IMPACT ON TRAVEL DECISIONMAKING OF ROAD USER CHARGING IN DUBLIN TRIAL

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Abstract

Road use pricing is a means of ensuring that transport users pay a sizeable amount of the external costs that are associated with transport but that are currently not paid by the transport user; a policy which supports the user pays principle. In the past, research on road use pricing concentrated on the technical aspects of road use pricing but more recently the issues needing attention include political and public acceptability. Road user charging is considered in this paper as part of a research project which looks at its potential as a means of managing traffic demand. It is examined in the context of how it would supplement the integrated package of existing measures in the Dublin Transportation Initiative. Preliminary indications of user response to distance and time based road user charging have been measured as part of the EUROPRICE project. In addition, the impact of the measure using cordon tolls on a city-wide basis is evaluated using the Dublin Network Model of Dublin. The aim of the paper is to compare the two pricing methods in terms of their impacts on decision making.

Keywords: road use pricing, urban, transport

1. Introduction

In the past, Dublin's transport system has relied heavily on private transport. All transport strategies devised before 1990 dealt primarily with providing road space for car users with much less emphasis placed on public transport. Up to that time and even much more recently, the key indicator of performance was the throughput of private vehicles on the network. Dublin is not the only city to have adopted this approach but clearly redressing the balance between private and public transport is all the more difficult in cities with such histories.

Dublin is currently going through a difficult and complex stage in its development, particularly in terms of providing transport infrastructure and services to match demand. The current alternative to the car is an unreliable bus service that suffers from capacity and reliability problems in peak periods, although this should be rectified with the introduction of Quality Bus Corridors (QBCs) and an increase in the number of buses in service. Upgrading the bus service is one of the key elements of the Dublin Transportation Initiative, a strategy devised in 1994. Other measures include Light Rail Transit, removal of long-term parking and environmental traffic cells. Implementation of the strategy, however, has been slower than expected and has been compounded by unprecedented increases in car ownership and usage levels associated with heightened economic activity. Management of traffic congestion, therefore, is becoming all the more difficult, despite the existence of balanced and innovative plans.

Road user charging is considered in this paper as part of a research project which looks at its potential as a means of managing traffic demand. It will be examined in the context of how it would supplement the integrated package of existing measures recommended in the Dublin Transportation Initiative (Dublin Transportation Initiative, 1994). Preliminary indications of user response to road user charging have been measured as part of the EUROPRICE project (O'Mahony, Geraghty et al, 1999) and are presented in the paper. In addition, the impact of the measure on a city-wide basis will be evaluated using the Dublin Network Model of Dublin.

2. Background

Promotion of policies for internalisation of the external costs of transport have been high on the priority list of EU R&D and at policy making level for some time, as indicated by the Green Paper entitled Towards Fair and Efficient Pricing in Transport (CEC, 1995). Evidence presented in the Green Paper indicates for many journeys there is a significant mismatch between prices paid by individual transport users and the costs they cause. The price paid for a journey rarely reflects the true costs of that journey. Costs related to environmental problems, accidents and congestion are only partly covered or in some cases not at all.

The EU has funded several R&D projects to research the feasibility, practicability and justification for using road use pricing as a traffic demand management measure. These projects include TRENEN, TRENEN II STRAN, AFFORD, TRANSPRICE, EUROTOLL, PETS, AIUTO, CAPRI and EUROPRICE. In summary, they examine the charge levels that should be applied, test the technology options and address the acceptability issues associated with road use pricing. In the past, research concentrated on the technology necessary to implement and operate road use pricing. Technology now exists in the form of electronic tolling to provide cordon systems whereby e.g. car users wishing to enter a city are required to pay for the privilege. Although it is possible to differentiate pricing for different periods of the day (charging more in the peak periods than in offpeak) this method of road use pricing internalises some of the external costs but not all and not on a precise basis. However, it is difficult or even impossible to implement first-best policies (charging a transport user precisely for the marginal external costs they impose) for both theoretical and practical reasons. Therefore one must concentrate on second-best policies.

Second-best policies include parking fees, toll booths, fuel taxes, kilometre charges, peak hour permits, cordon charges, area licenses, restriction of car parking space, minimum vehicle occupancy (such as High Occupancy Vehicle (HOV) lanes in the US), odd/even number plate constraints, public awareness campaigns and traffic calming. Clearly some of these policies internalise more of the external costs than others and some have serious implications with regard to acceptability.

