Identifying the characteristics of households with multiple car ownership

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ABSTRACT

This paper examines the characteristics of households with multiple car ownership in Dublin, Ireland. Data from the 2006 Census of Ireland are analysed to ascertain the characteristics of these households. The analysis of multiple car ownership presented herein examines individual specific, transport availability, and household characteristics to provide an indication of the individuals most likely to have access to more than one vehicle. The analysis of multiple car ownership presented in this paper examines both individual specific characteristics and household characteristics to provide an indication of the individuals most likely to have access to more than one vehicle. Understanding the characteristics of households with more than one car is important for many reasons. Ireland, like many countries has recently launched a number of electric vehicle and car sharing schemes. Traditionally these schemes have been aimed at reducing multiple car ownership, therefore it's important to develop an understanding of the households that would most likely give up an extra car and use a car club or an electric vehicle.

The results of this paper show that several factors impact upon multiple car ownership. Factors such as occupation, residential density, household structure, and public transport availability all have significant impacts upon the decision to own more than one car. The findings of the multinomial logistic regression modelling are applied to find an area in Dublin that has high potential for either changing the households' second or third vehicle to an electric car or the use of a car club.

INTRODUCTION

This paper examines the trends in multiple car ownership in Dublin to ascertain what specific factors impact upon these trends. In recent years Dublin, like many other international cities, has seen a dramatic increase in levels of car ownership. One of the interesting factors of this growth in car ownership is the large increase in households with more than one car available. The analysis presented in this paper seeks to determine, through the analysis of a number of explanatory variables, what factors impact upon.

The next section of the paper presents a review of the literature in this field; this is followed with a description of the methodologies used in this paper. The first results section presents a number of descriptive statistics and the second details the results of the multinomial logistic regression modelling. Following the results of the modelling an area is identified in Dublin with the highest multiple car ownership and the potential solutions for reducing high car ownership rates are discussed. The paper concludes with a summary of the main findings and a number of key conclusions.

LITERATURE REVIEW AND BACKGROUND

Over the past 20 years in Ireland the number of registered passenger vehicles has increase by over a million vehicles, which represents a 39% increase in the number of vehicles. Figure 1 below shows the trend of increasing car ownership in Ireland (*1*).

FIGURE 1 Growth in car ownership in Ireland
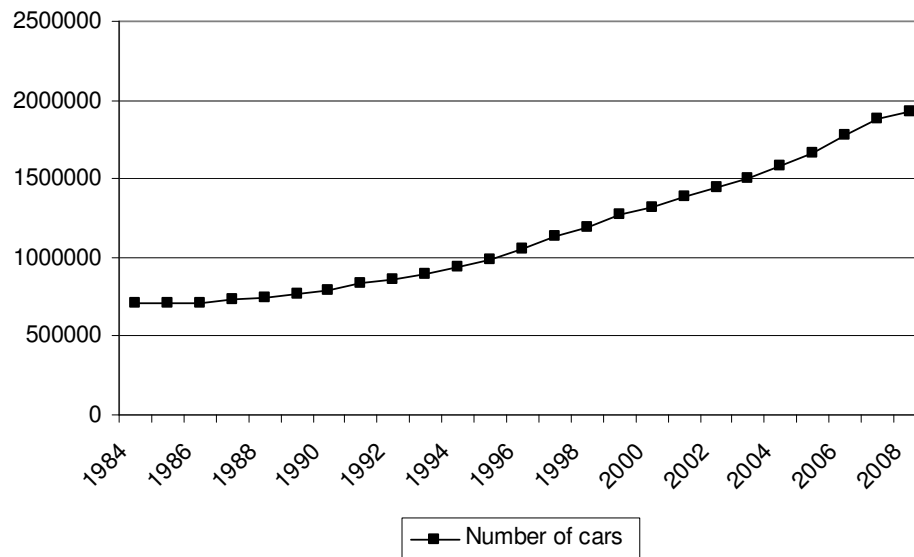
Car ownership rates in Dublin in 2002 and 2006 are presented in Table 1. The results show that between 2002 and 2006 there has been little change in car ownership levels. The findings demonstrate that in both years 37% of households had two cars and 12% have three or more cars.

