Examining the Barriers to Sustainable Inter-City Transport in Ireland

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ABSTRACT

Over the past decade the Irish government has invested intensively in a large national motorway network. One of the side effects of this investment has been that now inter-city travel is now considerably cheaper and quicker by car over any other mode. The main objective of this research is to identify and examine the barriers to sustainable inter-city transport in Ireland. The majority of sustainable transport research takes place in an urban context with very little research has focused on understanding the factors to encourage alternative modes on inter-city trips. A stated preference study was conducted to determine what are the factors that impact upon individuals' mode choice when conducting an inter-city trip. The results of this paper demonstrate that there are several factors that impact upon individuals' mode choice decisions when undertaking an inter-city trip. The main factor that was found to impact upon mode choice was the requirement to have a car in the destination city.

INTRODUCTION AND BACKGROUND

The growth in the Irish economy during the Celtic tiger is intrinsically linked with increased levels of private transportation. The number of registered private cars has almost doubled over the period between 1996 and 2008, an increase from 1,057,000 to 1,924,000 (*1*). This level of growth is unsustainable in respect to greenhouse gas emissions and energy consumption. Transport has been the area of greatest growth, where CO_2 emissions in 2007 were 182% higher than those in 1990. Energy use in Transport accounted for 36% of energy related CO_2 emissions in 2007 (*2*). During this growth period the Irish government constructed a large motorway network, which connects the Capital City (Dublin) to each of the four peripheral cities in the Republic of Ireland (ROI) (see Figure 1). Many argue that this motorway network has made sustainable modes of transport uncompetitive and has resulted in the majority of inter-city travel being conducted by car.

Internationally there has been very little research on modal choice for inter-city travel compared to urban travel. Ahern and Tapley (*3*) claims that before their research, the only Irish examination of inter-city travel was the strategic rail review of 2003. This research examines inter-city travel in Ireland and examines why individuals do not choose to use more sustainable modes of transport. This study seeks to ascertain what factors are most likely to persuade individuals to switch to more sustainable modes of transport when travelling long distances within Ireland. Modal choice decisions have a hugely diverse set of variables. The relative importance of each variable is proportional to an individual's situation, location, attitudes, and perceptions.

The ROI has five cities. Table 1 details the population and the distances between these cities. Dublin is the largest population centre in Ireland with a population in 2011 of approx. 1.27million (*4*). Figure 1 shows a map of Ireland including the five cities. The cost of travel is generally recognised as one of the most important factors that impact upon travel choice. Tables 2-4 detail the costs and travel time between the five cities in Ireland, by car, rail and bus. All of the trips reported are one-way and the cost is in Euro and US Dollars (using the exchange rate €1= $1.41) and the travel time is in hours. The results show that for each of the trips reported that car travel times are the shortest. The comparison of cost shows that in a number of cases that the bus is the cheapest option.

TABLE 1 Irish Cities

FIGURE 1 Map of Ireland

TABLE 2 Inter-city car travel times and costs

TABLE 3 Inter-city bus/coach travel times and costs

TABLE 4 Inter-city rail travel times and costs

LITERATURE REVIEW

This section of the paper discusses the literature relating to the factors that impact upon mode choice. Journey cost along with travel time were identified as the most important determinants in choice of mode in Ireland (*3*). 30% of rail users deem the cost of the trip as a very important factor when considering modal choice in Ireland (*5*). Beirão and Cabral (*6*) found that in Portugal most people acknowledged that public transport is cheaper, however it did not appear as a key factor in causing people to switch to public transport. Trip purpose with necessary trips such as commuter has are more responsive to change than leisure trips.

For bus services sensitivity to change increases with distance of trip, while for train journeys the sensitivity decreases, this is probably due to the different levels of comfort on each mode (*7*).

