Examining the factors that impact upon mode choice for frequent short trips

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ABSTRACT

This paper reports the findings of a study conducted to examine a number of factors that impact upon individuals' mode choice for non-work based short trips. To measure the impact of these factors a stated preference survey was conducted. The stated preference survey examines the impact that carbon emissions, calories burnt and weather conditions had upon the respondents' decision to walk, cycle, or drive a typical short trip. The types of trips suggested in the survey included, walking to a local shop, or visiting friends/family.

The stated preference survey was conducted in Dublin and the results were modelled using a nested multinomial logit model. The results of the stated preference study found that good weather was shown to encourage individuals to walk or cycle, whereas poor weather conditions was shown to favour driving, as one would expect. The amount of calories that an individual burnt when walking increased the attractiveness of this mode, but in an unexpected result, an increase in the amount of calories burnt when cycling lead to a decrease in the attractiveness of that mode. The model also indicated that the amount of carbon dioxide emitted when undertaking a short trip, was not an important concern for those who choose to drive.

INTRODUCTION AND BACKGROUND

Non-work based short trips account for a large percentage of trips taken by any individual. For the purpose of this study they are defined as non-commuting trips which could be walked by a fit and healthy adult. This broad definition encompasses trips such as visits to friends or relatives who live nearby, doing the shopping or using local sporting facilities. Trips of this nature are undertaken by every member of society who has some degree of mobility. An individual may undertake a trip in this category once a week or multiple times per day depending upon their circumstances, but whatever the frequency, trips of this nature are unavoidable.

Table 1 details the results from a 2006 household survey of 2,500 individuals living in Dublin. The results in Table 1 refer to the modes of transport used for short trips (*1*). The results in Table 1 show that for each of the types of trips examined, car has the greatest share of the mode choice. The results show some deviation from week day trips to weekend trips with a slight preference for driving for weekend trips with the exception of leisure trips.

TABLE 1 Mode of transport used by journey purpose

	Week Day			Weekend		
Mode	**Leisure**	**Visiting Friends/Relatives**	**Shopping**	**Leisure**	**Visiting Friends/Relatives**	**Shopping**
Car as driver	40.6%	27.8%	37%	23.9%	42.6%	37.9%
Car as passenger	11.7%	15%	7.9%	15.6%	22.5%	19%
Walk	34.3%	20.5%	39.9%	42%	14%	31.8%
Bus	5.2%	20.7%	10%	10%	14%	7.1%
Rail	4%	7.5%	2.9%	6.5%	6.9%	3.3%
Cycle	1.6%	3.6%	0.6%	-	-	0.9%
Taxi	1.4%	4.9%	0.4%	2%	-	-
Motorbike	0.6%%	0%	0.3%	-	-	-
Truck/van	0.1%	0%	0.6%	-	-	-
Other	0.5%	0%	0.4%	-	-	-
Total	100%	100%	100%	100%	100%	100%

As part of its national cycling framework document, the Department of Transport highlights a number of areas which it feels are vital in increases the levels of cycling across the country. These measures are to include traffic calming, the construction and maintenance of better cycle paths and financial incentives for cycling, such as the subsidized bicycle hire scheme, which began in early 2009. The document also highlights the need to improve both cyclist training and to instruct motorised road users how to drive in a non-intimidating and cycle friendly fashion (*2*).

It has been noted that poor weather has an adverse effect on people's decision to either cycle or walk. In a 2004 survey conducted by Dublin City Council, car commuters were asked to rate on a scale rating from very important to not very important, the factors which influenced them not to cycle to work (*3*). Although this data is about commuter trips, it provides an insight as to the relationship between perceived weather conditions and cycling in the Greater Dublin Area. 42% of those surveyed responded that unpleasant weather conditions were very important. When

commuters who owned bikes where asked why they did not cycle to work 19% claimed that it was due to bad weather. When people who cycle to work were surveyed it was found that the average Dublin cycle commuter cycles 3.9 days per week in the winter and 4.5 days in the summer, which is not a huge difference, although it should be noted that precipitation levels do not vary as much as may be perceived. It was found that both car commuters and cyclists had a poorer perception of the weather than is described by MET Eireann data. This was especially true of cyclists who cycled two or less days per week, as it greatly affected their decisions not to cycle during the winter months. A similar results was found in a study conducted in Melbourne which examined the cycling habits of students, it was found that only weather conditions which were classified as extreme caused a major (25%) decrease in the numbers of individuals who regularly cycled (*4*).