Research on road use pricing in Ireland has evolved in two projects; a scoping desk top study commissioned by the Department of the Environment and a demonstration type project funded by EU DGXVII. The former sought to examine the potential impact that road use pricing would make on the transport scene in Dublin. The latter formed part of a project, entitled EUROPRICE, funded by the EU DGXVII to evaluate the transport demand impacts and the energy impacts if road use pricing were to be introduced in Dublin. This was done by exposing a sample of volunteers to road use pricing in a trial and observing changes in travel decisions as a result. The results from both projects form the basis for this paper.

3. Trial Methodology

The trial involved applying distance and time based road use pricing and evaluating the impact on decision making relating to transport of 23 individuals. The aim was to see if road use pricing would change their travel behaviour. The most interesting aspects of the work were the fact that real subjects were used in the study and the method of road use pricing considered is novel and relates quite closely to the kilometre charging method under consideration more recently in the Netherlands.

3.1 Pricing Method

An in-car unit was designed that could apply the pricing regime in each of the vehicles of the participants. Time differentiated, distance and time based pricing was the method used in the study. This method is capable of internalising the marginal external costs of transport more closely than point based methods, such as cordon pricing, because it relates to the transport characteristics of the journey i.e. the longer the journey and the longer the time spent queuing the higher the charge. Time differentiation allows higher charges to be applied in peak periods when external congestion costs are higher. A heavier weighting was applied to the distance proportion of the road user charge to eliminate the likelihood of unsafe driving suggested by Bonsall and Palmer (1997).

To add incentive, the individuals were given real money budgets in advance of their participation. Although this does not represent the true life situation if road use pricing were to be introduced when individuals would pay for road use pricing from their own income, it was considered that some incentive would be required to illicit a relevant response. If an individual decided to find alternatives to using their car they were allowed retain the budget but if they wished to continue to use their car they could use the money to pay for road use pricing. Very low charges were applied in the offpeak periods and the charges applied in the peak period were such that the average peak period trip of each individual cost £5 (6.4 Euro). An LCD on the dashboard of each vehicle provided the driver with information on the pricing regime in place at any time, the distance they had travelled since their trip commenced as well as the length of time which had passed since the start of the trip. In addition, the balance of their budget remaining for the remainder of the week was also shown on the LCD.

Another feature of the in-car unit was its logging capability. It was designed to log trip data such as the start and end time of each trip, the distance and duration of each trip and the cost of each trip, as priced using the road use pricing regime in place at the particular time the trip was made. Baseline data was logged for three weeks prior to the road use pricing phase so that before and after comparisons of the data could be made.

3.2 Sample

Detailed characteristics of the sample are presented elsewhere (O'Mahony, Geraghty et al, 1999) but a summary is given here. Those individuals who had responded to a call for volunteers were evaluated in terms of their suitability for participation in the trial. As the study was conducted in an urban environment and because traffic congestion in Dublin during peak periods is excessive, one important criterion used for selection was that the individual used their car for their trips to and from work. The sample was made up predominantly of university based volunteers with a range of incomes. Almost all had free parking spaces at their place of work although the demand for parking usually outweighs supply.

3.4 Road Use Pricing Trial Results

The trip data from the in-car units were analysed to observe differences in behaviour between baseline and when road use pricing was in place. Twelve variables were evaluated:

- Number of trips per week
- Number of peak period trips per week
- Number of offpeak period trips per week
- Total time spent travelling by car per week
- Time spent travelling by car in peak periods per week
- Time spent travelling by car in offpeak periods per week
- Total distance travelled by car per week
- Distance travelled by car in peak periods per week
- Distance travelled by car in offpeak periods per week
- Amount of money spent per week on road use pricing
- Amount of money spent per week on road use pricing in peak periods
- Amount of money spent per week on road use pricing in offpeak periods

The impact of road use pricing on each of these variables is presented in Table 1. One may observe that there is a large difference between the baseline data and road use pricing data for the peak period with a smaller difference for the 'total' variables. There is less evidence of particular trends emerging in the offpeak data. The significance of the differences in the test data was tested using the t-test. The peak period data showed significance higher than the 95% confidence level and most of the 'total' variables also indicated highly significant impacts. The impact on offpeak period travel was not significant.