TABLE 1 Multiple car ownership levels in Dublin

	2002		2006	
	N	%	N	%
One	179,481	38	183,394	36
Two	172,671	37	185,457	37
Three or more	53,865	12	57,882	12
None	64,944	14	76,764	15
Total	470,952	100	503,497	100

Given the rapid growth in car ownership in the past 20 years in Ireland it is not surprising to note that almost 60% of individuals in Ireland drive to work every day. In terms of energy usage, the transport sector in Ireland is responsible for 43% of the final energy demand, and has grown by 181% between 1990 and 2007 (*2*). Also in terms of carbon emissions the transport sector was responsible for 36% of CO_2 emissions in 2007 (*2*).

A number of studies have examined the key factors that result in households owning more than one vehicle. Whelan (*3*) presents a model of car ownership for Great Britain. This model uses the national travel survey, a family expenditure survey and census data to examine what factors can contribute to the growth in car ownership. The results of this study show, as one might expect, that car ownership decisions are based on income, licence holding, employment, and purchase costs. Dargay (*4*) also examines car ownership levels in Great Britain, but focuses on the differences in car ownership in urban and rural areas. The findings of this study demonstrate that urban car owners are more sensitive to changes in motoring costs compared to their rural counterparts. This result suggests that car ownership in rural areas is a greater necessity. The results presented in McDonagh (*5*) concur with this rural/urban gap and highlights the necessity for car ownership in rural Ireland indicating that car ownership is a necessity rather than a luxury in rural areas.

Matas and Raymond (*6*) also found that car ownership was lower in areas with good quality public transport options. Cullinane (*7*) in a study in Hong Kong also found that where individuals had access to good public transport, they were unlikely to purchase a car. Dissanayake and Morikawa (*8*) examined the characteristics that influence car ownership in China and found that distance travelled, age, and the presence of children in the household all impacted upon car ownership decisions. Potoglou and Kanaroglou (*9*) examined the factors that cause households to own more than one car in Hamilton in Canada. The authors found that, as one would expect, as the number individuals per household and income increased, so too did the probability of owning more than one car. Potoglou and Kanaroglou (*9*) also used the number of bus stops in the surrounding area as a proxy variable for public transport availability and found that areas with greater public transport access were more likely to own fewer cars.

One of the objectives of this research is to identify areas with high car ownership and then target these areas for sustainable transport policies that could result in a decrease in multiple car ownership. Car sharing schemes have been found to be very successful in reducing multiple car ownership. Cervero (*10*) demonstrated that since the introduction of CarShare in San Francisco, 29% of members have reduced their car ownership by at least one vehicle. In a survey of members of carsharing schemes in North America it was found that car ownership dropped by 50% (Martin et al 2010). The PhillyCarShare scheme reported similar results with 24.5% of respondents indicating that they had given up at least one vehicle since joining the scheme (*12*).

The use of electric vehicles could also encourage sustainability in car ownership. Due to the limitations of plug-in hybrid electric vehicles (PHEV) it's long been reported that the growth potential of this market is in limited to the second vehicle market (*13*). Axsen and Kurani (*14*) examined the target market for PHEV's in the United States and found that a third of households in this target market had the required infrastructure for charging these vehicles. One method of ensuring greater access to these charging stations is to locate charging points in neighbourhoods. The results of this paper could be used to inform a policy of introducing PHEV charging points.

METHODOLOGY

The census data used in this paper was taken on the night of Sunday, 23rd April 2006 with 1.5 million Irish homes receiving the census forms two weeks before that. The dataset used is called the place of work census of anonymised records dataset (POWCAR) *(15)*. The POWCAR dataset contains information on the regular work trips of 1,834,472 individuals in Ireland. Unfortunately, income levels of respondents are not included in the dataset.

