

ANALYSIS OF THE NON-MOTORIZED COMMUTER JOURNEYS IN IRISH CITIES

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Abstract

Non-motorized commuting such as, walking and cycling to work has been recognized as critical in attaining sustainability in urban mobility. Owing to this recognition, in recent years there has been a surge of interest among policy makers and practitioners in improving and encouraging non-motorized commuting in Ireland. This paper presents a multiple logistic regression (MLR) based approach to explain the non-motorized mode share of commuter journeys in terms of relevant socioeconomic, transportation and household specific factors in five major cities of Ireland. The non-motorized modes are analyzed using the latest available Irish census data (2006). Age, gender, socioeconomic status and several commuter journey specific variables have been identified as the major determinants to influence the choice of travel mode for commuter journeys. The findings reaffirm that the significance of the major determinants in influencing the choice of non-motorized transportation as the preferred mode of commuting are often region or locality specific. Hence, the developed models are important tools in understanding the effectiveness of the policy interventions in promoting non-motorized travel in utilitarian purposes across the major cities of Ireland.

INTRODUCTION

Non-motorized transportation (NMT) is a critical element in attaining sustainability in urban mobilization. NMT which includes walking and cycling is increasingly being favored as an attractive alternative to motorized commuter journeys by policy makers and environmentalists. Favorable NMT policies and increased NMT mode share can provide both personal and social benefits. The individual benefits are improved health and fitness, basic mobility, improved accessibility and cost-effective travel. The social benefits are congestion reduction, roadway and parking infrastructure cost savings, energy conservation, reduced air and noise pollution and reduced accident risks to other road users [1].

In recent years in Ireland there had been a surge of interest in improving and encouraging non-motorized travel. The Irish Government has adopted a new transport policy 'SmarterTravel - A Sustainable Transport Future' as the transport policy for Ireland for the period of 2009-2020 [2]. According to the policy document, "Alternatives such as walking, cycling and public transport will be supported and provided to the extent that these will rise to 55% of total commuter journeys to work." As a consequence two new NMT related programs have been undertaken; 'Smarter Travel Workplaces', a program which promotes walking, cycling, public transport, car-sharing and trip reduction as part of a workplace mobility

management and the 'National Cycle Policy Framework, 2009-2020' has been adopted to promote a strong cycling culture in Ireland. This program aims to increase the bicycle mode share of all trips to 10% by 2020.

Adoption, implementation and success of these nationwide transport policies are dependent on their success at the regional and local levels. It is important to identify and analyze the major factors that influence a person's choice of NMT as the preferred mode of travel for commuter journeys in different parts of the country of Ireland. Understanding the variability of these major factors in different parts of the country is crucial to the success of the above-mentioned transport policies. In the present paper, we have analyzed commuter journeys in the five major cities of Ireland to identify the relative importance/significance of the factors which influence the choice of NMT as the preferred mode of travel to work.

The paper is divided into five sections. In the next section the research context in terms of existing literature is discussed. The section thereafter introduces the five cities of Ireland that are chosen for this modelling. Non-motorized commuter journeys are analysed in the penultimate section and the last section concludes the paper.

LITERATURE REVIEW

Commuter journeys account for a major portion of the total travel demand of a city. These journeys have been the subject of much research for decades. Understanding the reasons and influences behind commuter travel mode choice is important in analysing commuter behaviour and therefore improving the efficiency and sustainability of transport networks.

In the last couple of decades, the researches on commuter journeys have mainly focused on green modes of commuting such as cycling, walking or public transportation. The studies focus on exploring the commuter mode choice decisions relating to bicycles only [3-8], relating to pedestrians only [9-11] and also relating to both bicycles and pedestrians or non-motorized travel [12]. Pucher et al. [4] identified improved safety, climate, bicycle and pedestrian infrastructure, favourable transport policies, urban density etc. are the main factors in encouraging increase of NMT mode share in commuter journeys. Other researchers [9,13] identified urban density and land-use as the major determinants for NMT mode share. In 2005, Plaut [12] did a comprehensive study of non-motorized commuting in US using journey to work data. Car-ownership, race, gender and various locational variables were identified as the factors affecting the modal choice of NMT. Research has also been undertaken to identify the major determinants of NMT mode choice for commuter journeys in developing countries [14]. Apart from these, research has been performed to investigate the health benefits of active travel which includes cycling or walking to work [15,16].

