Transport policy prioritisation for Dublin

E. GIBBONS[1] & M. O'MAHONY[2,*]

1 *Dublin Corporation, Civic Offices, Dublin 8, Ireland;* 2 *Department of Civil, Structural & Environmental Engineering, Trinity College Dublin, Dublin* 2, *Ireland*

*(*Author for correspondence: E-mail: mmmahony@tcd.ie)*
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Abstract.
Internalisation of the external costs of transport is currently the subject of much debate. Estimation of costs such as those of pollution and congestion is a primary element in any strategy involving policies for use in the internalisation of these costs. The objective of the TRENEN II STRAN project, funded by the EU, was to develop a methodology for estimation of the marginal external costs of transport. The model developed during the project was used in a series of case studies. One of the case studies. that conducted for Dublin, is reported in this paper. A brief summary of the TRENEN approach is presented followed by the results for Dublin produced from policies such as Do Nothing, Uniform pricing (internali sing external costs by means of fuel taxation), Congestion Pricing (cordon pricing) and a first-best policy , the Full Optimum where one assumes that the policy maker has perfect pricing instruments availab le. As one would expect, the model shows that the greatest reduction in traffic level and external costs would occur if it were possible to introduce a highly differentiated and sophisticated pricing system. Increased taxation on fuel is not an efficient policy as it does not address the marginal external costs of congestion in a way that time-differentiated road-use pricing would. The results from testing of the different measures are interesting particularly those relating to parking and the way in which residents within the CBD and commuters to the CBD are dealt with.

Introduction

The transport system in many urban settings today is unbalanced in terms of demand and supply. This is particularly evident in Dublin where the increase in car ownership and usage has grown at an unpredicted rate in the last few years. The Dublin Transportation Initiative (DTI 1994), a strategy formulated in 1991-1994, is now at its implementation stage but is already out-of-date due to these unprecedented high growth rates. Many of the problems are associated with the poor level-of-service and lack of appropriate capacity of the public transport service. Public transport tends to be street-running and in most parts of the city is vying for the same road space as private transport. Fundamental to the imbalance is the lack of familiarity, acknowledgement and the fact that transport users do not pay for the full costs of transport particularly external costs.

Dublin is analysed using the TRENEN model, a model developed for use in the prioritisation of transport policies using the estimation of the marginal external costs of transport as an indicator. The paper is timely in that road use pricing is currently the subject of a scoping study by the authorities in Dublin to estimate its potential for use as part of a package of policies to address current transport problems in the city.

TRENEN model

Transport activities in an urban area are represented as a set of interrelated transport markets in the TRENEN model (Van Dender, Proost & Ochelen 1997). A market corresponds to the use of a particular transport mode (e.g. small petrol car) with a given occupancy rate (pooled or not) in a particular time interval (peak or off-peak) in a homogenous city. Demand is a function of the generalised costs on all markets. The generalised cost of a trip consists of resource costs, time costs and different types of taxes. The markets interact through changes in generalised costs. A market equilibrium is reached through maximisation of a welfare function under a set of constraints on the policy instruments. The welfare function is the weighted sum of consumer surpluses, producer surpluses, tax revenue and external costs.

The TRENEN model is somewhere between a general equilibrium model and a typical transport network model. In a general equilibrium model, transport is just one of the goods considered. In a typical transport model a network with spatial characteristics provides the framework for simulation of traffic flows. TRENEN takes a partial equilibrium approach in that the feedback on non-transport markets is neglected and prices on other markets are fixed. Tax revenue is returned in a lump sum way, and the valuation of externalities depends only on changes in the transport market.

Framework of the TRENEN model

The structure of the TRENEN model is explained in Van Dender, Proost and Ochelen (1997) but can be summarised diagrammatically as shown in Figure 1. The model comprises three components: a demand module, a supply module and an equilibrium price module. The model is calibrated for a given reference equilibrium using observed or forecasted money prices and quantities for all modes of transport together with information on the ease of substitution between transport and other goods as well as between the different modes of transport.