Travel time along with journey cost is one of the most important factors in people's choice of mode in Ireland (*3*). Limtanakool et al. (*8*) showed that the total travel time by rail and car (including access, egress and waiting times) gives a better explanation of behaviour than the absolute travel times. Paulley et al. (*7*) take a different standpoint and suggest that traditional urban public transport problems such as waiting times and reliability are less important in the inter-urban situation but in-vehicle time becoming a more critical factor. The difference between the two circumstances is as a result of the proportions of time spent on each task. Bel (*9*) studied the effects of non-monetary factors such as the change in travel times across different modes on rail demand. For distances between 100km (62 miles) and 400km (248 miles), changes in rail travel time had the greatest effect, closely followed by road travel while air travel was negligible. Van Exel and Rietveld (*10*) found on a busy travel corridor into Amsterdam that car users overestimated the travel time on public transport by 46% on average. If these perceptions were more accurate, two out of three car users that do not take public transport would consider using it from time to time.

A wide range of attributes that can be influenced by planning authorities and transport operators may define quality of service. Some of these attributes (access and egress time, service intervals and in-vehicle time) directly involve time, and can be quantified with relative ease. Others (vehicle or rolling stock characteristics, interchanges between modes, service reliability, information provision, marketing and promotion, and various bus specific factors) are more problematical because changes in these attributes are often accompanied by changes in other attributes, particularly fare and journey time (*7*). In a study conducted in Ireland, 28% of rail users claimed that the option to use a laptop would be an important factor when considering modal choice, and two out of three commuters expect that they would use Wi-Fi services at least once a week if available (*5*). Connolly et al (*5*) demonstrate that passengers on longer trips derive greater benefit from Wi-Fi and laptop use, this allows them equate some travel time with leisure time. Fearn (*11*) explains however that Wi-Fi is still infeasible in Ireland due to lack of coverage by the service Internet providers.

Beirão and Cabral (*6*) found that some car users would prefer to use public transport as it gives them a break from the stress of driving, this is only the case when the trip is comfortable i.e. seat availability and pleasant temperature. Comfort on public transport was important to all respondents to this survey. Cars users think their car allows them more flexibility and freedom, being able to keep a personal timetable and go wherever one want.

Many authors accept that travel behaviour is habitual, with its effect increasing with the number of trips (*12, 13, 14*). It is therefore easier to cause a switch from in those that rarely make the trip such as leisure travellers compared to regular trip makers such as commuters. Habits often cause car users to have misperceptions of public transportation. These misperceptions of travel alternatives may cause people to persist in sub-optimal travel patterns; some suggest that these individuals remember their worst experiences (*6*), others believe it is a protective measure as the misperception is an excuse not to try and use public transportation (*10*). Habitual decisions are usually only re-evaluated after a large context change such as moving residence (*13*). Sometimes these changes can be accidentally induced such as during the temporary closure of the Hanshin freeway in Japan. Drivers that changed to public transport during the closure continued to use it more frequently one year later than those who did not switch to public transport during the closure (*14*). Thøgersen (*15*) supplied a random sample of car drivers with one-month free bus tickets, this offer was enough to cause the sample group to break their habits and use public transport. The trail also had a

lasting effect on the perceptions of the group towards public transport, its usage increased from 5% of trips to 10% of trips in the short term and 7% of trips in the long term.

For inter-city trips vehicle interchanges will very often be necessary at the trip ends, as passengers change between an inter-city mode and urban public transport to reach their final destination. These passengers may have being ignored by typical urban transport evaluations and may face certain specific difficulties. The fact that vehicle interchanges may be necessary does not stop them from being seen as frustrating experiences, which may deter potential passengers from using public transport at all. Poor information provision, lack of helpful staff for information or help with luggage or children, no ticket integration, security issues and inadequate vehicle co-ordination make vehicle interchanges a emotionally stressful event (*16*). People do not want to change vehicles unless it is perceived as fast and easy (*6*). Walking and wait times are twice as distressing as in-vehicle time (*7*).