These studies have revealed that a person's socio-demographic status and a number transport and region specific factors can indicate the probability of choosing a non-motorized mode of travel. The work in this paper is an effort to carry out a similar investigative study to understand the identity and characteristics of non-motorized commuters in context of Ireland.

THE FIVE CITIES OF IRELAND

The paper aims to identify the determinants of the choice of non-motorized modes of travel, i.e. cycling and walking, as a means of commuting in Irish Cities. This study focuses on the five largest cities in Ireland: Dublin City, Cork City, Galway City, Limerick City, and Waterford City (figure 1). The information on non-motorized commuting in these five cities of Ireland has been obtained from the 'Place of Work Census of Anonymised Records' dataset (POWCAR) [17], collected as a part of the Census of Population of Ireland which was taken on the night of Sunday, 23 April 2006. POWCAR dataset provides information on the commuter journeys of all employed persons in Ireland who travelled to work. Information on the socioeconomic & demographic characteristics of the workers and the specifics of their commuter journeys are available from the dataset. This data contains information on the regular work trips of 1,834,472 individuals. Nearly 57% of the working population of Ireland relies on cars for their journey to work. The NMT mode share of commuter journeys is 17% out of which 13% walk to their workplaces while the remaining 4% cycle to work. Bus is used by 14% of the population and 7% uses rail as their chosen mode of journey to work.

TABLE 1 City Profiles

	DUBLIN CITY	CORK CITY	GALWAY CITY	LIMERICK CITY	WATERFORD CITY
Population	506,211	119,418	72,414	52,539	45,748
Area	130km ²	120km ²	45km ²	60km ²	90km ²
Working Population	442,833	84,112	39,892	35,025	25,389
(Percentage as fraction of total population)	-87.50%	-70.40%	-55%	-67.60%	-55.50%
Working & Residing	337,968	52,203	20961	19,041	13,704
Working, but not residing	56,752	13,085	5056	12,869	2,754
Residing, but not working	104,865	31,909	18,931	15,984	11,685
MODES OF TRAVEL					
Walking	56,065	9,991	5,285	4,895	2,787
Bicycle	16,697	1,109	1,098	654	339
Public Transport	108,435	5,473	1,982	1,498	744
Car (Driver)	223,578	57,959	27,254	23,981	18,419
Car(Passenger)	15,269	5,324	2,582	2,210	1,834
Motorcycle, Lorry, Van or other	14,818	3,372	1,279	1,379	994

In Table 1, broad information about the commuter journeys in the five chosen cities of Ireland have been provided. Dublin City is the capital of Ireland and the largest city in terms of area, residing and working population. The working population density of Dublin is around four times higher than Cork City, the second largest city of Ireland. In all five cities the road network is suited to private car based journeys. Other available modes of motorized transport in Dublin City are Dublin Bus, Luas (Light rail system), DART and Commuter trains (suburban railway networks). In Cork city, the available modes of public transport are the buses provided by Bus Eireann (National Bus Company of Ireland), and local and suburban railway services. Public transportation in Galway City, Limerick City and Waterford City mainly consists of buses provided by public and private companies. As for non-motorized modes of transport, pedestrian facilities in Irish Cities have been described as superior [18]. Prior to the 2006 census, some cycling facilities (Cycle lanes and parking) were available in all these five cities. Following the census, multiple schemes and policies have been adopted by the relevant city councils and national transport authority to improve non-motorized commuting facilities in Irish cities [2]. In Dublin city, Galway City and Limerick City around 16.4% of the total working population use non-motorized modes of transport for travelling to work. In Cork City and in Waterford City, 13% and 12% of the working population respectively walk or cycle to their work places. Overall, in all five cities, the percentage of employees walking to their workplaces is much higher than that using bicycle as their preferred mode of commuter travel. The statistics show that there is a huge chance of improvement in increasing the bicycle mode share of commuter journeys and appropriate policy interventions should be undertaken to encourage this.