LITRATURE REVIEW

The volume of literature available for non work based trips, especially short trips, is small in comparison with the literature concerning commuter trips. This an area with a lot of potential for research, with evidence showing that half of 6am-9pm trips and two thirds of 4pm-7pm trips in the United States are non-work based (*5*). However, it should be clarified that many of these trips are part of trip chaining from work.

Mackett (*6*) assessed the short trip making characteristics of residents of London, Leeds, Hereford, Ipswich, and rural Dorset. The study examined 1,624 short trips made by 310 individuals and involved detailed interviews before and after the study period. All trips considered in the study presented in this paper were less than 5 miles, with emphasis put on trips under one mile. The study examined the factors that individuals deemed important when deciding transport mode. For trips less than five miles, carrying heavy goods, which would exclude walking, or cycling was the most important factor, followed by the need to give a lift to friends and family. Time constraints and the trip length were the third and fourth factors considered.

A similar study on the short trip habits of the inhabitants of Puget Sound near Seattle Washington was conducted by Kim et al, (*5*). The study examined nearly 3,000 weekday trips excluding trips made by children. For this study the distance being examined was 1 mile, which represented the 95th percentile of distances people were willing to walk. The research found that both walking and cycling declined as a mode choice with the increase in an individual's age. It was also observed that those who had graduated from college were more likely to walk than those who had not. It is also interesting to note that females made more automobile short trips than males. It was noted that residents who were newer to the area were more likely to walk than those established for a longer period and that the physical environment was considered an important factor for short trips.

When considering the modal split for short journeys it is important to consider the individual's perception of their ability to make a modal choice, that they are not just restricted to driving. A study based on survey data in Auckland, New Zealand aiming to assess individuals' inclination to replace car trips with non-motorised modes, found that 38% of those surveyed agreed that they could replace car trips with cycling/walking while 42 disagreed (*7*). It was also found that there was an inverse relationship between socioeconomic status and the perceived ability to switch from car journeys to walking/cycling. The study showed that while the majority of those

surveyed identified walking as an acceptable form of transport for short journeys, the view of cycling was less positive.

If walking and cycling are to be promoted as forms of transport it is important to know the factors that are at present making these modes less attractive than driving. In a study examining the habits of commuters in Auckland and Wellington, it was found that a large number of people living within 1 mile of train stations used the park and ride facilities rather than walking (*8*). Although this study examines work trips it did uncover interesting findings such as the importance of the availability of free parking in relation to the decision whether or not to drive. It was also found that, as expected, the weather conditions had an influence on modal choice, with the perceived 'chance of rain' being also an important factor in the choice of mode. Ryley, (*9*) examined what incentives could be used to dissuade individuals from driving short trips in Edinburgh. This study found that increasing petrol and parking costs would deter individuals from driving short trips.

METHODOLOGY

Survey design and layout

The survey began with an introduction section which outlined the general purpose of the study, its relevance and who was conducting it. The second section was constructed with a number of questions designed to find out information about the respondents' travel patterns, their primary mode of commuting to and from work. This is designed to see if there is any link between commuting modes and the decision to either walk drive or cycle when undertaking short trips. The third section included questions which are designed to gauge the respondent's views of issues such as cycle safety, exercise, and physical fitness. It also asks the respondent to consider how important issues such as climate change and heart disease are to them, and if the respondent feels that they have the ability to affect these concerns. The fourth section of the survey contained the discrete choice scenarios. The final section consisted of questions designed to gather demographic information about the respondent.