Two multinomial logit regression models were estimated in this research. The choice variables examined in each of the models were the number of cars per household. Three levels of car ownership examine where 'one car available', 'two cars available' and 'three or more cars available'. The first model estimated examined the impact of a number of household and personal characteristics such as age, household composition, and occupation, on multiple car ownership rates. The second model examines the impact the mode of transport used and the proximity to other modes of transport has upon multiple car ownership rates. A description of each of the variables examined is presented in Table 2.

RESULTS AND ANALYSIS

This section of the paper presents a number of descriptive statistics and the results from the multinomial logistic regression modelling. These findings are then used to identify an area in Dublin with high levels of car ownership.

Descriptive statistics
Table 2 contains the descriptive statistics of the population of Dublin and a description of the variables examined in the regression modelling. The number of cars owned per-household segments the descriptive statistics presented in Table 2. The results for the age characteristics demonstrate that younger individuals were shown to be in households with multiple cars. This result would seem to make intuitive sense as these individuals may still be living with their parents, who would most likely also have one or more cars available. The second group of characteristics details the number of resident workers per-household. As one would expect households with greater numbers of resident workers were shown to have more than one car. Household composition was also examined, as one would assume that this variable would have an impact upon the number of cars per-household. The results show that couples with children were more likely to have more than one car.

The occupation of the respondent was also examined to determine what impact an individual's profession has upon the decision to own more than one car. The results show that professionals, employers and managers were more likely to come from households with more than one car. The variable that represents the mode of transport used to travel to work demonstrates, as one would expect, households with two or more cars were shown to have a higher proportion of individuals driving to work. The final three variables examined in this study relate to the area in which the individual lives. The Census data examined in this study is broken down by geographical areas called Dedicated Electoral istricts (DED). The public transport availability variables examine if the respondent lives in a DED that has a rail station and the number of bus stops in the DED. These variables are examined to ascertain if public transport availability impacts upon a household's decision to own more than one car. The final variable examined measures the impact that residential density has upon the decision to own more than one car. The residential density variables range from less than 1,000 individuals per km^2 to more than 12,000 individuals per km^2. The results show that those individuals living in lower density areas were more likely to own more than one car.

TABLE 2 Description of variables used in the logit regression modelling

		Population		One car		Two cars		Three or more cars	
		N	%	N	%	N	%	N	%
Age	15-24	70,652	14	20,468	11	18,857	10	13,274	23
	25-34	174,409	34	63,587	35	56,989	31	17,641	30
	35-44	116,611	23	45,184	25	51,035	28	5,537	10
	45-54	92,482	18	32,149	18	37,304	20	12,582	22
	55+	58,826	11	22,006	12	21,272	11	8,848	15
Household composition	Single person	47,338	9	30,883	17	1,522	1	266	0
	Lone parent 1 child < 19	27,400	5	13,976	8	4,474	2	1,770	3
	Lone parent 1 child >19	21,879	4	8,838	5	6,283	3	2,071	4
	Couple with 1 child <19	165,364	32	49,558	27	86,898	47	19,524	34
	Couple with 1 child > 19	61,365	12	13,452	7	23,480	13	20,406	35
	Couple – no children	85,942	17	35,020	19	37,001	20	1,500	3
	Other households	103,692	20	31,667	17	25,799	14	12,345	21
Occupation	Employers and managers	90,296	18	29,190	16	41,972	23	11,245	19
	Higher professional	51,323	10	18,215	10	21,647	12	5,869	10
	Lower professional	76,228	15	27,996	15	29,531	16	8,233	14
	Non-manual	146,392	29	52,892	29	47,847	26	16,558	29
	Manual skilled	43,325	8	16,182	9	14,225	8	6,007	10
	Semi-skilled	42,086	8	16,470	9	10,625	6	3,440	6
	Unskilled	18,729	4	6,959	4	3,335	2	1,219	2
	Own account workers	18,877	4	6,251	3	8,628	5	2,830	5
	Farmers	838	0	211	0	357	0	203	0
	Agricultural workers	604	0	225	0	152	0	72	0
	Other	24,282	5	8,803	5	7,138	4	2,206	4
Means of travel to work	Walk	70,080	14	26,026	14	11,000	6	3,365	6
	Cycle	20,602	4	9,062	5	3,958	2	954	2
	Bus	76,816	15	29,064	16	14,028	8	4,477	8
	Rail	39,534	8	16,133	9	11,397	6	3,113	5
	Motorcycle	6,607	1	3,313	2	1,660	1	474	1

