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Abstract: This paper considers travel mode choice for a range of journey purposes in Ireland using micro-data for 2009. Results suggest that demographic and socio-economic variables, location and public transport availability are important determinants of mode choice. The results also indicate an attachment to the car as a mode of transport for non-commuting journeys when available, and especially when used regularly for work journeys. Importantly, the determinants of mode choice are found to differ across journey purposes suggesting that it is not valid to generalise the results from studies considering only one journey purpose.

Key words: Mode choice; travel purpose; model comparison.
JEL Classification: R41; C25; D12.

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1.0 Introduction

It is widely recognised that climate change, because of its wide ranging impacts, is one of the most challenging issues facing the world today. The transport sector accounts for 15 per cent of greenhouse gas (GHG) emissions and CO2 emissions from transport are expected to grow by 40 per cent between 2007 and 2030 unless effective policies to reduce these emissions are introduced (International Transport Forum, 2010). Given that personal transportation in developed countries accounts for around two thirds of CO2 emissions from transport (International Transport Forum, 2010) it is not surprising that there has been an increasing focus on designing appropriate policy measures to reduce the emissions from personal transportation.

In order to design effective policies it is important to understand the determinants of travel behaviour and a key aspect of the sustainability of transport patterns is mode choice. This paper aims to analyse the factors that determine mode choice for commuting and non-commuting (i.e., shopping, education, *etc*.) travel in Ireland.

There are a number of reasons why an analysis of mode choice for Ireland is particularly interesting. While Ireland will meet its Kyoto target for the period 2008 to 2012 primarily due to the decreased level of economic activity resulting from the extended recession, emissions from non-Emissions Trading System (ETS) sources that include transport will exceed their allocated share (Curtis 2012). Furthermore, achieving targets for 2020, which encompass a reduction of non-ETS emissions by 20 per cent compared to 2005 levels, will be more challenging and current projections suggest that emissions may actually grow (Curtis, 2012). Emissions from transport are expected to be the key

contributor to this growth in emissions[1]. Personal transport accounts for approximately two thirds of fuel use in Ireland and this has increased by over 100 per cent between 1990 and 2011 (Sustainable Energy Authority of Ireland, 2012). Car ownership has increased by 135 per cent between 1990 and 2010 and while little is known about trends in non-commuting travel patterns for Ireland, for commuting journeys the proportion driving to work steadily increased while the proportions using most other forms of transport to work have decreased[2]. Consequently, effective policy measures are required in Ireland to improve the sustainability of transport patterns and such measures need to be based on an understanding of the underlying behavioural drivers.

An extensive international literature has considered mode choice, usually employing discrete choice modelling techniques (see Ben Akiva and Lerman 1985, McCarthy, 2001, Koppelman, 2008). This literature has focused primarily on commuting journeys (Asensio, 2002; De Palma and Rochat, 2000; Salon, 2009), but a number of papers have also considered other journey purposes such as shopping (Bhat, 1998), education (Ewing et al., 2004; Yarlagadda and Srinivasan, 2008), and leisure (Ohnmacht et al 2009).

To date research on Irish personal transport patterns has focused largely on commuting behaviour. For example Commins and Nolan (2010, 2011) found household composition, public transport availability, journey time and work location to significantly affect commuting patterns. Excess commuting in the Dublin region has been found to be

[1] Emissions from transport are projected to grow by 44% between 2009 and 2030 (Curtis, 2012).
[2] Data based on CSO census 1981, 1986, 1991, 1996, 2002, 2006 and CSO National Travel Survey 2009. Available from www.cso.ie.

greater for commuters using private modes rather than public transport (Murphy, 2009)[3] and Vega and Reynolds-Feighan (2009) identify the importance of travel time in commuting modal choice in the Dublin region[4]. This body of research, while providing important insights into the determinants of commuting mode choice decisions, ignores a significant proportion of trips, as commuting accounts for just 24 per cent of total trips in Ireland in 2009 as reported in the National Travel Survey (CSO, 2011). The most common purposes were 'shopping, food or drink', which comprised 25 per cent of trips, and 'visiting family/friends and social' purpose, which accounted for a further 16 per cent[5].

This paper utilises a discrete choice model to examine the influence of demographic, socio-economic and supply-side characteristics on individuals' mode choices for a number of journey purposes namely work (commuting); travelling to school or education; travelling to a shop, restaurant or public house; visiting family, friends and other social occasions; personal business; companion journeys to school or other education; and other companion journeys. Tests are then carried out to check if the factors determining mode choice differ across journey purposes.

We find that the determinants of mode choice vary by journey purposes, which implies that it is not valid to generalise the results from an analysis of commuting mode choice to other journey purposes.

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[3] Murphy (2009) defines excess commuting as a level of commuting that exceeds the minimum level of commuting possible if individuals commuted to their closest employment location.

[4] Other papers on commuting in Ireland include Horner, 1999, Morgenroth, 2001, Keane, 2003, Walsh et al. 2006 and Vega and Reynolds-Feighan, 2009.

[5] These proportions are similar to those found in other countries. For example in the UK in 2010 16 per cent of trips were commuting trips and a further 3 per cent were for business purposes (Department for Transport, 2011) and in Germany in 2008 the respective proportions were 14 per cent and 7 per cent (Infas, DLR 2010).

The paper is organised as follows. Section 2 gives details of the methodology that is employed, section 3 outlines the data that is used for the analysis and empirical results are presented in section 4. Section 5 provides a discussion and conclusion.

2.0 Methodology

The decision of how to travel can be modelled as a discrete choice model. In this paper we use a multinomial logit (MNL) model. For any journey an individual must choose between a set of alternative transport modes. There are *n* different transport modes, generating a set of *J=n* alternatives faced by an individual. Discrete choice models are usually based on the assumption of utility-maximising behaviour. The unobserved utility of the individual *i* is a function of the attributes of the alternatives (z_{ij}) and characteristics of the individual (x_i) and an error term, as follows:

$$U_{ij} = x_i\alpha_j + z_{ij}\beta + \epsilon_{ij} \quad (1)$$

An individual *i* chooses the alternative *j* that gives the highest utility among all possible alternatives.