Variables Influencing the Choice of Travel Mode in Five Cities

The commuter journey related information available from the POWCAR dataset for the chosen five cities of Ireland can be largely divided into three categories. Each category is discussed in detail in this section along with the descriptive statistics as provided in table 2.

Socio-Economic Information: Information on gender, age, marital status, highest level of education, socioeconomic group, industry of work and car-ownership per household is available under this category from POWCAR dataset. The information on age is provided as a categorical variable of five-year-age group. The information on highest level of education, socioeconomic group and industry of work are indicative of the income of an individual. Out of these three variables, socioeconomic group has been chosen for modelling. Along with that, gender, age and car-ownership per household were included in the MLR model to identify their influence on the choice of NMT as the preferred mode of commuter journeys. From table 2, it can be observed that in all five cities while women are less likely to cycle than men and more likely to walk to work. The workers within the age group of 15 to 24 years are keen users of active transport and this trend decreases as the workers get older.

Among socioeconomic groups, self-employed workers and farmers rely mainly on motorized transportation.

TABLE 2 Description of Non-Motorized Travel in Five Cities

	Dublin City		Cork City		Galway City		Limerick City		Waterford City	
	Walk	Cycle	Walk	Cycle	Walk	Cycle	Walk	Cycle	Walk	Cycle
	%	%	%	%	%	%	%	%	%	%
Gender										
Male	16.6	8.1	16.4	2.8	16.4	6.2	17.1	4.4	14	3.2
Female	26.8	3.1	28.9	1.1	23.6	2.6	30.3	1	21.6	0.4
Age										
15 to under 24	27.1	4.7	31	2.1	35.3	6.3	30.1	3.3	27.8	2.1
25 to under 44	22.2	6.5	22	2.5	17.8	4.8	21.4	2.9	15.1	2.1
45 to under 65	16.5	4.9	17	1.3	13.7	2.8	21.6	2.6	16.7	1.5
Over 65	15.5	2.8	15.3	0.7	16.7	1.4	23	2.3	15.7	1.7
Socioeconomic Group										
Management & Higher Professional	20.8	6.5	19.4	2.2	14.6	3.3	15.7	2	10.6	1.3
Lower Professional & Non-manual	26	5.2	28.7	2.1	25.8	4.1	31.4	1.9	22.9	1
Manual & Semi-skilled	14.7	7	15	2.3	16.6	6.3	15.7	4.6	14.7	3.7
Unskilled	26	6.7	29.6	2.5	28.7	10	34.5	5.1	30.2	2.9
Own Account Workers	6.1	2.3	6.2	0.7	5.1	1.1	8.6	1	6.4	0.3
Farmers & Agricultural Workers	8	5	10	0	7.7	1.9	3	3	15.2	0
Resident Persons										
1-2	24.3	6.2	25.3	2.2	18.8	4	23.6	3.1	19.7	1.8
3-4	20.1	5.4	20.6	2	21.1	4.6	22.9	2.7	16.3	1.7
5-7	17.5	5.5	19.5	2	18.9	5.3	21.9	3.1	15.5	2.9
8+	22.2	4.5	25.2	1.9	15.8	10.5	23.3	0	14.9	0.9
Household Composition										
Single Person Household	24.2	6.2	25.5	2.2	17.2	4	24	4	22	2.2
Lone Parent with resident child(ren) ≤ 19yrs	27.3	2.1	23.5	0.8	13.8	1.7	31.6	1.5	18.9	0.8
Lone Parent with resident child(ren) > 19yrs	17.5	4.2	20.3	1.1	20.2	4.1	23.6	3.2	23.1	1.8
Couple with resident child(ren) ≤ 19yrs	13.7	5.5	14.2	1.7	9.5	2.8	16.6	2.5	11.2	1.4
Couple with resident child(ren) > 19yrs	13	4.5	14.8	0.9	14.9	3.7	18.8	2.9	17.1	1.4
Couple with no resident child(ren)	21.7	6.5	22.2	2.3	16.2	3.8	19.7	2.7	15.4	1.4
Number of Vehicles										
0	38.4	8.1	49.8	4.3	52.9	11	46.9	6.3	53.1	5.9
1	19.8	6.4	22.6	2.3	19.9	4.9	21.9	2.7	18.6	2.1
2+	10.4	3.3	8.6	0.8	8.6	2	9.9	1.1	6.9	0.7
Departure Time										
Before 06:30	12.3	6.1	15.6	3.1	18.8	8.6	14.2	5.5	13.2	3.2
06:30-07:00	11.6	4.5	16.9	2.3	20.2	5.5	12.1	3.3	19	2.3
07:01-07:30	14.7	4.6	13.9	1.6	14.9	4.4	11.8	2.6	15.5	3.8
07:31-08:00	17.3	5.2	16.1	1.7	14.2	4	15.3	3.6	31.2	2.2
08:01-08:30	24	5.9	19	1.7	13	3.2	21.6	2.7	13.6	1.1
08:31-09:00	34.2	8.3	33.5	2.5	26	3.9	35.9	2.8	20.2	1.4
09:01-09:30	31.3	7.8	29.7	3.1	27.4	5.6	35	1.7	24.2	1.1
After 09:30	30.4	6.4	34.6	2.6	31.6	6.5	37.4	2.5	31.6	1.6
Distance to Work in km										
Mean (SD)	7.51 (9.05)		7.95 (13.15)		8.51 (17.00)		8.64 (14.13)		7.62 (16.42)	
Journey Time in km										
Mean (SD)	29.1 -20.1		20.21 (14.42)		19.65 (17.43)		19.96 (15.70)		16.55 (16.52)	