	Car – driver	260,754	51	83,558	46	131,006	71	41,439	72
	Car – passenger	19,977	4	9,706	5	5,448	3	1,917	3
	Other means	1,028	0	401	0	235	0	103	0
	Work from home	8,218	2	2,636	1	3,880	2	1,175	2
	NA	9,364	2	3,495	2	2,845	2	865	1
Rail available	No	407,629	79	146,070	80	149,063	80	46,975	81
	Yes	105,351	21	37,324	20	36,394	20	10,907	19
Bus stops per DED	None	115,984	23	41,470	23	43,654	24	13,792	24
	1-5 stops	178,111	35	66,078	36	59,058	32	19,367	33
	6-10 stops	120,903	24	41,443	23	45,625	25	14,469	25
	11-20 stops	48,259	9	16,870	9	17,856	10	5,472	9
	21 + stops	49,723	10	17,533	10	19,264	10	4,782	8
Residential density	Less than 1000 per km^2	58,183	11	18,711	10	26,236	14	8,346	14
	1001-3000 per km^2	129,864	25	44,917	24	53,419	29	17,045	29
	3001-6000 per km^2	228,171	44	83,296	45	87,704	47	27,483	47
	6001 - 9000 per km^2	67,057	13	26,596	15	15,085	8	4,394	8
	9001 – 12000 per km^2	21,680	4	7,936	4	2,664	1	522	1
	12001 + per km^2	8,025	2	1,938	1	349	0	92	0

Results of the multinomial logistic regression models
The results of the estimated multinomial logistic regression models are presented in Tables 3 and 4. Two models were estimated to examine the factors that impact upon an individual's car ownership decisions. The descriptive statistics presented in Table 2 are used in the models estimated in Tables 3 and 4. The first model presented in Table 3 details the impact that household characteristics have upon car ownership decisions. The second model in Table 4, examines the impact that several transport availability and location characteristics have upon multiple car ownership. The results for the age variables, in Table 3, demonstrate that those in the lower age brackets were more likely to be from households with fewer cars available. Individuals aged 35-44 were shown to be most likely to be from households with two or three or more cars. The second set of variables related to household structure examines how household composition impacts upon the number of cars available. The findings demonstrate that single persons and lone parents, as expected, are most likely to own one car. Couples with children were shown to be most likely to have multiple cars available. Couples with resident children older than 19 where shown to be most likely to have three or more cars available. Presumably this high probability is because the resident children have purchased a car.

The occupation groupings of the population are examined to ascertain the impact economic status has upon the number of cars per-household. The results show that employers and managers, higher and lower professionals and non-manual workers were found to be more likely to have more than one car available. The opposite result was found for non-skilled and skilled workers as they were shown to be less likely to have multiple cars available.

The second model presented in Table 4 examines how transport availability impacts on multiple car ownership. The results for the mode of transport used to travel to work, as one would expect, demonstrated that those with two or three or more cars available where shown to be more likely drive alone to work over any other mode of transport. The results also show that those individuals with more that one car available were unlikely to walk or cycle or to use public transport.