A key choice in estimating a multinomial logit model is in deciding the alternatives of the dependent variable. In our model of mode choice the dependent variable comprises seven alternatives: car driver; car passenger; walk; bus; rail; cycle; van/lorry/other. We first estimate two MNL models, one for commuting trips and the other for non-commuting trips (i.e., aggregating all non-commuting journey purposes), and test whether the model parameters differ across commuting and non-commuting journeys. We then estimate MNL

models separately for each journey purpose and once again test for significant differences in model parameters across the various purposes[6].

A key assumption of the MNL is the Independence of Irrelevant Alternatives (IIA). This property means that the ratio of the probabilities of choosing two alternatives is independent of the introduction of another alternative (Greene, 2012). We test for IIA using the Hausman test but are unable to reject the null hypothesis and thus cannot validate whether the models satisfy the IIA property. Testing for IIA is problematic, and Long & Freese (2006) instead point to the discretion of the econometrician in choosing MNL over the tests. Furthermore, Cheng and Long (2007) show using Monte Carlo simulations that the commonly used tests for the IIA assumption over-reject IIA. Given that the alternatives in our model are sufficiently distinct and comprehensive as they encompass all possible choices we believe that MNL estimation is valid. Furthermore, while alternative methods such as the nested or mixed logit are becoming increasingly common in the literature, they require detailed information on the attributes of the alternatives (e.g., travel time), which is not available in our data.

3.0 Data

This paper utilises micro-data from a special module of the Irish Quarterly National Household Survey (QNHS). The Quarterly National Household Survey (QNHS) is a large-scale, nationwide survey of households in Ireland. It is designed to produce quarterly labour force estimates. The QNHS also conducts special modules on different social topics each quarter. The module conducted in the fourth quarter of the 2009 QNHS was the pilot

[6] We combined travelling to school or education with companion journey to school or education and also with other companion journeys, giving six separate MNL models.

National Travel Survey (NTS). The NTS surveyed one randomly selected person, aged 18 years and over, from 7,245 households (in total, 7,221 adults responded). The NTS data was collected by issuing participants with a travel diary in which they recorded their travel details for a randomly assigned travel reference day. The 24 hour reference period commenced at 4 am on the nominated day and finished at 3.59 am the following morning. After the travel reference day, these individuals were contacted by QNHS interviewers and either interviewed in person or by telephone to complete the survey questionnaire. Only travel within the island of Ireland, made by residents of the state, was included in the survey.

The NTS differs from the main existing source of micro-data on Irish travel patterns which has been used in research on commuting patterns, the Place of Work Census of Anonymised Records (POWCAR) from the 2006 Census of Population (COP) in a number of respects. Firstly, non-commuting journeys are included. Secondly, as a result, the composition of the NTS sample is wider, including students, unemployed, retired and those on home duties in addition to those in employment. However, only adults aged 18+ years were surveyed. Thirdly, in the NTS the journey purpose 'work' includes both commuter and business travel while the POWCAR data does not include business travel. The NTS does however exclude business travel of professional drivers and those whose role involves much travel (such as bus and taxi drivers and postal delivery workers).

Table 1 presents details on the share of total journeys by purpose and the main modes of transport for each purpose. Both the average number of daily journeys and the median is four; therefore, it is important to correct the standard errors for clustering at the individual level. Travel for work is an important journey purpose, comprising 24 per cent

of total journeys. Travel for shopping, food or drink purposes comprises a slightly larger proportion of total journeys at 25 per cent Car driving is the most popular mode of transport for all purposes, in particular for work and companion purposes.

Table 1: Journey Purpose by Main Mode %

	Work	School/ Educ.	Shop Food Drink	Visit Family Friends & Social	Personal Business	Comp. School/ Educ.	Comp. Other	Other	Total
Car Driver	73%	44%	61%	58%	65%	83%	81%	53%	65%
Car Passenger	3%	9%	12%	15%	12%	2%	7%	11%	9%
Walk	8%	13%	21%	16%	16%	13%	7%	31%	16%
Bus	4%	24%	3%	4%	2%	1%	1%	2%	3%
Rail/DART/ LUAS	2%	3%	0%	1%	1%	0%	0%	0%	1%
Bicycle	2%	3%	1%	0%	1%	0%	0%	1%	1%
Van/Lorry/ Other	8%	3%	2%	5%	3%	1%	3%	2%	4%
Share of Total Journeys %	24%	2%	25%	16%	10%	9%	4%	10%	100
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: Educ. Refers to travel to college and other education purposes, and Comp. Refers to companion journeys.

The survey collected details on the availability and use of public transport, bicycles and vehicles (cars/vans). The public transport options vary throughout Ireland; bus is the main form of public transport, rail is more limited in location and routes, DART is a coastal suburban rail line serving Dublin and north County Wicklow, and Luas is a tram system serving two routes in Dublin. For each journey, specific details relating to each

journey and each stage of the journey are included such as its origin and destination, purpose, main mode[7], distance travelled and travel time.

Importantly the dataset provides extensive information on the demographics and socio-economic characteristics of the household and the individual, relating to age, sex, household composition and economic status. While the quality of the survey responses appears high and there are few missing responses, data relating to educational attainment included is not recorded well as respondents were given an option to indicate that they were 'over 65' resulting in no education information to be collected for this group.

A potential limitation to the NTS data is that the travel diaries relate to the period October 2009 to January 2010. Besides the usual seasonal variations that apply, that particular period included some extreme weather that led to school closures and traffic disruption in some parts of the country. As the travel date is not recorded it is not possible to capture this effect. Observations with no daily journeys were excluded as were observations relating to journeys made outside of Ireland, and in total 8 percent of observations were excluded under these criteria.

For the purpose of this study, mode choice (with seven alternatives) is the dependent variable. The set of explanatory variables used in the analysis is limited by the variables in the dataset, with the main limitation being the absence of any variables relating to the attributes of the alternatives. However, the data contain a rich set of characteristics for each individual as well as information on the journey, mode availability and location. In terms of individual characteristics, variables relating to age, sex, family composition and economic status are included. Based on the outcomes of previous

[7] Main mode, where multiple modes are used, is recorded as mode used for the greatest distance. If two or more modes have equal distance the mode used first is recorded.

research (Pooley, et al., 2010; Commins and Nolan, 2011) we expect household composition to have an effect on mode choice, for example Commins and Nolan (2011) report couples with young children are significantly less likely to walk, cycle or take public transport to work.