Table 1. Impact on measured variables of road use pricing (O'Mahony, Geraghty et al, 1999)

VARIABLE (per week)	AVERAGE / WEEK	AVERAGE / WEEK	% CHANGE	t-test result (>1.725 - 95% conf)
Total Trips	24.5	23.1	-5.7	1.38
Peak Trips	10.2	8.0	-21.6	3.63
Offpeak Trips	14.3	15.1	+5.6	0.95
Total Travel Time (mins)	422.6	382.7	-9.4	1.82
Peak Travel Time (mins)	234.8	193.2	-17.7	2.9
Offpeak Travel Time (mins)	187.8	189.5	+1.0	0.11
Total Distance Travelled (km)	158.5	138.9	-12.4	1.87
Peak Distance Travelled (km)	74.7	56.2	-24.8	3.49
Offpeak Distance Travelled (km)	83.8	82.7	-1.3	0.12
Total Amount Spent	39.9	32.8	-17.8	2.34
Amount Spent in Peak Period	28.9	22.3	-22.6	0.18
Amount Spent in Offpeak Period	10.9	10.5	-1.0	0.4

4. Modelling Road Use Pricing

The Dublin Transportation Network Model system has been designed so that it can be applied at a strategic level for medium to long-term planning. It can also be refined and focused for supporting (tactical) detailed scheme design and implementation issues. The model system has been developed by the Dublin Transportation Office in an incremental way from the strategic (and simpler) level to the more detailed tactical level retaining always the capability of being run at the coarser level. Furthermore, the model system has been designed from the outset to be easy to update and enhance in the future.

In the trip generation models the number of trips generated in a zone is modelled as a function of socio-economic characteristics of that zone. Generation models typically do not include transportation variables such as travel times and costs. Usually, however, the level of car ownership is included as an explanatory variable.

The trip distribution methodology makes use of the observed trip patterns collected in the origin and destination surveys conducted by the Dublin Transportation Office and Dublin Corporation. Future year trip matrices are produced by incrementally adjusting the observed base year matrices to match the zonal growth rates produced by the trip generation models.

Mode split modelling is undertaken using logit formulation and applying generalised cost parameters derived from disaggregate stated preference surveys. Road traffic assignment is undertaken within a true equilibrium framework.

Mode choice and assignment in congested urban networks are not independent effects. This is explicitly recognised in the Dublin Network Modelling system; trip makers who have a car within their choice set are subject to 'equilibration' between mode choice and assignment models. This means that there is consistency in the treatment of generalised cost, the key determinant of travel choice, between assignment and mode choice.

The Dublin Network Model (DTI, 1994) covers Dublin city and county and parts of the counties bordering Dublin county; in other words the area which is within commuting distance of the city. The supply of transport infrastructure in this area is represented by a series of networks. Each mechanised mode has its own network - one representing the road system for use by cars and commercial vehicles, one representing the bus routes and their associated operating frequencies and one representing the rail services and associated operating frequencies.

4.1 Model Details

The 367 zone DTO SATURN/SATCHMO transportation model was used for the road use pricing runs. The model exercises were run by the Dublin Transportation Office. The average values of time used were £6.76 (8.6 Euro) per hour for the peak period and £7.63 (9.7 Euro) for the off peak period (Oscar Faber et al, 1999)

4.2 Model Test Description (Oscar Faber et al, 1999)

Two road pricing schemes were considered for the peak period. These were:

- an inner cordon covering the boundary of the central business district (CBD)
- an area-wide system, defined by the line of the outer ring road (about 10km from city centre) where a charge is made for time spent travelling within the area bounded by that road.

An elasticity of –0.2 was used for the two tests. A standardised charge of £3 (3.81 Euro) per trip was applied both tests.

The tests were as follows:

Test 1

- Inner cordon only
- Cordon charge £3 (3.8 Euro)
- Elasticity –0.2

Test 2

- Outer ring road cordon
- Charge relates to time spent travelling within cordon

- Average charge £3 (3.8 Euro)
- Elasticity –0.2

4.3 Modelling Results

Test 1 applies a charge at the inner (canal ring) cordon and thus intercepts only those trips entering or crossing the centre of Dublin. Those trips starting in the centre of Dublin incur no charge. Out of a total of 133,378 trips within the Greater Dublin area, only 33,134 (25%) would incur the charge (3.8 Euro). With an elasticity of – 0.2, nearly 4,000 trips are suppressed with a further 1,600 diverting around the centre.