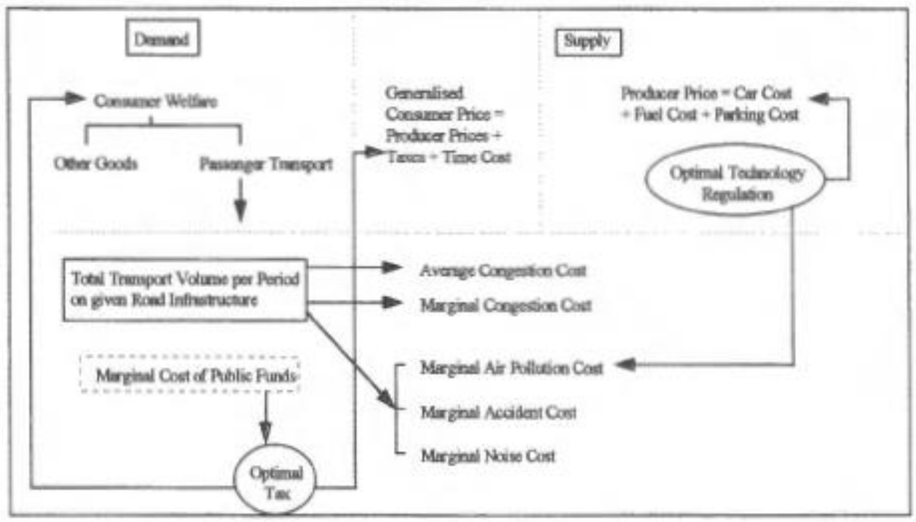

Figure 1. Structure of the TRENEN model (Van Dender, Proost & Ochelen 1997).

The utility function used in the TRENEN model (Van Dender, Proost & Ochelen 1997) contains seven levels of decision making resulting in a wide range of options available to the transport user. Supply of private and public transport is assumed to take place under constant returns to scale, implying that changes in volumes have no effect on the marginal production costs.

For the private transport mode a distinction is made between large and small cars, between petrol and diesel cars and between pooled and non-pooled cars. Resource costs are taken as constant per veh.km for each of these categories. An option of improved technology is available for both petrol and diesel cars. The public transport options available in Dublin are bus and rail. Public transport modes are represented by a linear cost function which contains a fixed cost and a proportional variable cost differing by period. Walking times to public transport stops and waiting times contribute to the generalised cost of public transport in the same way as in network models. Waiting times vary as a function of public transport volumes. Frequency is increased up to the point where the marginal savings in waiting time for all users equal the marginal resource cost of improving the frequency of the service.

Elasticities

Transport is generally demanded only when necessary and therefore the ease of substitution between transport and other goods, at 0.6, is quite low. This would indicate that consumers who demand transport do not have much choice in the matter. Consumers are more willing to substitute between peak and off-peak transport but to an even greater extent the size of car and type of fuel used. Low levels for walking and cycling indicate that it is difficult to get consumers to switch from motorised and non-motorised modes of transport.

This is reflected in the small values associated with the substitution elasticities. For the remaining alternatives available (private or public travel, solo or pooled travel, bus or rail travel) consumers are more willing to substitute between these alternatives in the off-peak period than in the peak period. The substitution elasticity values i.e. the relative degree of substitution between two goods in response to a price change, used are presented in Table 1. Some elasticities required by the model were not available for Dublin and assumptions were made using elasticities measured elsewhere. Although this was not ideal those used are considered to be reasonable estimations.

External costs of transport

The TRENEN model requires a speed-flow relationship to describe how average speed is influenced by traffic flow. The speed-flow relationship or congestion function provides the necessary means to compute the time loss suffered by other road users if an additional Passenger Car Unit (PCU) joins the traffic flow. The time loss is then combined with information on the value of time in order to calculate the marginal external congestion cost of an additional PCU kilometre. The speed-flow relationship characteristics are presented in O'Mahony, Kirwan and McGrath (1997).