We include a number of variables relating to vehicle availability (car, bicycle) and public transport availability (bus; train; DART/LUAS). Research has also found that the growth in car ownership and car use is a reflection of the limited availability of public transport services (see Vega & Reynolds-Feighan, 2008). Therefore, we expect the availability of public transport modes to increase the probability of these modes being chosen and therefore include a variable for the availability of bus, mainline train, DART and Luas to help capture the effect for highly urbanised areas. In addition the time of travel has been found to be an important factor in journey planning (Lee, et al., 2010), but also in terms of frequency of public transport services (Kamruzzaman & Hine, 2012), and so we include variables relating to travel during the morning and evening peak periods (7am to 9am and 5pm to 7pm).

In addition, a dummy variable for commuting by car is included in the model for non-commuting journeys only and a dummy variable for free work parking is included in the commuting journeys model only. We also include continuous variables for journey distance and journey distance squared. Finally, dummy variables for urban dwellers are included, as is a dummy variable for residents of Dublin, the capital city. It has been argued that those resident in compact urban areas favour active transport as travel distances tend to be shorter (Maat & Timmermans, 2009). Dublin is included as a separate dummy to the urban dummy in order to capture the extra effect of living in the capital city,

with higher densities of shops, other businesses, pedestrianised areas and bus and cycle lanes.

Other available variables, for example education, dwelling unit occupancy, economic sector, were tested but dropped from the final analysis due to insignificance (results available on request from the authors). A frequent finding in the literature is that high income households prefer travel by car (Sohn & Yun, 2009; Hensher & Rose, 2007), and as income rises the probability of choosing public transport modes decreases (Hensher & Reyes, 2000). While household income is recorded, and is an important explanatory factor in previous research, it is unfortunately only recorded in the NTS for those who are at work. Therefore, we use employment status as a proxy for income. As a robustness check we re-run the models for the sample of working individuals only, adding income as a right-hand side variable. However our results indicate that income had no explanatory power in these models (results available on request from the authors). All explanatory variables are described in Table 2 and summary statistics are provided in Table 3.

Table 2: Variable description

Variable Description		
Demo-graphic	Age 18-24	=1 if in Age Group, 0 otherwise
	Age 25-34 (ref)	=1 if in Age Group, 0 otherwise
	Age 35-44	=1 if in Age Group, 0 otherwise
	Age 45-54	=1 if in Age Group, 0 otherwise
	Age 55-64	=1 if in Age Group, 0 otherwise
	Age 65-	=1 if in Age Group, 0 otherwise
	Female	=1 if female, 0 otherwise
	Male (ref)	=1 if male, 0 otherwise
	CoupleNoChild (ref)	=1 if family unit is a couple with no child(ren), 0 otherwise
	Single	=1 if not a family unit, 0 otherwise
	CoupleChild	=1 if family unit is a couple with child(ren), 0 otherwise
	LoneParent	=1 if family unit is single person with child(ren), 0 otherwise
Socio-Economic	Full-time (ref)	=1 if in full time employment
	Part-time	=2 if in part time employment
	Unemployed	=3 if unemployed
	Student	=4 if not economically active/student
	Home	=5 if involved in home duties
	Retired	=6 if retired
	Other	=7 if other ie not any of the above
Mode Availability	Bus	=1 if local bus service available, 0 otherwise
	No bus (ref)	=1 if no local bus service available, 0 otherwise
	Train	=1 if local mainline train service available, 0 otherwise
	No train (ref)	=1 if no local mainline train service available, 0 otherwise
	DART/Luas	=1 if local DART or Luas service available, 0 otherwise
	No DART/Luas (ref)	=1 if no local DART or Luas service available, 0 otherwise
	BTDL	=1 if bus/train/DART/Luas services all available, 0 otherwise
	No BTDL	=1 if bus/train/DART/Luas are not all available, 0 otherwise
	Car	=1 if own or has regular use of vehicle, 0 otherwise
	No car (ref)	=1 if do not own or have regular use of vehicle, 0 otherwise
	Bicycle	=1 if household has one or more bikes, 0 otherwise
	No bicycle (ref)	=1 if household has no bikes, 0 otherwise
	Drive to Work	=1 if drives to work, 0 otherwise
	Does not drive to work (ref)	=1 if does not drive to work, 0 otherwise
	Free work parking	=1 if free parking available at workplace, 0 otherwise
	No free work parking (ref)	=1 if free parking not available at workplace, 0 otherwise
	Peak AM	=1 if journey commenced between 7am and 9am, 0 otherwise
	Not peak AM (ref)	=1 if journey not commenced between 7am and 9am, 0 otherwise
	Peak PM	=1 if journey commenced between 5pm and 7pm, 0 otherwise
	Not peak PM (ref)	=1 if journey not commenced between 5pm and 7pm, 0 otherwise
	Urban	=1 if located in urban location, 0 if rural area
	Rural (ref)	=1 if located in rural location, 0 if urban area
	Dublin	=1 if located in Dublin[8], 0 otherwise
	Rest of country (ref)	=1 if not located in Dublin, 0 otherwise
	Journey Kilometres	Continuous variable, distance travelled on the journey

[8] Dublin includes Dublin city, Dún Laoghaire-Rathdown, Fingal and South Dublin.