Kinsella and Caulfield (*17*) show that the needs of visitors into an urban public transport system are different to those of the native population. The provision of information was the factor with the greatest difference in perceived importance between the two groups. Similarly, Beirão and Cabral (*6*) found that a lack of information was a barrier among respondents in Portugal. A lack of information made the bus system hard to access and was often avoided. An inter-city public transport journey is therefore affected by the accessibility on the urban public transport system at the trip ends. People unfamiliar with the city will regularly seek out public transport information before setting out on a journey, and the lack of this information will deter individuals from using public transport (*17*).

METHODOLOGY

In stated preference studies individuals are asked to choose between a number of different alternatives which vary by their attribute level. In this study respondents were presented with 3 different modal choices, driving, taking a bus or a train, for an inter-city trip between two cities that are 200 KM (124 miles) apart. The distance of 200KM was chosen to represent a typical Irish inter-city trip with particular emphasis on trips to Dublin. The attribute for each of the three modes choices differs in terms of travel time, cost and regularity. The attribute levels are based on present and possible values occurring to the service providers.

Table 5 details the attributes and attribute levels used in the stated preference survey. The cost attributes where presented in Euro and the values were taken from market prices at the time of the survey (July 2010). The travel times were estimated upon current travel times by each of the modes. The final attribute regularity (frequency of service) was presented in the number of public transport services per hour.

TABLE 5 Attributes and attribute levels

The survey was conducted on-line over a two-week period in July 2010. Human resource departments of large organisations were contacted and asked to circulate the survey on the company's general distribution e-mail list. A total number of 191 responses were received from 12 different organisations.

Discrete choice modelling is based on the assumption that each individual chooses the option that will maximise his or her own utility; therefore we can use the random utility theory, which will be explained, in this sub-section. In this theory it is assumed that each individual will obtain a benefit from each alternative option but will endeavour to use the option that they will derive the highest utility (as seen in equation 1). The individual will only choose option *i* if it's utility is greater than all others *j*.

$$U_{in} > U_{ij} \forall j \neq i \qquad \text{Equation 1}$$

The utility factor is based on two different components, V_i which is measureable or deterministic and is based on the alternatives in the choice set, and a random component ε_i, which cannot be measured. In the case of this study the deterministic factor V_i depends on travel time, cost and regularity while the random factor reflects an individual's more abstract perceptions of each mode of transport, such as maintaining personal space or ease of transporting luggage. As the random component cannot be measured, it is assumed to be set to a probability distribution defined by the model used to analyse the data. As the random component cannot be modelled, the probability that individual *n* will choose alternative *i* can be expressed as in the Equation 2:

$$P_i = \Pr ob(U_i > U_j) \forall j \neq i \qquad \text{Equation 2}$$

Therefore, the probability that the respondent will choose alternative *i* is the probability that the utility of that alternative is greater than any of the other alternatives in the choice set. The multinomial logit model is arguably the most widely used discrete choice models and is referred to as the 'workhorse' of choice models (*18*). This sub-section deals with the main features of this model. The model is based on the assumption that the random term, ε_i, is identically and independently distributed or Gumbel distributed. This results in the probability of choosing an alternative as expressed in Equation 3.

$$P_i = \frac{e^{V_i}}{\sum_{j=1}^{J} e^{V_j}} \qquad \text{Equation 3}$$

P_i is the probability that the individual will choose alternative *i,* V_i is the deterministic element of utility for alternative *i* and *J* is the number of alternatives in the choice set.

RESULTS

An important aspect of this study is to identify the current travel patterns of the respondents and to attempt to understand the guiding factors that moulded these patterns. The survey required respondents to quantify the average number of trips they would take per year by each mode of transport on their most regularly travelled inter-city route. These trips were subcategorised by purpose of trip, whether the trip was for business or leisure. In total there was 2,170 trips investigated in the study. Leisure trips are by far the most popular reason for inter-city travel with a 77.7% share of the trips in this study. The number of possible motivations for an inter-city leisure trip is considerably larger than the number of incentives behind a leisure trip. Business trips share of 22% is significant.