Data collection

The survey was conducted online and distributed via emailed amongst a number of businesses and Government Departments in central Dublin. It must be noted that as this survey was internet based and was via human resource departments that it would be producing a sample which would require internet access and also would generally be in employment. The survey was sent out to 1,000 employees and 206 fully completed surveys were returned, which gives a response rate of 21%.

Stated preference design

In the stated preference scenarios respondents were asked to choose between three modes of transport, walk, cycle, or drive. Each of these three modes were characterised by three attributes. Table 2 contains the details of the attributes and attribute levels considered. The first attribute was the emissions. The three levels of carbon emissions for driving, 200g, 240g, and 405g of CO_2. As not all individuals would be able to appreciate the impact of for example 405g of CO_2, a carbon equivalent was presented to respondents in the form of the number times a household appliance would have to be used to equate to the emission from the trip. Each level corresponds to the emissions of different types of cars undertaking a 1.5km trip. Both

cycling and walking also have three levels each but all of these are set to q zero as there are no direct carbon emissions resulting from these modes of transport.

The second attribute examined relates to the calories burnt while. As with the carbon emissions attribute, the calories burnt have three levels for walking and cycling. These three levels are high, medium, and low, but each level takes a specific value for each mode of transport (see Table 2). In the case of driving, all calories burnt have been set to zero. This is to reflect the fact that driving does not contribute to any more calories burnt than would be burnt under normal metabolic rest conditions. While all levels are set to zero, it is important to know that there are three distinct levels even if they have the same value. The calorie burn values for walking and cycling are taken from the DTO trip planner for a trip of 1.5 km. The DTO trip planner is an online travel planner which calculates travel time, emissions, and calorie burns (*10*).

The final attribute labelled weather conditions has two attribute levels are being considered. These were labelled with the simple names 'Good' or 'Bad'. This attribute is very much open for interpretation and many Irish people would consider the weather in Dublin to be perpetually bad. For this reason an explanatory note is included in section 4 of the survey to the effect that bad weather is defined as perception of the perceived threat of precipitation during the trip duration while good weather will be defined as the absence of precipitation and that it is unlike to rain during the trip. While the threat of rain is subject to individual interpretation, providing the respondent with exact information regarding meteorological conditions was judged to be unnecessary.

Factorial design

The fractional factorial design for this project was performed using the SPSS software. The software package produced a total of 27 treatment combinations, following the method proposed in Hensher (*11*).

TABLE 2 Attribute levels

	Attribute Levels		
Attributes	Walk	Cycling	Driving
Carbon Dioxide Emissions	0 g	0 g	200g
	0 g	0 g	240g
	0 g	0 g	405g
Calories Burnt	75 cal	36 cal	0 cal
	95 cal	45 cal	0 cal
	110 cal	54 cal	0 cal
Weather Conditions	Good	Good	Good
	Bad	Bad	Bad

As 27 scenarios would be too many to expect one person to perform as part of a single survey, the decision was taken to split the survey into four versions. Figure 1 below shows and example scenario from the survey.

FIGURE 1 Example stated preference scenario

	Walk	Cycle	Drive
Emissions	0 g Co_2	0 g Co_2	240 g Co_2
Calories	75 calories burnt	45 calories burnt	0
Weather conditions	Bad	Bad	Good
Please select one option	☐	☐	☐

RESULTS AND ANALYSIS

Sample characteristics

Table 2 shows that there is a good age distribution among people between 20 and 65 years of age. The results show that a greater number of females completed the survey. Half of all those who completed the survey reside in the older inner suburbs in Dublin city, followed by the outer suburbs and dormitory towns, which account for nearly 23%. It can be seen that all areas have significant representation with the exception of the option labelled 'Other' which was included to account for those people who lived in the further commuter counties. The majority of those surveyed earn between twenty and eighty thousand Euros per-annum. Within this range there is also a good distribution of earnings.