The external air pollution costs used in the TRENEN model are extrapolated from the ExternE Transport project (1997). They take into account the impact of pollutant emissions on local concentration levels and refer to the external costs of air pollution on human health, materials, crops, ecosystems and global warming. The marginal external air pollution costs for the different types of vehicle considered in the TRENEN model are shown in Table 2.

In calibrating the TRENEN model for Dublin the values presented in Table 3 were used since the necessary accident data for Dublin was not available. The willingness to pay of relatives and friends of the victim to avoid the accident was not included in the cost estimate. Average noise production by traffic in Brussels was studied by Mayeres et al. (1997) and was related to traffic flow and composition. The marginal noise contribution for an extra veh.km could then be estimated.

Generalised prices

The generalised price tends to vary between peak and off-peak periods due to changes in congestion levels. For the private transport user, the generalised price is the sum of the resource cost, the time cost and any taxes that are being paid. The generalised price for public transport consists of the money price (fare paid) plus the value of time. Indeed, where public transport is subsidised (as indicated by a negative tax) the money price may be in fact lower than the corresponding marginal resource cost.

The marginal social cost associated with a particular transport service consists of the marginal resource cost, the time cost and the marginal external cost. The difference between the generalised price and the marginal social cost for each transport mode therefore arises in the difference between the taxes and the external costs. The magnitude of this difference gives an indication of the inefficiency in the particular transport pricing policy being examined.

Table 1. Substitution elasticities used in the TRENEN project.

Transport and other goods	0.6	
Peak and off-peak transport	0.8	
Big and small cars	1.5	
Fuel types	1.5	
	Peak	*Off-Peak*
Motorised and non motorised travel	0.3	0.3
Private and public travel	1.05	1.95
Solo and pooled travel	0.6	1.6
Bus and rail travel	1.1	1.65

Table 2. Marginal external air pollution costs (Van Dender, Proost & Ochelen 1997).

Vehicle Type	Cost (EURO – €)
Diesel Car	0.04 (€/veh.km)
Petrol Car	0.006 (€/veh.km)
Diesel Bus	0.04 (€/pass.km)
Train	0.006 (€/pass.km)

Table 3. Marginal external accident costs (Van Dender, Proost & Ochelen, 1997).

Vehicle Type	Cost (EURO (€) per vehicle km)
Car	0.03
Bus	0.02
Train	0.003

Policy implementation in Dublin

Policy implementation in Dublin to date has largely been regulatory by nature. The emphasis is on better use of existing assets by:

- encouraging improved use of existing road space
- development of the traffic control system control of road works in the city centre
- strategic routes analysis to identify problems and propose solutions.

A large emphasis has been placed on encouraging modal shift from the private car to public transport. The bus service in the city is being promoted through the development of 10 radial Quality Bus Corridors and extending the hours of operation of bus lanes to 12 hours a day. The number of taxis has been increased by issuing of new licenses and taxis are permitted to use the bus lanes. Parking policy measures recently introduced include an increase in long-term parking fees , removal of free on-street parking and the introduction of a wheel clamping and a tow-away service as part of a strict parking enforcement regime. Pedestrian facilities are being reviewed with the overall objective of making the city a more pedestrian-friendly environment and the introduction of a strategic cycle network is underway.

Policy measures for the future of the city include: the completion of an orbital road network around Dublin City (C-ring), introduction of a light rail system for the city and its surrounding region and construction of a Dublin Port Tunnel to redirect heavy goods vehicles away from the city centre. Road pricing was not included as one of the measures recommended in the DTI in 1994 but it received brief mention as an option for consideration in the future. More recently it is the subject of a scoping study commissioned by the DoE and as such has not yet reached public and political debate stage.