The breakdown of modal choice within each trip purpose category is interesting. Rail travel holds a large share (41%) of inter-city business trips yet a much smaller share (12%) of leisure trips. The opposite is true for bus travel. Bus has a large share of leisure trips relative to business trips, which are 20% and 4% respectively. Overall the

private car is the favourite method of inter-city transport with a share of 57%. Rail and bus travel are similar with a share of 18.5% and 16.5% respectively.

TABLE 6 Details of trips taken

Table 7 details the descriptive statistics of the sample collected. The results for the gender mix show a good mix between male and females. The age categories of the respondents' shows that 37% of respondents were aged between 25-34 and 27% were aged 34-44. Income is the final variable presented in Table 7. The results show that 55% of the sample earn between €30,000 and €50,000.

TABLE 7 Details of the sample

To help understand the barriers to public transport, the survey asked respondents to rate the extent of which a list of factors affects their inter-city modal choice decision process. The respondent could choose between 'no concern', 'slight concern', 'concern' and 'major concern'. The percentage of individuals that selected each option is summarised in Table 8.

Reliability was the factor that received the highest percentage of 'major concern' votes (52.4%). The ability to get from door-to-door as easily as possible and the amount of time spent travelling were also predominately 'major concerns', with 48.2% and 49.7% respectively. The environment (7.9%) and familiarity (10.5%) were factors that are rarely seen as major concerns when planning an inter-city trip.

22.5% of the respondents do not consider the environment when choosing a mode of transport. This is closely followed by ability to mix travel and work/leisure times (20.9%) as the least concerning factor.

To get a clearer picture of the relative importance of each factor a simple scoring system is utilised. Responses are awarded a score ranging from -2 for no concern to +2 for a major concern. The cumulative score indicates the relative importance of each factor. Factors with high scores are more important in the population's modal choice process. The ability to get from door to door with ease, time spent travelling and the ease of getting around the destination city are found to be the most important factors. The environment, mixing travel time with work or leisure and available information are found to enter the cognitive process the least.

TABLE 8 Factors impacting on inter-city mode choice

STATED PREFERENCE RESULTS

The base models comprise of variables presented in the stated choice experiments, namely, travel time, cost and regularity of service. Analysis of the survey results provides coefficients for each of the variables for each of the three modes of transport. These coefficients describe how a change in that particular variable will change the likelihood of an individual choosing that method of transport. The coefficients can be combined into utility equations, which will describe the benefit gained from a good or service.

The results of the MNL model are presented in Table 9. The findings show that almost all the coefficients are significant at the 99% confidence level, with the only admission is the cost variable for the car which has a t-ratio of 1.9 indicating that it is only significant to the 90% confidence level. The model produced a good fit with the $\rho^2(0)$ equal to 0.334 and the $\rho^2(c)$ value is equal to 0.198.

The results demonstrate that the utility of bus travel will increase the most from a reduction in travel times (-0.021) followed by car (-0.017) and train (-0.010), travel times are a considerable barrier to bus travel but are not a substantial barrier to rail travel. The coefficient of bus cost is most cost sensitive (-0.103) followed by train (-0.061), while driving had the lowest cost disutility of -0.037 which shows that the cost of car travel did not deter people from choosing it in comparison with the its alternatives. The importance of service regularity was found to be more significant in the case of rail travel with a coefficient estimated at -0.005 when compared with bus travel (-0.003). For both train and bus transport, a reduction in travel times is more important to travellers than a decrease in time between services. This is especially the case for bus travel as the coefficient for time is considerably larger than the coefficient for regularity, -0.021 and -0.003 respectively.