Housing Specific Information: This includes information on accommodation type, nature of occupancy, residents per household, workers per household, household composition, year household was built, sewerage, number of vehicles per household and residence one year ago as available from POWCAR dataset. Out of these variables, residents per household and household composition are the two variables chosen for the modelling purpose. From table 2 it can be observed that individuals and couples living on their own (no children) tend to use NMT mode of travel for their commuter journeys more than other others. It can also be noted, that couples living with children (of any age group) tend to use NMT the least of all other groups.

Commuter Trip Specific Information: The information on this category includes means of travel, time of departure, distance to work, journey time, and address of workplace as available from POWCAR dataset. It has been observed from similar studies in other countries [12,7], that journey distance and journey time are two very important factors in influencing a commuter's choice of travel mode. It can be seen from table 2, that in all five cities, the people using active transport travel on an average more than 7 km for their commuter journeys and they generally travel between 15-30 minutes to reach their workplace using NMT mode. Departure time, distance to work and journey time are three variable chosen from this category to investigate their influence on NMT mode share of commuter journeys in the chosen five cities of Ireland.

MULTIPLE LOGISTIC REGRESSION MODEL OF NMT MODE SHARE

A Multiple Logistic Regression (MLR) modeling approach has been utilized to identify and investigate the major determinants of the choice of NMT as the preferred mode of commuter journeys for main cities in Ireland. The MLR models developed to analyze the NMT mode choice for commuter journeys in the five main cities of Ireland are presented in the paper. Each of these models is developed in two stages. In the first stage, all the independent variables are modeled individually against the outcome to determine which categories are significant in influencing choice of mode. The significant categories from each variable are then put in the main effect MLR model developed for each city. The reference categories chosen for comparison in the single variable models are kept the same for the main model. The coefficient estimates of different categories, as obtained from the main model are presented in table 4. The t-statistics for each category are provided in brackets. The reasonable adjusted R^2 values indicate that the developed MLR models are capable of explaining a good proportion of the variation in NMT mode choice for commuter journeys. It can also be noted, that the R^2 values are higher for cities with bigger working population such as Dublin City or Cork City.

The significance of the different input variables which influence the choice of an individual to use NMT for commuter journeys has been calculated in the previous two subsections. In this section a qualitative discussion of the same is provided. Both the single and multivariable models show that even though there are a higher number of working males in every city, women are more likely to use NMT for their journey to work. The exception is Cork City, where men are equally as likely to use NMT as women. However, the use of bicycles is more popular among men compared to women. The influence of age on the inclination to use NMT indicate that those aged between 15 to 24 years are approximately 1.6 to 2.6 times more likely to use NMT for commuter journeys when compared with those over 65. The odds fall slightly for those aged between 25 and 44 years. Those aged between 45 to 64 years show that their choice of mode are not significantly different from those over 65 for all cities. In Limerick city, the age of an employee does not influence his choice of NMT.