The model presented in Table 4 examines what impacts public transport availability and urban density has upon a household's decision to own multiple cars. The first variable measures the impact of rail availability on the decision to own multiple cars. The rail availability coefficient demonstrates that households without access to a rail station are more likely to own a car or multiple cars. The second set of public transport availability variables examine the impact of the number of bus stops per DED has upon the decision to own multiple cars. The results show that in areas with a larger number of bus stops individuals are more likely only own one car. The final set of variables estimated measure the impact of urban density on the number of cars per-household. As one would expect individuals living in high-density areas were less likely to own multiple cars. The results also show that households with two or three or more cars were shown to live in low density areas.

TABLE 3 The impact of household characteristics on multiple car ownership

	One car available	Two cars available	Three or more cars available
Intercept	.281**	-.113**	-.951**
Age			
15-24	-.948**	-.345	-.514
25-34	-.581**	-.681	-.735
35-44	-.293**	-1.305	-1.277
45-54	-.255**	-.236	-.255
55+	0[b]	0[b]	0[b]
Household composition			
Single person	.383**	-2.462	-3.331
Lone parent 1 child < 19	.766**	-.110	-.223
Lone parent 1 child >19	.626**	.513	.184
Couple with 1 child <19	1.719**	2.452	1.920
Couple with 1 child > 19	1.354**	2.141	2.692
Couple – no children	.830**	1.015	-1.301
Other households	0[b]	0[b]	0[b]
Occupation			
Employers and managers	.922**	1.602	1.800
Higher professional	.922**	1.469	1.587
Lower professional	.670**	1.042	1.093
Non-manual	.235**	.378	.455
Manual skilled	.509**	.577	.841
Semi-skilled	-.109**	-.384	-.363
Unskilled	-.497**	-1.067	-.955
Own account workers	1.379**	2.071	2.416
Farmers	.834**	1.750	2.592
Agricultural workers	.173**	.046	.398
Other	0[b]	0[b]	0[b]
Number of cases	503,497		
R-squared	.350		
Log likelihood	1183.3		

** Significant at 1%, * Significant at 5%

TABLE 4 The impact of transport characteristics on multiple car ownership

	One car available	Two cars available	Three or more cars available
Intercept	-1.456**	-3.211**	-3.303**
Means of travel to work			
Walk	-.456**	-1.020**	-1.993**
Cycle	-.150*	-.728*	-1.957**
Bus	-.528**	-1.051**	-.998**
Rail	.085**	-.085**	-.185**
Motorcycle	.496**	-.023**	-.082**
Car – driver	3.700*	4.317**	4.364**
Car – passenger	.643**	.217**	.369**
Other means	1.550**	2.564**	2.854**
Work from home	-.213**	-.577**	-.201*
NA	0[b]	0[b]	0[b]
Rail available			
No	.266**	.323**	.386*
Yes	0[b]	0[b]	0[b]
Bus stops per DED			
None	.196**	.194**	.472**
1-5 stops	.201*	.161**	.480**
6-10 stops	.335**	.191**	.172**
11-20 stops	.233**	.024**	.052**
21 + stops	0[b]	0[b]	0[b]
Residential density			
Less than 1000 per km^2	2.117**	3.870**	4.099**
1001-3000 per km^2	1.988*	3.648*	3.892*
3001-6000 per km^2	1.898**	3.461**	3.697**
6001 - 9000 per km^2	1.262**	2.314**	2.441**
9001 – 12000 per km^2	.809**	1.410**	1.146*
12001 + per km^2	0[b]	0[b]	0[b]
Number of cases	503,497		
R-squared	.332		
Log likelihood	-1478.251		

** Significant at 1%, * Significant at 5%

IDENTIFYING AN AREA WITH HIGH CAR OWNERSHIP

This section of the paper examines an area identified in Dublin with high car ownership rates to explore potential options for reducing the need for a second and third car. The average car ownership rates in Dublin are presented in Table 4. Dublin is split into four administrative areas, Dublin City, South Dublin, Fingal and Dun Laoghaire-Rathdown. The area identified was selected due to the large car ownership levels. Table 5 details the average car ownership per household for each of the administrative areas and the chosen study area. The study area was chosen as it had the highest car ownership rate. As shown in Table 5, the study area identified has a population of 41,515 and an average car ownership of 1.84 cars per household. The

results show that average car ownership in the study area was 25% higher than the county average.