TABLE 3 Characteristics of the sample

		N	%
Age	Under 20	3	1
	20-29	45	22
	30-39	66	32
	40-49	52	25
	50-65	40	19
	Over 65	0	0
Gender	Male	81	39
	Female	125	61
Region	City centre	20	10
	Inner suburbs	103	50
	Outer suburbs	47	23
	Rural	31	15
	Other	5	2
Income	Less than 10,000	4	2
	10,000-20,000	0	0
	20,001-30,000	30	15
	30,001-40,000	34	17
	40,001-60,000	82	40
	60,001-80,000	34	17
	80,001-100,000	7	3
	Greater than 100,000	10	5
	Do not wish to answer	5	2

Table 4 shows that public transport, be it bus or rail and drive are the most popular modes of transport when undertaking a commuting trip. Walking and cycling combined account for 20% of the total modal share. As this study is examining choices involving walking, cycling and driving it is interesting to note that walk and cycling combined accounts for a smaller share of commuter trips than driving. The results show that a large majority of those surveyed have access to at least one car with only 14% having no access. Table 4 shows that 86% of the people surveyed stated that they had at least one car available for short trips. The results show that 62% of respondents indicated that they did not have own a bicycle.

TABLE 4 Transport characteristics of the sample

		N	%
Mode of transport	Walk	26	10.8
	Cycle	22	9.2
	Drive	70	28
	Rail	44	18.3
	Bus	61	25.4
	Other	2	0.8
	Car passenger	15	6.2
Bicycles available	None	149	62
	One	61	25.5
	Two	21	8.75
	More than two	9	3.75
Cars available	None	31	14
	One	149	62
	Two	52	20.8
	Three	8	3.2
	More than three	0	0

Respondents were asked how often they make a number of short trips, the results of which are listed in Table 5. The options given are ‘very frequently’, ‘frequently, infrequently’, and ‘never’. These terms are to be defined by the respondents themselves. The options were weighted with ‘very frequently’ being assigned 4 and falling to a weight of 1 for ‘never’. The average weight for each trip type is given in Table 5. It should be noted that any weight below 2.5 would indicate that the trip is taken infrequently and a weight of over 2.5 suggests that the trip is taken frequently. The results indicate that trips to local shops tend to be taken most frequently of the all the trips presented with an average weight of 3.19. Visiting friends or ‘any other short trip’ were shown to be the second and third most popular trips respectively.

TABLE 5 Frequency of short trips

	Average weight	**Rank**
Local shops	3.19	1
Visiting friends	2.7	2
Any other short trip	2.64	3
Leisure activities cinemas/restaurants	2.61	4
Visiting relatives	2.54	5
Using local sporting facilities	2.25	6
Medical visits	2.05	7

Respondents were asked to rate a number of trip considerations in a similar way to the findings presented in Table 5. The results of these trip considerations are given in Table 6. The results are cross-tabulated with the mode of transport used to travel to work. The results are interesting as while they confirm that weather is an important trip consideration, they show that travel time, safety, and load to be carried are more important. The weather conditions consideration is given greatest importance by car passengers with a value of 3.43. The subset with the lowest consideration for weather conditions is those who cycle to work. Although this mode is extremely exposed to weather conditions, the group surveyed may represent 'die hard' cyclist who will cycle regardless of the weather.

As expected the load to be carried consideration was least important both car drivers and car passengers as it can be assumed that these individuals are more likely to drive to the shops/ other short trips. The consideration of 'parking' is most important to both car passengers and drivers and found to be lowest amongst walkers and those who use public transport when commuting. This was as expected since walkers would be more likely to walk short trips, and those using public transport may also be more likely to walk compared to those who drive to work. The topography was found to be the most important for those who cycle to work. If it assumed that commuting cyclists are more likely to cycle during short trips, it makes sense that the terrain of a trip would be of greatest concern to this subgroup as very hilly terrain can make cycling extremely difficult.