The other socio-economic determinants are the socioeconomic class and the car-ownership per household. Similar to the studies in other countries [12,14], it is observed that those in the highest earning positions such as management and higher professionals are less likely to use NMT. The unskilled workers, lower professionals, and non-manual workers are most likely to use NMT. In Dublin City and Cork City it is observed that higher professionals are more likely to walk or cycle than the agricultural workers. However, this might be due to the small number of agricultural workers in these big cities and that any number of higher professionals using NMT would increase the odds ratio in comparison to agricultural workers. The car-ownership is generally identified as a major determinant in an individual's

choice of NMT [6,7]. In this study, the car-ownership variable does not come out as significant as expected. This is due to the fact that information is not available on car-ownership per employee, instead information is provided on car-ownership per household and consequently the influence of the variable is not as significant as expected.

TABLE 4 Main Effect Model

	Dublin City	Cork City	Galway City	Limerick City	Waterford City
Male	-.121 (-8.01)	-	-0.145 (-3.01)	-0.108 (-2.07)	-0.028 (-2.48)
Age 15-24	0.230 (9.55)	0.537 (10.53)	0.607 (9.29)	-	0.504 (6.87)
Age 25-44	0.191 (11.97)	0.227 (6.29)	-	-	-
Age 45-64	-	-	-	-	-
Management & Higher Professional	0.165 (8.85)	0.115 (2.37)	-0.065 (-2.01)	-.279 (-6.46)	-0.419 (-6.12)
Lower Professional & Non-manual	0.257 (16.05)	0.336 (9.43)	0.258 (5.1)	0.297 (5.92)	0.097 (1.77)
Manual & Semi-skilled	-.052 (-2.95)	-0.061 (-.89)	0.140 (2.45)	-.279 (-5.18)	-
Unskilled	0.728 (27.84)	0.726 (12.66)	0.854 (9.6)	0.859 (11.21)	0.907 (10.29)
Own Account Workers	-1.167 (-27.72)	-1.139 (-11.75)	-1.144 (-8.83)	-1.001 (-7.95)	-0.566 (-4.75)
1-2 Resident Persons	0.141 (3.69)	-	-	-	-
3-4 Resident Persons	-	-0.210 (-2.71)	-	-	-
5-7 Resident Persons	-0.073 (-3.43)	-0.215 (-2.53)	-	-	-
Single Person Household	0.482 (12.94)	0.470 (5.75)	-	-	-
Lone Parent with resident child(ren) ≤ 19yrs	0.133 (3.53)	0.016 (0.2)	-0.703 (-6.99)	0.042 (0.89)	-0.617 (-6.01)
Couple with resident child(ren) ≤ 19yrs	-0.053 (-3.45)	-0.167 (-2.14)	-0.706 (-11.57)	-0.458 (-7.39)	-0.747 (-10.38)
Couple with resident child(ren) > 19yrs	-0.085 (-2.14)	-0.114 (-2.37)	-0.274 (-3.59)	-0.227 (-2.9)	-0.407 (-4.41)
Couple with no resident children	0.343 (9.39)	0.194 (2.48)	-0.065 (-2.04)	-0.214 (-3.02)	-0.384 (-4.73)
Own 0 vehicles	-	-	-	-	-
Own 1 vehicle	-0.049 (-3.49)	0.081 (2.43)	0.042 (0.92)	-	0.140 (2.67)
0-1km to place of work	1.784 (67.04)	2.135 (39.47)	1.730 (23.54)	1.644 (22.25)	1.678 (21.12)
2-4km to place of work	0.91 (20.45)	0.823 (17.61)	0.432 (10.14)	0.215 (8.89)	-0.321 (-4.64)
5-9km to place of work	-1.203 (-54.75)	-1.70 (-26.59)	-1.782 (-20.94)	-1.638 (-18.86)	-2.053 (-17.94)
10-14km to place of work	-2.353 (-52.63)	-3.953 (-16.52)	-3.116 (-13.39)	-3.148 (-11.07)	-4.018 (-8.84)
15-24km to place of work	-3.130 (-36.46)	-4.810 (-11.72)	-3.945 (-8.71)	-4.433 (-8.8)	-
Journey Time 0-15min	1.032 (34.92)	1.044 (12.25)	1.561 (16.17)	0.764 (9.79)	0.891 (6.58)
Journey Time 16-30min	0.932 (31.35)	0.792 (10.01)	0.806 (8.68)	0.273 (3.54)	1.496 (14.73)
Journey Time 31-44min	0.791 (23.43)	0.892 (13.98)	1.085 (8.23)	-	1.700 (10.45)
Journey Time 45-60min	-.022 (0.51)	-	-	-	-
Departure Time 06:30-07:00	-0.181 (-5.76)	-	-	0.012 (0.12)	0.316 (2.82)
Departure Time 07:01-07:30	0.081 (4.76)	-0.220 (-3.81)	-0.371 (-4.28)	-0.058 (-0.64)	0.135 (1.47)
Departure Time 07:31-08:00	0.201 (8.12)	-	-0.377 (5.43)	-	-
Departure Time 08:01-08:30	0.408 (17.3)	-	-0.512 (-8.01)	0.343 (4.57)	-
Departure Time 08:31-09:00	0.841 (26.54)	0.655 (13.36)	-	0.808 (10.93)	0.356 (5.17)
Departure Time 09:01-09:30	0.626 (20.7)	0.424 (6.72)	0.240 (3.04)	0.607 (6.4)	0.549 (5.18)
Departure Time After 09:30	0.491 (17.68)	0.599 (11.43)	0.361 (5.22)	0.714 (8.78)	0.704 (8.47)
R-square	0.675	0.591	0.545	0.512	0.521