Table 3: Summary statistics

Summary Statistics				
Variable name	Mean	Std Dev	Min.	Max.
Age 18-24	.060	.237	0	1
Age 25-34 (ref)	.182	.386	0	1
Age 35-44	.262	.440	0	1
Age 45-54	.198	.398	0	1
Age 55-64	.137	.344	0	1
Age 65-	.161	.367	0	1
Female	.561	.496	0	1
Male (ref)				
CoupleNoChild (ref)	.420	.494	0	1
Single	.255	.436	0	1
CoupleChild	.202	.402	0	1
LoneParent	.123	.328	0	1
Full Time Employed	.426	.495	0	1
Part Time Employed	.154	.361	0	1
Unemployed	.085	.277	0	1
Student	.024	.154	0	1
Home Duties	.177	.382	0	1
Retired	.102	.302	0	1
Other Economic Status	.033	.179	0	1
Bus	.710	.454	0	1
Train	.324	.468	0	1
Dart/Luas	.122	.327	0	1
BTDL	.037	.188	0	1
Car	.823	.382	0	1
Bicycle	.345	.475	0	1
Drive to Work	.445	.497	0	1
Free Work Parking	.388	.487	0	1
Peak AM	.147	.354	0	1
Peak PM	.156	.363	0	1
Urban	.616	.486	0	1
Dublin	.242	.428	0	1
Journey Kilometres	12.523	24.589	0	500[9]

[9] There are a number of long journeys but, cross-checking the transport mode and journey time recorded for each, we are confident they are accurate. The models were run excluding journeys greater than 100 kilometres, which comprise 1.4% of the journeys, and the results do not change significantly. Results available on request from the authors.

4.0 Results

As noted, a variety of MNL models with seven mode choice alternatives, are estimated. First, we discuss the results from MNL models of mode choice for commuting and non-commuting journeys (results presented in Tables 4 and 5). Then we examine in greater detail the non-commuting journeys by estimating separate MNL models for six journey purposes (namely, work; school/education; shopping/food/drink; social; personal business; other) (results presented in Annex 1)[10]. Results are presented in the form of odds ratios. Odds ratios are the exponentiations of the coefficients and show how the change in a particular variable affects the odds of choosing one mode of transport over the reference category, driving a car.

4.1 Non-Commuting Journeys

Not surprisingly the youngest and oldest age groups in the dataset are more likely to be car passengers than car drivers for non-commuting travel, compared to those aged 35 to 44. Females are over 3 times more likely to be car passengers and, in line with expectations less likely to cycle, and to use a van, lorry or other transport, than to be car drivers. Household type matters for mode choice. Relative to an individual who is part of a couple without children and compared to travelling as car driver, a single person is much more likely to use active transport or take the bus, and a single person with children is less likely to travel as a car passenger. It appears that a person who is part of a couple with children is more likely to be a car passenger and, in contrast to previous research into commuting journeys by Commins and Nolan (2011), walk and use the bus for non-work journeys.

[10] In these models public transport modes were aggregated.

We now focus on mode availability and its effect on mode choice. Predictably, owning a bicycle greatly increases the chance cycling will be the mode of choice over car driving for non-work journeys. As expected, the availability of a bus service increases the likelihood of taking the bus over car driving. The joint availability of bus, mainline train, DART and Luas is associated with a higher likelihood of walking, rather than driving a car, to complete a non-work journey. Surprisingly the joint availability of these public transport options suggest that rail is less likely to be chosen over driving a car. This may be due to the fixed nature of the rail infrastructure which is less attractive for short and intra-city journeys[11]. The higher likelihood of walking however is as expected as the effect is probably coming from the fact that the simultaneous availability of these modes occurs in quite compact urban areas where the easy availability of public transport may be correlated with the presence of footpaths and cycle lanes. The urban dummy provides a similar result; for those living in an urban area walking is significantly more likely than driving a car. The results imply that for those living in Dublin using public transport is more probable than driving a car, again as suggested in the literature this extra effect for Dublin may be explained by the more widespread and frequent services in the area as well as disincentives to driving such as congestion and parking restrictions.

It seems people become attached to their cars, because the availability of a car results in travellers being significantly less likely to use any other form of transport. Also those who drive a car to work are more likely to drive a car on non work journeys than take any other mode of transport. Those working part time, on home duties, students, retired and in the other category are less likely to walk than drive a car, relative to those in

[11] In this respect it should be noted that Ireland does not possess a dense rail network, and distances between rail stations is often quite long. Dublin has just two unconnected tram lines and the commuter rail services serve only a limited catchment.

full time employment. Students are more likely to take the bus than drive a car, relative to full time employed. This result is unsurprising as students can avail of discounted bus fares and also would in general have lower incomes than full time employed. Although the results indicate those in the over 65 category are more likely to be car passengers than drivers, retired people seem to be more often choosing to drive a car over being a passenger. Perhaps the lower ages in the over 65s bracket are driving this result or it could be driven by those in early retirement.

Table 4: Multinomial Logit Model with transport mode choice as dependent variable for Non-Commuting Journeys; Odds ratios

	Car Driver	Car Passenger	Walk	Bus	Rail/DART / Luas	Bicycle	Van/Lorry/ Other
Age18-24		3.649***	1.852**	1.657	1.940	0.550	1.243
Age25-34		1.146	0.888	1.114	1.648	1.417	1.540
Age35-44		Ref	Ref	Ref	Ref	Ref	Ref
Age45-54		1.110	0.946	0.627	0.924	1.396	0.866
Age55-64		1.395*	1.200	0.974	1.163	2.255	0.979
Age65+		2.378***	0.918	1.162	0.721	2.344	1.100
Female		3.088***	0.842	1.430*	0.828	0.163***	0.393***
Couple No Child		Ref	Ref	Ref	Ref	Ref	Ref
Single		0.957	1.640***	2.588***	1.611	4.167***	1.655**
Couple with Child		2.128***	1.662***	2.334***	1.683	2.527*	1.023
Lone Parent		0.433***	1.034	1.074	0.775	1.252	0.778
Full time employed		Ref	Ref	Ref	Ref	Ref	Ref
Part time employed		1.189	0.709**	1.802*	1.179	2.002	0.491**
Unemployed		0.859	0.965	1.007	1.096	0.477	0.822
Student		0.665	0.483**	2.884***	3.136	1.868	0.320
Home Duties		0.722	0.659**	1.026	1.149	2.608	0.271***
Retired		0.483***	0.582**	0.752	1.081	0.634	0.261***
Other economic status		0.858	0.568**	1.365	0.355	0.467	0.886
Bus available		0.881	1.139	3.090***	2.757*	1.782	0.765
Train available		1.011	0.838	1.029	3.455***	0.447**	0.824
Dart/Luas available		0.703	0.727*	0.861	18.73***	3.142*	1.787
B/T/D/L available		0.791	2.348***	1.604	0.161***	1.144	0.318
Car available		0.008***	0.009***	0.005***	0.010***	0.009***	0.031***
Bicycle available		0.913	0.962	0.835	0.508*	99.42***	0.967
Drive to Work		0.566***	0.621***	0.277***	0.339*	0.328**	0.846
AM-peak		0.634***	0.750**	1.135	1.266	1.096	0.828
PM-peak		1.191*	0.985	1.150	1.388	0.839	0.982
Urban		0.733**	1.589***	1.528*	0.565	1.942*	0.782
Dublin		1.314	1.232	3.613***	3.723**	0.457	1.133
Journey Kilometres		6.649***	0 (0)***	59.15***	101.7***	0.001	1.001
Journey Kilometres^2		0.626**	352,544***	0.193***	0.327**	5.000	1.111
Constant		4.605***	106.3***	0.194***	0.023***	0.019***	3.051**
Observations		13,188	13,188	13,188	13,188	13,188	13,188