TABLE 5 Comparison of car ownership rates in Dublin

Region	Population	Average car ownership per household	Comparison to the county average
Dublin (Total)	503,497	1.47	-
Dublin City	210,054	1.15	-22%
South Dublin	106,054	1.70	+16%
Fingal	107,687	1.67	+14%
Dun Laoghaire-Rathdown	79,644	1.72	+17%
Study Area	41,515	1.84	+25%

Table 6 examines the descriptive statistics of the study area. The results in Table 6 also compare the results of the study area to the descriptive statistics for the Dublin area to provide an indication what factors in the study area impact upon the increase levels of car ownership in this area.

The results show that in the study area individuals tended to be marginally older compared to the Dublin average. The difference in household composition shows that households in the study area have a higher percentage of resident workers and tend to be couples with and without children. A greater percentage of individuals in the study area were shown to drive or take a train to work compared to the Dublin average. Data showed that 54% of individuals in the study area have access to a rail station compared to 21% of the rest of the Dublin area. The number of individuals with access to bus stops in the study area was shown to be less than of the rest of Dublin. This is an interesting finding in that the area examined is relatively well serviced by public transport, but there is still high car ownership. Finally, the population density of the study area was also shown to be considerably less than the rest of Dublin.

TABLE 6 Descriptive statistics of the study area

		N	%	%	% difference
Age	15-24	4306	10	14	-4
	25-34	12131	29	34	-5
	35-44	10693	26	23	+3
	45-54	8859	21	18	+3
	55+	5526	13	11	+2
Number of resident workers	0	-	-	11	-11
	1	2750	7	26	-19
	2	10006	24	48	-24
	3	8817	21	10	+11
	4+	19749	48	5	+43
Household composition	Single person	2750	7	9	-2
	Lone parent 1 child < 19	1403	3	5	-2
	Lone parent 1 child >19	1322	3	4	-1
	Couple with 1 child <19	17475	42	32	+10
	Couple with 1 child > 19	5949	14	12	+2
	Couple – no children	7716	19	17	+2
	Other households	4900	12	20	-8
Occupation	Employers and managers	9579	23	18	+5
	Higher professional	4087	10	10	-
	Lower professional	6579	16	15	+1
	Non-manual	10200	25	29	-4
	Manual skilled	3201	8	8	-
	Semi-skilled	2342	6	8	-2
	Unskilled	796	2	4	-2
	Own account workers	1998	5	4	+1
	Farmers	390	1	0	+1
	Agricultural workers	238	1	0	+1
	Other	2105	5	5	-
Means of travel to work	Walk	1875	5	14	-9
	Cycle	520	1	4	-3
	Bus	2670	7	15	-8
	Rail	5952	15	8	+7
	Motorcycle	393	1	1	-
	Car – driver	24987	63	51	+12
	Car – passenger	1453	4	4	-
	Other means	102	0	0	-
	Work from home	958	2	2	-
	NA	505	1	2	-1
Rail available	No	19122	46	79	-33
	Yes	22393	54	21	+33
Bus stops per DED	None	22440	54	23	+31
	1-5 stops	15810	38	35	+3
	6-10 stops	-	-	24	-24
	11-20 stops	3265	8	9	-1
	21 + stops	-	-	10	-10
Residential density	Less than 1000 per km^2	16333	39	11	+28
	1001-3000 per km^2	22979	55	25	+20

3001-6000 per km^2	2203	5	44	-39
6001 - 9000 per km^2	-	-	13	-13
9001 – 12000 per km^2	-	-	4	-4
12001 + per km^2	-	-	2	-2

CONCLUSIONS

Increasing car ownership levels is a global problem. One of the greatest areas of growth in car ownership is in households purchasing additional vehicles. The results of this paper show that several factors impact upon a household's decision to own multiple cars. The results presented in this paper show that in Dublin 49% of households have two or more vehicles and this increases to 66% in the study area. These high figures detail the extent of the problem in Dublin.