Despite the fact that there is a 3% reduction in the number of trips, the reduction in the number of vehicle-kilometres is only 1.7%. The influence on travel times is far greater than the reduction in the number of trips or vehicle-kilometres. This demonstrates that the policy is effective in reducing congestion. As would be expected, the improvement is greatest in the central area (within the canal ring), though there is still a significant effect outside this.

Table 2 Traffic Impact Results (Courtesy of Dublin Transportation Office)

Indicator		Baseline (DTO Strategy 2006)	Test 1	Test 2
Original No. of Trips		133,378		
No. of trips intercepted		0	33,134	92,188
% of original			24.8	69.1
Trip Reductions		0	3,988	16,550
% of original			-3.0	12.4
Vehicle Kms.	Total	2,030,733	1,996,033	1,872,238
	Change from		-34,700	-158,495
	Baseline		-1.7	-7.8
Average Trip Length (Kms)	% Change	15.2	15.6	16
Vehicle Hours - Central Area	Total	14,199.5	13,170.9	10,399.5
	Change from			
	Baseline		-1,028.6	-3,800
	% Change		-7.2	-26.8
- Outer Area	Total	71,097.9	67,531.6	60,020.8
	Change from			
	Baseline		-3,566.3	-11,077.6
	% Change		-5.0	-15.6
- Total	Total	85,297.4		
	Change from		80,702.5	70,419.8
	Baseline		-4,594.9	-14,877.6
	% Change		-5.4	-17.4

Test 2 charges vehicles according to journey time within the outer ring cordon. This affects 69% of total trips. The charge has been calculated so that an average trip incurs a charge of £3 (3.8 Euro). Short trips incur a lower charge and long trips incur a higher charge. More than 17% of the total number of trips are suppressed. This results in a reduction of 7.8% in the number of vehicle-kilometres. There is a greater suppression of short distance trips than long distance trips. The reduction in vehicle hours is more than twice as great as the reduction in vehicle-kilometres. This indicates a significant reduction in delays for those vehicles remaining.

5. Summary of Trial and Modelling Results

Although the road use pricing methods applied are quite different it is worth examining the orders of magnitude of response to the measure, shown in Table 3.

Table 3. Summary of trial and modelling results

Variable	Trial (Distance and Time Based Pricing)	Modelling Test 1 (Cordoning of CBD)	Modelling Test 2 (Time based Pricing)
Reduction in Number of Trips (%)	21.6	3.0	12.4
Reduction in Vehicle kilometres travelled	24.8	1.7	7.8
Reduction in Time Spent in Vehicle	22.6	5.4	17.4

Essentially it is not correct to compare the results of the trial with those of modelling. However, it does display the difficulty in predicting the likely outcome of introducing road use pricing. Generally, the results produced by the model indicate a weaker response to road use pricing than those presented by the trial. There are a couple of reasons for this. Firstly, one might expect that in a short trial such as the one presented where individuals are given a real money budget they may well wish to maximise the amount of money they receive. There is no way of proving that this is how the individuals responded but it is a likely scenario. If there was such a response by the participants, one might expect the impact to be higher in this case than in a real-life situation if road use pricing was introduced on a full-scale basis. Secondly, it is difficult to identify the most suitable elasticity values to use for road use pricing given that there are so few examples available world wide to gain experience from. The elasticities used here were loosely related to the elasticity of fuel price increases.

As one may observe in Table 3, the time and distance based methods prove to be more effective than point-based charging. This is because the distance and time based methods internalise more closely the external costs of transport which typically means that the cost per trip is greater than when a cordon based charging system is employed.

6. Conclusions

The conclusions of the paper are as follows:

1. There was a significant reduction in peak period travel as a result of road use pricing in the trial.
2. Total travel demand was also reduced marginally as a result of road use pricing in the trial.
3. The effectiveness of road use pricing was considerably higher in the trial than in the modelling exercises. This may be due to the fact that the trial was short and that individuals may have been trying to maximise their short-term gains.
4. As expected, distance and time based pricing and time based pricing were more effective than point-based charges.

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