TABLE 6 Cross-tabulation between mode of transport and trip considerations

	Travel time	Weather conditions	Trip destination	Load to be carried	Time of day	Parking	Safety	Topography
Drive	3.07	3	2.74	2.93	2.75	3.02	3.14	1.93
Bus	3.33	3.09	2.94	3.13	2.85	2.54	3	1.96
Rail	3.29	3.02	2.9	3.34	3.05	2.68	3.32	1.98
Walk	3.1	3.05	2.81	3.14	2.86	2.43	3.1	1.71
Cycle	3.14	2.82	2.91	3.18	2.5	2.91	3.05	2.18

The survey also asked respondents to rate a number of factors to gauge their concern with health and environmental issues and to examine if the responses impacted upon their mode choice. As with the previous question in this section, this question was rated between ‘very important’ and not ‘important at all’, with weights ranging from 4 to 1 respectively. For this question it was decided that a cross tabulation with the respondents mode of commuting may provide some insight on their motivations towards the issues or conversely on their mode choice decision.

It can be seen that climate change is of greatest importance to cyclist indicating that it may be a factor in their mode choice. It is of least importance to car passengers, while car drivers share roughly the same opinion as walkers and those who commute via public transport which may mean that car drivers don't take emissions into consideration when making mode choices. These results are mirrored in when diminishing energy resources is considered. Rising levels of obesity appears to be most important to walkers followed by cyclists. Heart disease is considered most important by walkers while levels of consideration are roughly the same among the other modes. Both personnel fitness and keeping physically active were most important to cyclist with scores of 3.91 in each case. This would suggest that cyclist base their decision to cycle partially on awareness of the importance of keeping fit

and active. While there is a difference between exercising to lose weight and to keep fit, it can be assumed that this group will place greater importance on the calories burnt during the discrete choice scenarios than other groups would.

TABLE 7 Cross-tabulation between mode of transport and personal considerations

	Climate change	Diminishing Energy supply	Rising obesity	Heart disease	Keeping active	Personal fitness	Price of petrol and diesel
Drive	3.21	3.26	3.3	3.39	3.49	3.44	3.23
Bus	3.26	3.26	3.41	3.43	3.5	3.31	2.72
Rail	3.34	3.37	3.41	3.39	3.56	3.49	3.05
Walk	3.33	3.24	3.52	3.62	3.67	3.62	2.67
Cycle	3.45	3.45	3.45	3.32	3.91	3.91	2.91

STATED PREFERENCE RESULTS

The results from the nested multinomial logit model are presented in Table 8. The utility coefficients relating to carbon emissions from cycling and walking and the calories burnt while driving have been omitted as they remained constant during the survey and where therefore eliminated from the model. This meant that each of the utility equations have two coefficients weather and calories in the case of cycling and walking, and emissions and weather conditions when driving. The model structure allowed for interaction between the walk and cycle options. The rho squared with respect to constants accounts for the data that is not explained by the constant but instead by the variables, in this case the value is 0.1794

An examination of the walking coefficients shows that with a t-ratio value of 18.6, the weather coefficient for walking is extremely significant and has a positive coefficient of 1.287. In the utility equation good weather is represented by +1 and bad weather by -1. This positive coefficient sign suggests that good weather contributes towards a positive utility while bad weather would contribute to a lower or negative utility/disutility. This result would appear to be intuitive, as good weather would provide encouragement for walking, where as bad weather would be a major deterrent as walkers are especially exposed to the conditions. The walking calorie coefficient has a t-ratio value of 4.2, indicating it is significant at a 99% confidence level. The value of the coefficient was .0083, the result of which is that as the amount of calories burnt increases, so does the utility of walking. This again is an intuitive result, confirming that when people are considering mode choices, the calorie burn attribute of walking increases the likelihood of choosing this option.