The results of the analysis presented in this paper demonstrate that several factors impact upon the number of cars owned. As one would expect factors such as the number of resident workers, the age of the individual and the household composition all impacted upon the number of cars available. The occupation of the respondent didn't have as significant an impact as one would have thought. The results demonstrated it was not just the individuals in the higher paid occupations that were disposed to multiple car ownership. The availability of public transport options was also shown to impact upon car ownership. In the study area despite 54% of the population having access to a rail station, car ownership levels were still found to be high. This result may be due to a number of issues with the areas serviced by the rail station or other factors such as household composition being more important.

The results presented in this paper go some way to explaining the factors that impact upon multiple car ownership. Understanding the factors that contribute to high vehicle ownership levels is important when implementing policies to reduce these high levels of ownership. Also identifying areas of high vehicle ownership can help with the planning and success of sustainable transport schemes such as electric car charging stations and car clubs.

REFERENCES

1. Central Statistics Office. *Transport 2008*. Dublin. 2009
2. Sustainable Energy Ireland. *Energy in Transport: 2009 Report*. Dublin. 2009
3. Whelan, D. Modelling car ownership in Great Britain. *Transportation Research Par A*. Vol 41. 2007. pp 205-219
4. Dargay, J.M. Determinants of car ownership in rural and urban areas: a pseudo-panel. *Transportation Research Part E*. Vol 38. 2002. pp351-366
5. McDonagh, J. Transport policy instruments and transport related social exclusion in rural Ireland. *Journal of Transport Geography,* Vol 14. 2006. pp355-366
6. Matas, A. Raymond, J. Changes on the structure of car ownership in Spain. *Transportation Research Part A*. Vol 42. 2008. pp187-202
7. Cullinane, S. The relationship between car ownership and public transport provision: a case study of Hong Kong. *Transport Policy*. Vol 9. 2002. pp29-39

8. Dissanayke, D. Morkawa, T. Investigating household vehicle ownership, mode choice and trip sharing decisions using a combined revealed/stated preference Nested Logit Model: case study in Bangkok Metropolitan Region. *Journal of Transport Geography.* Vol 18. 2010. pp 402-410

9. Potoglou, D. Kanaroglou, P.S. Modelling car ownership in urban areas: a case study of Hamilton, Canada. *Journal of Transport Geography.* Vol 16. 2008. pp42-54.

10. Cervero, R. Golub, A., Nee, B. City CarShare: Longer-term travel demand and car ownership impacts. In *Transportation Research Record: Journal of the Transportation Research Board. No. 2139.* Transportation Research Board of the National Academies, Washington D.C., 2007, pp. 70-80

11. Martin, E., Shaheen, S., Lidiker, J. Carsharings impact on household vehicle holdings: Results for a North American shared-use vehicle survey. Presented at 89th Annual Meeting of the Transportation Research Board, Washington D.C., 2010

12. Lane, C. PhillyCarShare: First-year social and mobility impacts of carsharing in Philadelphia, Pennsylvania. In *Transportation Research Record: Journal of the Transportation Research Board. No. 1927,* Transportation Research Board of the National Academies, Washington D.C., 2005, pp. 158-166

13. Collantes, G. Sperling, D. The origin of California's zero emission vehicle mandate. *Transportation Research Part A.* Vol 42. 2008. pp 1302-1313

14. Axsen, J. Kurani, K. Early U.S. Market for plug-in hybrid electric vehicles: Anticipating consumer recharge potential and design priorities. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2139,* Transportation Research Board of the National Academies, Washington D.C. 2009. pp 64-72

15. Central Statistics Office. *Census of population of Ireland 2006, Place of Work, Census of Anonymised Records (POWCAR) Users Guide.* Dublin. 2007