TABLE 9 MNL Model results

CONCLUSIONS

The main objective of this research was to examine the barriers to sustainable inter-city transport. Factors that affect the modal choice process were identified during a literature review. The magnitude of these barriers have been examined using a stated choice approach, utilising discrete models to measure the magnitudes, the results of which are presented in this paper. This study recognises that travel time is an important consideration. It was found to be a central concern for those that are more likely to drive. The attitude that was found to best explain car use is that the car will get to the final destination faster than public transport. Travel time is an especially major barrier to bus travel.

The cost of transport has been found not to be a significant barrier to public transport as shown in the MNL models. Driving had the lowest cost disutility, which shows that the cost of car travel did not deter people from choosing it in comparison with its alternatives. If the cost of transport is important to an individual then they are more likely to choose bus travel.

The MNL models showed that rail transport is a more attractive alternative to bus travel. As part of the stated preference study, the attitudes of the individuals that are more likely to choose the car as their method of transport were assessed. It was found that the three attitudes that most associated with car drivers are based around these factors. They believe that their cars will get them to their final destination faster than public transport, public transport stations are difficult to access, and that bringing luggage on public transport is difficult. These are weaknesses in the public transport services that must be addressed.

This research has established that the most important mile travelled during an inter-city trip is the final mile. The final mile is a term used to describe the final leg of the journey from the transportation hub of the destination city to the trip end. The attractiveness of an inter-city public transport route is intrinsically linked with ease of access of the stations at both of the end points. The results of the stated preference study demonstrate that mobility of an individual in the destination city is an especially important consideration amongst those that are more likely to choose car transport. Car users believe that public transportation hubs are inaccessible and that it is easier to circulate through Dublin city by private car than public transport.

This research may represent the first step in moving towards a more sustainable system of transport. The recent developments on the inter-city transport network have revolved around the expansion of motorways. This survey has demonstrated that the main considerations of inter-city modal choice include travel time, reliability, ease of door-to-door transport, and timetable control. The new motorways will increase the utility derived by car

users and therefore the number of car trips per year will rise. These changes were necessary but occurred without similar improvements in the public transport network.

This research has added to the arguments for improving urban transit systems. Inter-city transport is intrinsically linked with the accessibility of the cities at both end of the trip. The attractiveness of sustainable inter-city transport is proportionally linked to the ease of public transport within the destination city. Efforts must be made not only to improve urban transit, but to make it more attractive to those that may be unfamiliar with it.

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LIST OF TABLES AND FIGURES

TABLE 1 Irish Cities

City	Population - 2011	Distance from Dublin in KM	Distance from Dublin in miles
Dublin	1,270,603	-	-
Cork	518,128	253	157
Galway	250,541	208	129
Limerick	191,306	195	121
Waterford	113,707	164	102