The coefficient relating to the calories burnt for the cycling coefficient seems to be counter intuitive. This coefficient is statically significant at 99% confidence level. The sign of the coefficient has a value of -.0116. This result suggests that the calorie burn from riding a bicycle is detrimental to its utility and also that this effect increases as the level of calories burnt increases. This is particularly surprising as it has already been seen that an increased calorie burn increased the utility of the walking alternative. One possible explanation for this result may be that people perceive calorie burns from cycling to be more associated with sweating and therefore

the need to shower. This would suggest that the combination of transport and exercise is not considered positive and is a deterrent to cycling. Information from the comments section suggest that some individuals would cycle to work if they had shower facilities available, and the observed sign of the coefficient may be a reflection of these concerns. It should be noted that in none of the scenarios, the calorie burn from cycling never exceeds that of walking. As with walking, the coefficient relating to weather in the cycling utility equation is both positive and statistically significant. This suggests that good weather increases the utility of cycling. This was expected, as cyclists are if anything more exposed to the weather due to its effect on road conditions and visibility.

The emissions for driving had a coefficient with a value of -.0070, which would suggest that an increase in emissions would signal a decrease in the utility of driving. The weather coefficient of the drive alternative had t-stat value of 1.9 meaning it cannot be accepted at 95% confidence level but can be accepted at 85% confidence level. The sign of this coefficient is negative which means that bad weather (-1) would increase the utility and encourage driving and that good weather (1) would decrease the utility and discourage people to drive. The association between bad weather and driving was expected, appearing to confirm anecdotal evidence. The value of the t-stat ratios indicates that the attributes selected (weather, emissions) do not manage to explain the decision to choose to drive to the same degree that the attributes for walking and cycling (calories, weather) do for their modes. This means that the utility of driving must be explained by other factors such as comfort, travel time or convenience, which come from, factors which haven't been examined or individual's idiosyncrasies.

TABLE 8 Results of the stated preference modelling

		Coefficient (t-ratio)
Walking	Calories burnt	.008 (4.2)***
	Weather	1.287 (18.6)***
Cycling	Calories burnt	-.012 (-2.6)***
	Weather	.742 (7.0)***
Driving	Emissions	-.007 (2.9)**
	Weather	-.143 (-1.9)*
N		1411
Logsum		.441
ρ2(0)		.2994
ρ2(c)		.1794
Final likelihood		-1086.1

***Significant at 99%, ** Significant at 95%, * Significant at 85%

CONCLUSIONS

The responses to the attitudinal questions in the survey highlighted problems with aspects of cycling such as the conditions of cycle paths and the lack of safety when cycling in mixed traffic. Environmental issues such climate change and carbon footprints appear to have been considered very important, and the majority of those surveyed believed they could personally help ease the effects of climate change.

Health issues such as rising levels of heart disease and obesity appear to be considered important by the respondents, as was the need to keep fit and active. The respondents disagreed with the survey when it was stated that Irish people where in good health. This may be a positive result as it shows the respondents were at least aware of the problem of sedentary lifestyle and lack of exercise, which is present in Irish society.

Although weather conditions were considered to be an important attribute when making a short trip, they were found to be less important than trip distance, trip time and the load that may need to be carried. This appeared to agree with the research by Mackett (*6*). The consideration "trip terrain" was found to be unimportant, suggesting that topography may not be an excuse for choosing against non-motorised transport. The level of bicycle access was found to vary with respect to the respondent's area of residence but in no region was it found to exceed 50%. This clearly represents a major impediment to people taking up cycling for non work based trips.

The weather conditions played a major role in the respondent's mode choice selection. The utility coefficient, which constantly had the highest t-ratio value, was the weather coefficient for walking confirming the hypothesis that weather conditions are a very important consideration when deciding whether or not to walk. The sign of the coefficient suggests that good weather encourages people to walk and that conversely bad weather discourages people from walking. This result was as expected and agreed with popular opinion.

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