. Both plots were tested for normality using the Shapiro-Wilk test. The results show that both plots presented in Figures 5 and 6 are normally distributed.

FIGURE 5 Relationship between DEPVAR and annual CO2 emissions



Shapiro-Wilk: p<.000

FIGURE 6 Relationship between DEPVAR and cost of trip



Shapiro-Wilk: p<.000

MODEL RESULTS

Table 3 details the results of the model used to determine the impacts that deprivation and a number of other variables have upon mode choice. The results in the first column relate to coefficients in areas with the greatest level of deprivation in the study. The first set of results examines the relationships between the mode of transport used to travel to work and the deprivation level. The results also show that in more affluent areas individuals are more likely to drive alone to work and less likely to use public transport compared to the individuals living in the most deprived areas of the city. The results for the socio-economic grouping shows that, as one would expect, that in the most deprived areas individuals were more likely to be 'non-manual', 'manual skilled', 'semi-skilled' or unskilled workers. These workers typically have lower incomes. The results for those individuals in the more affluent areas were shown are 'employers and managers' or 'higher professionals', and these groups are more likely to have higher incomes.

The findings for the distance travelled by the individuals' demonstrate that those in more affluent areas were shown to travel the greatest distances to get to work. The opposite result was found for those living in the most deprived areas in Dublin. The results for the cost of transport trips shows that individuals in the more affluent areas were shown to have higher transport costs. This result is as one would expect as individuals living in these areas where shown to travel larger distances.

The results for annual emissions show that individuals living in the more affluent areas of Dublin were shown to have higher emission profiles compared to those living in the more deprived areas of the city. The final result presented in Table 3 examines the car ownership levels. The results show that individuals living in the most deprived areas were more likely to own no cars or one car compared to those living in the more affluent areas as they were shown to have higher car ownership levels.

TABLE 3 MNL Model results

		DEPVAR = -12.7 - 1.4	DEPVAR = 1.5 - 13.9	DEPVAR = 14 - 23
Intercept		1.262**	1.600**	0.559**
Mode of transport	Walk	0.471**	0.404**	0.381**
	Cycle	0.556**	0.488**	0.508**
	Bus	0.436**	0.307**	0.507*
	Rail	0.582**	0.827**	0.496**
	Motorcycle	0.622**	0.346**	0.405**
	Car-drive alone	0.907*	1.066**	1.458**
	Car-Passenger	0.474*	0.304*	0.362**
	Work from Home	0b	0b	0b
Socio-economic group	Employers and managers	-0.728**	0.438**	0.612**
	Higher Professional	-1.04**	0.786**	0.716**
	Lower Professional	-0.58**	0.284**	0.123*
	Non-manual	0.089*	0.212**	-0.101**
	Manual skilled	0.985*	0.835**	-0.116**
	Semi-skilled	0.972**	0.833**	0.376**
	Unskilled	1.342**	1.045**	0.534**
	Own account workers	-0.147**	-0.036**	0.009**
	Farmers	-0.31**	0.574**	0.113**
	Agricultural workers	0.134**	1.198**	0
	Other	0b	0b	0b
Distance travelled	Less than 2KM	0.695**	0.403**	0.345**
	3-5 KM	0.499**	0.589*	0.475**
	6-10 KM	0.382**	0.799**	0.592**
	11-15 KM	0.281**	0.664**	0.705**
	16-20KM	0.201*	0.396**	0.678**
	21KM +	0b	0b	0b
Cost per-trip	Less than €4.30	0.195**	0.055**	0.054**
	€4.40 - €6.80	0.043**	0.109**	0.156**
	€6.90 - €10.00	0.035**	0.128**	0.264**
	€10.10 +	0b	0b	0b
Annual emissions	Less than 34.4kg	0.168**	-0.177**	-0.172**
	34.5kg – 220kg	0.395**	0.256**	0.494**
	221kg – 516kg	0.117**	0.345**	0.341**
	517kg +	0b	0b	0b
Number of vehicles per-household	No car	1.527**	0.551**	0.274**
	1 car	0.969**	0.552**	0.613**
	2 cars	0.167**	0.194**	0.431**
	3+ cars	0b	0b	0b
Number of observations		333,877		
R2		0.234		
-2 log likelihood at convergence		320.23		

** Significant at a 99% level, * Significant at a 95% level, 0b values are set to equal zero because they are redundant

CONCLUSIONS

The results of this paper present a contribution to the field of research social exclusion and transport characteristics. The results of this paper demonstrate that in Dublin there is a clear relationship between the level of affluence in an area and transport characteristics. The results presented in this paper demonstrate that in Dublin, households in more affluent areas are more likely to travel longer distances to travel to work on a regular basis and that these households are responsible for higher emissions.

The results show that in the most deprived areas of Dublin city that individuals' trips are relatively sustainable. Individuals are more likely to travel by sustainable modes and travel shorter distances which in turn results in lower annual emissions. The main difference demonstrated in the results of this paper when comparing those living in affluent and deprived areas are that car ownership levels are considerably lower in the deprived area and these individuals are more likely to travel by more sustainable modes of transport. While this paper provides a good overview of how deprivation impacts transport characteristics. Further study is required in Dublin to show if cost of transport is limiting individuals' participation in social activities.

ACKNOWLEDGEMENTS
The authors would like to thank the Central Statistics Office of Ireland for providing the data for this study.

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