FIGURE 1 Map of Ireland

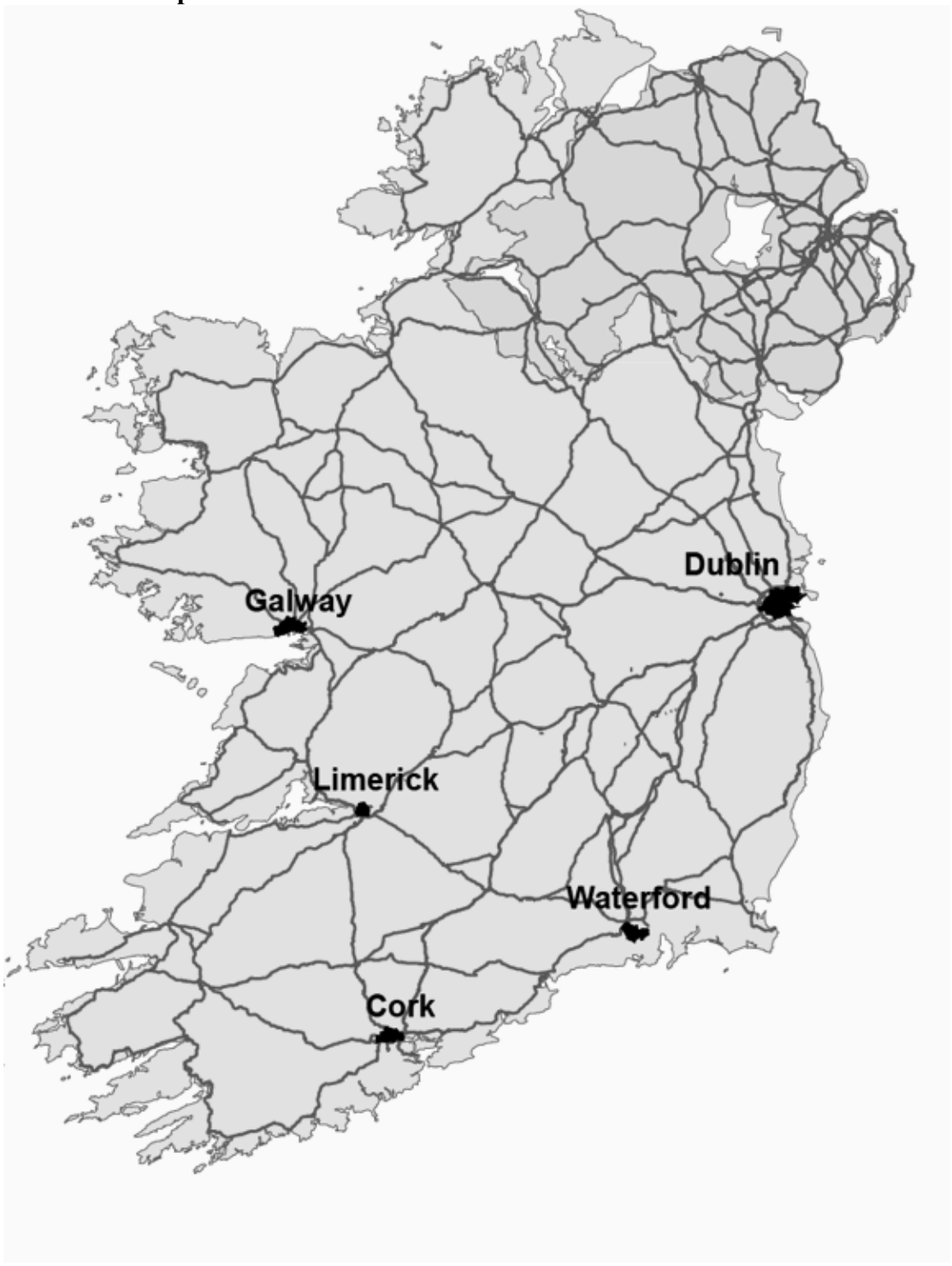

TABLE 2 Inter-city car travel times and costs

Cost Travel time	Dublin	Cork	Galway	Limerick	Waterford
Dublin		€42.50/$60.00	€41.84/$59.00	€30.19/$42.56	€25.54/$36.00
Cork	2.75hrs		€30.96/$43.65	€15.48/$21.82	€18.58/$26.19
Galway	2.5hrs	3hrs		€21.52/$30.34	€35.29/$49.75
Limerick	2.5hrs	1.5hrs	2.1hrs		€19.81/$27.93
Waterford	2.1hrs	1.8hrs	3.5hrs	2hrs	

TABLE 3 Inter-city bus/coach travel times and costs

Cost Travel time	Dublin	Cork	Galway	Limerick	Waterford
Dublin		€19.80/$27.91	€17.10/$24.11	€19.80/$27.91	€16.20/$22.84
Cork	4.5hrs		€26.10/$36.80	€19.80/$27.91	€25.70/$36.23
Galway	3.7hrs	4hrs		€19.80/$27.91	€35.10/$49.49
Limerick	3.7hrs	1.75hrs	2.25hrs		€24.80/$34.96
Waterford	3.25hrs	3hrs	5.8hrs	2.45hrs	