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

4.2 Commuting Journeys

It is interesting to compare the effect characteristics have on mode choice for commuting and non-commuting journeys. For both types of journeys for example females are more likely to use the bus than drive a car. Also common to both journey purposes females are more likely to be car passengers than car drivers. Females are statistically less likely to cycle than drive a car for non-work journeys, yet this result is not significant for work journeys. These results could be driven by the fact that women do most of the shopping trips and school runs, the journeys that are more difficult by bicycle. The estimates suggest that household type matters for non-commuting journeys yet household type is not an important determinant of mode choice for commuting journeys.

As with non-commuting journeys, owning a bicycle is associated with more use of cycling rather than driving a car to get to work. Interestingly, for those who have a bicycle it appears they are also more likely to be car passengers over drivers and also more likely to take the bus, while on work journeys. Where rail is available this mode is chosen above car driving for non-work and work journeys. However while train availability appears to decrease the likelihood of cycling over car driving for non-commuting journeys, and the joint availability of the public transport alternatives sees a greater likelihood of individuals walking instead of driving a car, these results are not statistically significant for commuting journeys. The availability of a car suggests that driving is the most likely mode of transport for commuting trips; this result is the same for non-commuting journeys. The availability of free parking at the workplace is significantly associated with mode choice for commuting journeys with all other modes of transport significantly less likely to be chosen than driving a car. A commuter is much more likely to use the bus than drive a car to work if they are located in Dublin. This is not surprising as there are more bus services available compared to other parts of the country and also greater parking costs and

restrictions; this is also the case for non-commuting journeys although the result extends to rail as well for non-commuting journeys.

As we are just examining commuting journeys here, individuals that are unemployed, students, retired and other are excluded. Part-time employed differ statistically from full time employed in being less likely to choose rail over car driving for commuting journeys. Perhaps this is due to the cost of rail- the available commuter tickets do not offer savings if used on a part-time basis.

Table 5: Multinomial Logit Model with transport mode choice as dependent variable for Commuting Journeys; Odds ratios

	Car Driver	Car Passenger	Walk	Bus	Rail/DART / Luas	Bicycle	Van/Lorry/ Other
Age18-24		3.694**	0.920	1.855	2.291	0.230	0.473
Age25-34		0.803	1.208	1.500	1.949	1.552	1.436
Age35-44		0.731	0.866	1.397	1.763	1.054	0.850
Age45-54		Ref	Ref	Ref	Ref	Ref	Ref
Age55-64		1.439	0.852	1.533	1.186	2.014	0.711
Age65+		0.358	0.983	3.227	2.858	0.285	0.722
Female		1.828**	1.108	1.893**	1.941*	0.485	0.078***
Couple No Child		Ref	Ref	Ref	Ref	Ref	Ref
Single		0.476*	1.925	1.308	1.017	1.755	0.948
Couple with Child		1.014	1.666	0.840	0.428	1.203	0.659
Lone Parent		0.301**	0.606	0.405*	0.372	0.210**	0.829
Full time employed		Ref	Ref	Ref	Ref	Ref	Ref
Part time employed		0.523	0.983	0.570	0.216**	1.145	0.860
Bus available		1.663	1.603	11.21**	0.563	2.346	1.308
Train available		1.117	0.665	0.836	2.905**	0.421	0.460***
DART/Luas available		1.409	0.718	0.462*	11.11***	0.657	0.551
B/T/D/L available		0.176*	1.381	0.324	0.275*	2.627	1.956
Car available		0.011***	0.031***	0.014***	0.049***	0.023***	0.091 ***
Bicycle available		2.192***	1.178	3.132***	1.748*	1.338e+08***	0.858
Free Work Parking		0.274***	0.066***	0.048***	0.041***	0.032***	0.591**
AM-peak		0.898	1.290	1.081	1.261	1.138	0.880
PM-peak		1.221	1.064	1.202	1.540	0.854	0.851
Urban		1.344	1.196	11.66***	14.48***	1.049	0.986
Dublin		1.160	2.456**	4.569***	2.723*	1.526	0.865
Journey Kilometres		0.669	0 (0)***	788.0*	320.9***	3.16e-07***	0.778
Journey Kilometres^2		1.127	1.201e+15***	1.72e-06	0.154*	157.7***	1.268
Constant		2.242	96.87***	0.014***	0.016***	1.68e-07***	4.313**
Observations	4,069	4,069	4,069	4,069	4,069	4,069	4,069

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

4.3 Comparing the Determinants of Mode Choice across Journey Purpose

With the data available it is possible to test whether specific variables have a different effect across journey purposes. For example mode availability might have very different effects for different journey purposes perhaps due to differing needs to be on time or comfort considerations. As a first step, a comparison of the odds ratios for each mode for work and non-work journey purposes (Tables 4 and 5 above) suggests that these differ substantially. Similarly, comparing odds ratios across all journey purposes (in Annex 1) suggest that there are substantial differences.