The household composition and number of residents in the household are two household specific variables considered in the study. The results show that the number of people in a household in Galway City, Limerick City, and Waterford City has no significant influence on the choice of NMT. From all cities, it is observed that the number of residents (greater than 8) has a positive influence on the use of NMT. From household composition information, it is

observed that a person living on their own is most likely to use NMT compared to the other groups. Couples with resident children, regardless of their ages, are the least likely to use non-motorised transport of all the groups across all the cities. In the larger cities of Dublin and Cork, couples with no resident children are the most likely to use NMT.

According to the analysis in the paper, commuter journey specific variables are the most significant determinants in influencing one's choice of commuter travel mode. The workers living closer to their place of work are more likely to use NMT. The odds decrease as the distance increases and they fall dramatically after 5km. The comparison between the five cities for the group of employees living within 0-1km from their place of work shows that with increase in city size and population, the chances of walking or cycling to work decreases. Except for in Waterford City, the group of employees who are most likely to use NMT are those with a journey time of less than 15 minutes. The influence of the variable departure time is varied across all cities with each city producing different significant results. The results that are similar show that the probability of a person using NMT increases for people leaving for work later in the morning as compared to those leaving before 06:30am. A possible explanation for this is that the employees who use NMT live nearer to their workplaces and therefore do not need to leave as early.

CONCLUSION

Non-motorized transportation or active travel has been recognized as a perfect solution to the economic, environmental, and health concerns of today's world, therefore it is important to identify and understand the factors that influence the choice of active travel for journey to work. This paper presents disaggregate logistic regression models explaining the NMT mode share in commuter journeys in five most populous cities in Ireland in terms of socio-demographic, transportation and local factors. The study presented in this paper is first of its kind for Ireland. The models have identified gender, age, socioeconomic class, household composition, distance and time of commuter journeys and departure time as the factors which significantly influence an employee's inclination to use NMT for commuter journeys rather than motorized means. It has also been identified, that car-ownership information should be investigated in greater detail to understand the influence of this variable in the choice of travel mode.

The results revealed that there are many differences in the factors influencing travel mode choice between the five chosen cities of Ireland. Knowing these differences in the factors affecting the choice of commuter travel mode in different cities, it will possible for policy makers to target particular groups of employees to increase the NMT mode share of commuter journeys. The presented models will provide the theoretical and empirical foundation in understanding the variability of NMT mode share and in exploring the effectiveness of the policy interventions promoting NMT across main cities in Ireland.

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