TABLE 4 Inter-city rail travel times and costs

Cost Travel time	Dublin	Cork	Galway	Limerick	Waterford
Dublin		€66.00/$93.06	€48.00/$67.68	€50.00/$70.50	€34.50/$50.55
Cork	2.8hrs		€59.00/$83.19	€35.00/$49.35	€42.50/$59.92
Galway	2.6hrs	3.8hrs		€36.00/$50.76	€65.00/$91.65
Limerick	2.25hrs	1.45hrs	2.hrs		€42.50/$59.92
Waterford	2.1hrs	3hrs	4.1hrs	2.7hrs	

TABLE 5 Attributes and attribute levels

	Train	Bus	Car
Cost	€60/$84	€15/$21	€23/$32
	€30/$42	€10/$14	€20/$28
	€10/$14	€5/$7	€18/$25
Travel time	2h 50min	4h 30m	2h 45m
	2h 25min	3h 30m	2h 10m
	2hr	2h 45m	1h 45m
Regularity	2 services per hour	2 services per hour	-
	1 service per hour	1 service per hour	-
	0.5 services per hour	0.5 services per hour	-

TABLE 6 Details of trips taken

Purpose	Mode	No. trips	% trips	No. trips	% trips
Leisure	Car	989	58.7	1686	77.7
	Carpool	155	9.2		
	Train	203	12.0		
	Bus	339	20.1		
Business	Car	248	51.2	484	22.3
	Carpool	19	3.9		
	Train	197	40.7		
	Bus	20	4.1		
Total		2170		2170	100

TABLE 7 Details of the sample

	No. of respondents	%
Gender		
Male	94	49
Female	97	51
Total	191	100
Age		
Under 24	32	17
25-34	71	37
35-44	52	27
45-54	24	13
55-64	12	6
65+	0	0
Total	191	100
Income		
Under €30,000	43	23
€30,001 - €50,000	105	55
€50,001 - €70,000	30	15
€70,001 - €90,000	4	2
€90,001 - €110,000	1	-
Over €110,001	5	3
Skipped question	3	2
Total	191	100

TABLE 8 Factors impacting on inter-city mode choice

Factor	No concern	Slight concern	Concern	Major concern	Score
Being able to set your own timetable	5.2%	20.4%	35.1%	39.3%	4.3
Being able to relax while traveling	5.2%	33.1%	40.8%	20.9%	-2.6
The ability to get from door-to-door as easily as possible	3.1%	8.9%	39.8%	48.2%	24.7
The amount of time spent travelling	1.0%	9.6%	39.7%	49.7%	26.2
The cost of transport	4.2%	19.9%	37.7%	38.2%	9.4
The ease of transporting luggage	9.9%	24.1%	39.3%	26.7%	-4.6
Being able to get around the destination city with ease	3.1%	17.3%	41.9%	37.7%	18.4
Available information	13.6%	36.1%	33.0%	17.3%	-30.3
The environment	22.5%	42.4%	27.2%	7.9%	-60.2
The ability to mix travel time with leisure or work time	20.9%	28.3%	39.8%	11.0%	-30.3
Safety while travelling	13.6%	20.8%	33.5%	31.9%	-14.6
Reliability	3.1%	12.6%	31.9%	52.4%	13.1
Familiarity	13.6%	35.6%	40.3%	10.5%	-22.5

TABLE 9 MNL Model results

Variables		**Coefficient**	**t-value**
Train	Cost	-0.061	-14.1
	Travel time	-0.01	-3.8
	Regularity	-0.005	-2.7
Bus	Cost	-0.103	-4.0
	Travel time	-0.021	-9.5
	Regularity	0.003	3.9
Car	Cost	-0.037	-1.9
	Travel time	-0.017	-6.6
N		1305	
ρ^2 (0)		0.334	
ρ^2 (c)		0.198	
Final likelihood		-995.030	