However, while this first look might be suggestive of differences, such a comparison is not valid as the results of the multinomial logit depend on two parameters, a scale parameter that is a function of the variance and a vector of utility parameters that are confounded (see Ben-Akiva and Lerman, 1985). Therefore in order to carry out formal tests it is necessary to first isolate the scale parameter. Swait and Louviere (1993) provide a convenient method to achieve this and to compare parameters across data sets (see also Louviere et al 2000). The method involves a search for the relative scale parameter in one data set relative to another, which allows for the estimation of a nested model and a likelihood ratio tests for parameter and scale factor equality across the two data sets[12]. The results of the tests are summarised in Table 6. The test results show that the parameters for mode choice are different across travel purposes in fourteen out of fifteen comparisons. The only exception is for the comparison between travelling to school and other purpose. This result is important as it shows that it is not valid to generalise from the

[12] We also applied an alternative method, restricting the sample to only those individuals who undertook both of two selected journey purposes, and the independent variables are interacted with one of those journey purposes. The interaction marginal effects are calculated for each outcome (mode choice) and tested for statistical significance. While this is straightforward to apply it implies a significant reduction in sample size such that the test could only be applied to a number of non-work journey purposes. In all cases the parameters are found to differ significantly.

results for one travel purpose to travel behaviour for all travel. In particular policy analysis and prediction based on the results of a model run for just one travel purpose will be biased.

Table 6. Test results from the Swait-Louviere Test for Parameter Differences across Travel Purposes

Travel Purposes	Parameter are equal adjusting for scale parameter differences	Parameter are equal and scale parameters equal	MNL models are identical
Commuting – School		X	X
Commuting – Shop	X		X
Commuting – Visit	X		X
Commuting - Personal Business	X		X
Commuting - Other	X		X
School – Shop	X		X
School – Visit		X	X
School - Personal Business		X	X
School - Other			
Shop - Visit	X		X
Shop - Personal Business	X		X
Shop - Other	X		X
Visit - Personal Business	X		X
Visit - Other		X	X
Personal Business - Other	X		X

Note: X denotes that the hypothesis was rejected at all conventional significance levels.

5.0 Conclusions

We examined individuals' mode choices with a particular emphasis on non-commuting journeys, a topic generally neglected in previous empirical research in Ireland and elsewhere on mode choice. The decision of how to travel was modelled as a discrete

choice model. Mode choice was modelled as a function of demographic, socio-economic and supply-side characteristics using a MNL model. Deciding the alternatives of the dependent variable is a key choice in estimating a MNL model. The seven alternatives used here were car driver; car passenger; walk; bus; rail; cycle and 'van, lorry or other' with car driver as the reference category. The model was run for commuting trips as well as the non-commuting trips (and we also disaggregated non-commuting trips to gain additional insights).

The results illustrate the importance of demographic, socio-economic and supply-side variables in the analysis of mode choice and are largely in line with past research both in Ireland and internationally. Age, sex and household composition have significant effects on mode choice. Females, the young and the old are less likely to be car drivers than passengers, possibly indicating mode choice decisions made with reference to other household members. Perhaps for similar reasons, those who are part of a couple with children are less likely to be car drivers than passengers. Single people without children are significantly more likely to choose walking and taking the bus over driving for non-commuting travel. Single people without children generally do not have to take into considerations the schedules of others such as children of school-going age and it is possible that they have less chained, or linked, trips and as such driving is not necessitated.

In terms of choosing active transport modes, walking and cycling, we find that location and transport availability is important. Results suggest that resident in an urban location lends itself well to walking and cycling for non-commuting trips. This is further emphasised with the joint availability of bus, train, Dart and Luas (which is indicative of a compact urban setting) associated with increased likelihood of walking, for non-commuting journeys, over driving. Urban dwellers choosing active transport over driving

is likely a result of the infrastructure and provisions in place in towns and cities, such as footpaths, cycle lanes and street lighting. Where public transport is available it is less likely the car will be driven as travel mode, however there is some indication people become car dependent as the availability of a car is associated with a reduced likelihood of choosing any other mode of transport for both commuting and non-commuting journeys. Similarly, the availability of free parking at work is associated with a significantly reduced probability of taking all other modes to work.

The fact that public transport is more likely to be chosen over driving if it is available is not surprising. The Dublin dummy variable has a large odds ratio for the bus alternative, greater than 3 for both commuting and non-commuting trips, and for the rail alternative, greater than 4, for commuting trips. As well as the greater public transport services provided in the Dublin area, the parking restrictions and costs associated with Dublin city driving are another potential explanation for the increased likelihood of choosing public transport over driving in Dublin.

Finally, we have shown that it is important to estimate separate models for each travel purpose as tests suggest significant differences across journey purposes. For instance, we found that household composition is more important in determining mode of transport for non-commuting journeys. It is therefore not valid to generalise the results from a model of mode choice for one journey purpose. This is important as there is a heavy focus on commuting to work in the literature despite the fact that other journey purposes such as shopping, visiting friends and family, and leisure, together account for a much greater proportion of total daily trips.

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Annex 1: MNL Model estimates for Journey Purposes by Transport Mode

Table A; Transport Purpose Commuting; Car Driver as transport mode reference category

	Car passenger	Walk	Public transport	Bicycle	Van/Lorry/ Other
Age18-24	3.117*	0.505	1.963	0.241	0.413
Age25-34	0.800	1.346	1.912*	1.462	1.424
Age35-44	ref	ref	ref	ref	ref
Age45-54	0.745	0.837	1.723	1.064	0.810
Age55-64	1.521	0.858	1.590	1.468	0.727
Age65+	0.208	0.871	4.290**	0.131	0.455
Female	2.079**	1.434	1.926**	0.449	0.085***
Couple no Child	0.496*	2.944**	1.291	1.426	1.028
Single	ref	ref	ref	ref	ref
Couple with Child	0.826	1.344	0.581	0.567	0.695
Lone Parent	0.395	1.125	0.579	0.591	0.942
Full time Employed	ref	ref	ref	ref	ref
Part time Employed	0.620	1.097	0.546	1.826	0.904
Bus available	1.645	2.211	1.698	2.714	1.335
Train available	1.008	0.649	0.978	0.369*	0.421***
DART/Luas available	1.190	0.476	0.981	0.469	0.438
B/T/D/L available	0.495	3.878	1.856	10.78**	3.447
Car available	0.165***	0.509	0.279***	0.844	0.742
Drive to Work	0.024***	0.005***	0.006***	0.003***	0.078***
AM-peak	0.873	1.214	1.053	1.287	0.863
PM-peak	1.209	0.986	1.165	0.962	0.830
Urban	1.410	1.902	19.50***	1.076	1.086
Dublin	0.818	1.597	3.025***	0.908	0.760
Journey Kilometres	1.000	0.360***	1.050***	0.867***	0.999
Journey Kilometres^2	1.000	1.003***	1.000***	1.000***	1.000
Constant	2.195	35.31***	0.059***	2.353	3.296**
Observations	4,069	4,069	4,069	4,069	4,069

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

Table B; Transport Purpose School/Education/Companion School/Education; Car Driver as transport mode reference category

	Car passenger	Walk	Public transport	Bicycle	Van/Lorry/ Other
Age18-24	0.588	1.160	0.628	0.063**	1.16e-09***
Age25-34	0.184**	0.951	0.532	1.754	1.153
Age35-44	ref	ref	ref	ref	ref
Age45-54	0.173*	0.741	0.123*	1.35e-08***	0.180
Age55-64	0.080	1.254	0.198	1.86e-09***	0.337
Age65+	1.53e-08***	0.124	5.38e-08***	3.40e-08***	2.39e-08***
Female	0.689	0.889	0.635	0.013***	1.465
Couple no Child	4.841***	4.537	23.84**	285.1***	4.619
Single	ref	ref	ref	ref	ref
Couple with Child	20.6***	2.268	10.75*	2.89e-05***	5.727
Lone Parent	1.757	1.029	2.763	9.908**	0.255
Full time Employed	ref	ref	ref	ref	ref
Part time Employed	0.496	1.045	1.831	2.364	0.322
Unemployed	0.189	0.537	1.569	1.51e-08***	7.204
Student	0.517	0.649	6.990**	0.429	4.18e-09***
Home	0.850	1.700	3.421	0.724	0.182
Retired	3.35e-08***	0.404	1.50e-07***	2,777***	3.18e-08***
Other	0.092	0.256	2.921	2.34e-08***	2.383
Bus available	0.565	1.049	2.900	1.115e+07***	0.589
Train available	1.619	0.747	1.192	0.144	0.294
DART/Luas available	1.762	0.646	2.098	4.46e-10***	2.431
B/T/D/L available	0.216	1.925	0.127*	7.327e+10***	2.72e-08***
Car available	0.004***	0.008***	0.003***	0.024***	0.040***
Drive to Work	0.419	0.730	1.275	0.509	0.594
AM-peak	1.167	1.158	1.401	0.684	0.9
PM-peak	0.539	0.670	1.551	0.700	2.203
Urban	0.616	3.627**	4.009*	5.155	1.611
Dublin	1.861	2.698**	6.209***	3.579	1.678
Journey Kilometres	1.088	0.280***	1.189***	7.520*	1.111
Journey Kilometres^2	0.999	1.011***	0.998**	0.653*	0.999
Constant	11.29	43.88***	0.015***	1.17e-08***	0.189
Observations	1,958	1,958	1,958	1,958	1,958

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

Table C; Transport Purpose Shopping/Food/Drink Car Driver as transport mode reference category

	Car passenger	Walk	Public transport	Bicycle	Van/Lorry/ Other
Age18-24	5.248***	1.829	1.454	11.09**	0.395
Age25-34	1.189	0.638*	3.270*	2.730	1.325
Age35-44	ref	ref	ref	ref	ref
Age45-54	0.741	0.729	2.811	13.90**	1.348
Age55-64	1.129	0.588*	2.748	11.87**	0.914
Age65+	1.521	0.618	2.661	8.074*	0.772
Female	5.681***	0.979	2.773**	0.138**	0.249***
Couple no Child	0.873	1.393	2.235*	1.601	1.929
Single	ref	ref	ref	ref	ref
Couple with Child	2.202***	1.260	1.833	0.814	0.959
Lone Parent	0.28***	0.958	0.672	0.527	0.879
Full time Employed	ref	ref	ref	ref	ref
Part time Employed	0.890	0.519**	1.329	0.626	0.485
Unemployed	0.764	0.740	0.451	0.226	0.666
Student	0.089**	0.0901***	0.594	1.003	2.19e-07***
Home	0.431**	0.387**	0.572	2.192	0.297
Retired	0.554	0.360**	0.621	0.254*	0.205**
Other	0.479	0.464*	0.730	0.0627*	0.391
Bus available	0.979	0.946	2.351*	1.227	0.610
Train available	0.888	1.033	1.244	0.983	0.462*
DART/Luas available	0.732	0.533*	0.977	12.60***	2.359
B/T/D/L available	0.691	3.178**	1.927	1.25e-07***	5.106
Car available	0.006***	0.003***	0.002***	0.005***	0.014***
Drive to Work	0.208***	0.300***	0.133***	0.154**	0.918
AM-peak	0.823	0.894	0.892	4.574*	0.399
PM-peak	1.392	0.878	1.236	1.009	1.192
Urban	0.986	1.840**	1.426	1.181	0.734
Dublin	1.240	1.193	6.503***	0.248	0.418
Journey Kilometres	1.025**	0.256***	1.095***	0.835*	0.956**
Journey Kilometres^2	1.000	1.007***	0.999**	1.001	1.000**
Constant	7.325***	1,595***	0.144**	1.358	10.60***
Observations	4,257	4,257	4,257	4,257	4,257

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

Table D; Transport Purpose Visit Family/Friends & Social/Entertainment;

Car Driver as transport mode reference category

	Car passenger	. Walk	Public transport	Bicycle	Van/Lorry/ Other
Age18-24	2.623**	1.626	2.828*	1.975	2.617*
Age25-34	1.356	0.656	1.456	0.720	1.469
Age35-44	ref	ref	ref	ref	ref
Age45-54	1.862**	0.772	1.069	0.472	0.929
Age55-64	1.898*	0.874	0.920	1.186	1.330
Age65+	3.859***	0.573	2.064	0.774	1.006
Female	3.016***	0.461***	1.025	0.009**	0.363***
Couple no Child	0.557**	1.167	0.764	6.149	1.029
Single	ref	ref	ref	ref	ref
Couple with Child	1.170	1.621	0.854	9.111	1.110
Lone Parent	0.427**	1.315	0.703	2.818	1.064
Full time Employed	ref	ref	ref	ref	ref
Part time Employed	1.062	0.715	0.744	3.996	0.573
Unemployed	0.695	0.793	0.651	0.108*	0.583
Student	0.865	0.748	0.838	8.09e-10***	0.098**
Home	0.431**	0.535	0.463	11.37*	0.341*
Retired	0.422**	0.641	0.474	0.478	0.126***
Other	1.070	0.561	0.447	0.333	0.769
Bus available	1.009	1.540	2.813*	0.671	0.889
Train available	1.142	0.807	1.155	0.233**	1.477
DART/Luas available	0.810	0.901	3.177**	8.04e-09***	3.320**
B/T/D/L available	0.641	1.215	0.917	3.189	0.077**
Car available	0.004***	0.003***	0.003***	0.004***	0.019***
Drive to Work	0.861	0.700	0.309**	7.22e-08***	0.988
AM-peak	0.552	0.486	2.008	1.03e-08***	1.223
PM-peak	0.972	0.785	1.023	1.496	0.727
Urban	0.810	1.320	1.684	8.556**	0.833
Dublin	0.887	1.199	1.321	0.090**	0.839
Journey Kilometres	1.005	0.405***	1.018**	1.453	0.989
Journey Kilometres^2	1.000	1.002***	1.000	0.939	1.000
Constant	14.61***	814.4***	2.221	1.191	7.939***
Observations	2,780	2,780	2,780	2,780	2,780

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

Table E; Transport Purpose Personal Business; Car Driver as transport mode reference category

	Car passenger	Walk	Public transport	Bicycle	Van/Lorry/ Other
Age18-24	14.99***	20.01***	0.402	1.47e-06***	1.027
Age25-34	2.279	0.522	0.344	3.852	1.771
Age35-44	ref	ref	ref	ref	ref
Age45-54	0.617	1.039	0.060**	2.282	0.572
Age55-64	1.048	1.899	0.211*	6.838	0.439
Age65+	2.373*	1.446	0.232	5.280	0.578
Female	3.953***	1.550	0.550	0.361	0.593
Couple no Child	0.449**	0.684	2.976	1.101	1.243
Single	ref	ref	ref	ref	ref
Couple with Child	1.593	0.942	5.255**	0.465	1.427
Lone Parent	0.116***	0.211**	1.119	1.31e-07***	0.559
Full time Employed	ref	ref	ref	ref	ref
Part time Employed	2.339*	0.725	4.578*	5.970*	0.907
Unemployed	0.499	3.103*	8.478**	9.908*	0.403
Student	0.094**	0.034***	10.91**	4.48e-06***	0.983
Home	1.324	1.081	12.05***	3.39e-07***	0.095*
Retired	0.326*	0.759	4.397	0.594	0.209*
Other	0.717	0.958	26.73***	1.050	1.331
Bus available	0.813	2.094*	0.887	3.426	0.592
Train available	1.404	0.739	0.968	0.939	0.696
DART/Luas available	1.437	0.860	1.729	11.65**	3.13e-08***
B/T/D/L available	1.859	5.146**	0.218	8.36e-08***	5.395**
Car available	0.002***	0.004***	0.005***	0.008***	0.059***
Drive to Work	0.548	0.791	0.882	0.455	0.412
AM-peak	1.115	1.487	0.476	1.533	1.230
PM-peak	1.419	0.684	0.664	2.303	0.867
Urban	0.289***	1.146	18.12**	0.575	1.086
Dublin	1.103	1.336	8.944***	0.718	1.533
Journey Kilometres	1.037***	0.338***	1.093***	0.713	1.003
Journey Kilometres^2	1.000***	1.003***	0.999***	0.987	1.000
Constant	12.59***	116.3***	0.019**	0.615	3.121
Observations	1,769	1,769	1,769	1,769	1,769

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.

Table F; Transport Purpose Other; Car Driver as transport mode reference category

	Car passenger	. Walk	Public transport	Bicycle	Van/Lorry/ Other
Age18-24	4.356**	0.848	0.469	1.84e-09***	0.339
Age25-34	1.122	1.410	0.802	1.102	3.554**
Age35-44	ref	ref	ref	ref	ref
Age45-54	1.270	1.275	0.348	0.265	1.286
Age55-64	1.262	2.986***	0.434	0.114	1.419
Age65+	2.561**	1.358	0.545	0.046***	5.582*
Female	1.750*	0.860	0.913	0.033***	0.248***
Couple no Child	1.271	2.257***	6.241**	7.963***	0.988
Single	ref	ref	ref	ref	ref
Couple with Child	2.503***	1.913***	13.18***	2.357	0.227**
Lone Parent	0.499	1.598*	5.701**	2.198	0.414
Full time Employed	ref	ref	ref	ref	ref
Part time Employed	2.934**	1.024	4.952**	0.558	0.641
Unemployed	1.878	1.723	0.425	1.23e-09***	1.487
Student	2.065	1.541	1.485	3.41e-09***	6.251*
Home	2.623*	1.163	2.354	11.83**	1.264
Retired	1.057	1.054	1.662	1.590	0.959
Other	4.062**	0.898	5.011**	1.57e-10***	7.344**
Bus available	0.896	1.032	3.780**	0.850	0.826
Train available	1.034	0.770	1.707	0.129*	0.892
DART/Luas available	0.505	1.037	1.203	4.668	2.586
B/T/D/L available	2.69e-09***	2.077*	0.590	1.31e-08***	7.38e-10***
Car available	0.025***	0.036***	0.012***	0.024***	0.047***
Drive to Work	0.857	0.878	0.166*	0.402	1.541
AM-peak	0.915	0.638**	1.297	3.01e-09***	0.976
PM-peak	0.881	0.888	1.912	0.147	0.861
Urban	0.522**	1.135	0.377	1.005	0.478
Dublin	1.798	0.926	4.610*	0.337	1.388
Journey Kilometres	1.024***	0.744***	1.038***	1.003	1.005
Journey Kilometres^2	1.000**	1.000	1.000**	1.000	1.000
Constant	0.786	14.87***	0.036***	2.550	0.714
Observations	2,424	2,424	2,424	2,424	2,424

Note: Standard errors (not shown) are clustered at the individual level. Significance level is denoted as follows *** p<0.01, ** p<0.05, * p<0.1.