Results and discussion

The TRENEN model was calibrated for Dublin for the year 2005. A set of policy scenarios was designed for test by the TRENEN model: a reference pricing scenario, a congestion pricing scenario, a uniform pricing scenario and the full optimum scenario. In the context of Dublin, the congestion pricing scenario and the uniform pricing scenario are reasonable options for test within the constraints of the TRENEN model. It is likely, given geographical and enforcement constraints, that cordon pricing (modelled by congestion pricing scenario) is the way forward if road pricing is to be selected as a traffic restraint measure for Dublin.

The model was run for the reference scenario with and without improved emission technology for cars. The other three policy scenarios were run with and without charging all car users for the resource costs of parking as well as for standard and improved technology. Table 4 details the naming convention adapted for the different pricing policy scenarios. "Reference parking" refers to the case where the resource cost of parking is not paid whereas "improved parking" denotes payment of this cost.

The reference scenario represents the situation whereby policy and infrastructure remain unchanged in 2005. The uniform pricing scenario is a policy study where fuel costs equal the resource cost of fuel plus the EU target levels of excise duty and VAT; the price of gasoline rises from 0.79 €/l to 0.93 €/l and the price of diesel rises from 0. 73 €/l to 0.81 €/l. The price of public transport is constrained to equal that in the reference level.

The congestion pricing scenario simulates the application of a congestion charge to road transport. In the case of the TRENEN model this represents a crude form of cordon pricing. The model distinguishes between those living inside and outside the cordon. Congestion pricing results in a higher price in the peak period for commuters passing the cordon. Fuel prices and public transport prices are constrained to their reference level.

The full optimum scenario implies that authorities have perfect pricing instruments available to them and that they can be used to charge consumers on a precise basis for the full marginal social cost of transport. This policy scenario is used as a benchmark against which to measure other second-best policy scenarios.

Table 4. Naming convention for the different pricing policy scenarios.

REF1	Reference pricing, reference parking, standard technology
REF2	Reference pricing, reference parking, improved technology
UP1	Uniform pricing, reference parking, standard technology
UP2	Uniform pricing, reference parking, improved technology
UP3	Uniform pricing, improved parking, standard technology
UP4	Uniform pricing, improved parking, standard technology
CP1	Congestion pricing, reference parking, standard technology
CP2	Congestion pricing, reference parking, improved technology
CP3	Congestion pricing, improved parking, standard technology
CP4	Congestion pricing, improved parking, improved technology
FO1	Optimal pricing, reference parking, standard technology
FO2	Optimal pricing, reference parking, improved technology
FO3	Optimal pricing, improved parking, standard technology
FO4	Optimal pricing, improved parking, improved technology

Comparison of scenarios

The key results from the different policy scenarios for 2005 are summarised here (Gibbons 1999). Welfare gains are presented as a percentage of total income. When the model is allowed to optimise without constraint, as in the full optimum scenario, the highest welfare gains are achieved as one would expect (see Figure 2). Although the % change from the reference appears small, the internalisation of the external costs of transport can be of the order of 500 E per household per year.

In the congestion pricing scenario, the welfare gain can be attributed to the increase in tax revenue and the shift from private to public transport by commuters. In this scenario taxes on the commuter are almost as high as taxes in the full optimum scenario. The uniform pricing scenario, with reference parking charges, shows very little change from the reference situation. The variation in costs associated with an inhabitant driving a small petrol car alone in the peak period for each of the model scenarios is illustrated in Figure 3. Resource costs remain more or less the same, with a slight increase for the scenarios including improved technology. The parking resource cost does not change but is only taken into account by travellers who pay for parking. A slight increase in taxes is observed in the uniform pricing scenario but the significant change occurs in the full optimum scenario. An inhabitant is not affected by the congestion pricing charge and therefore their taxes remain low. Time costs and external costs decrease with each new scenario, the greatest reductions taking place in the congestion pricing and full optimum scenarios.

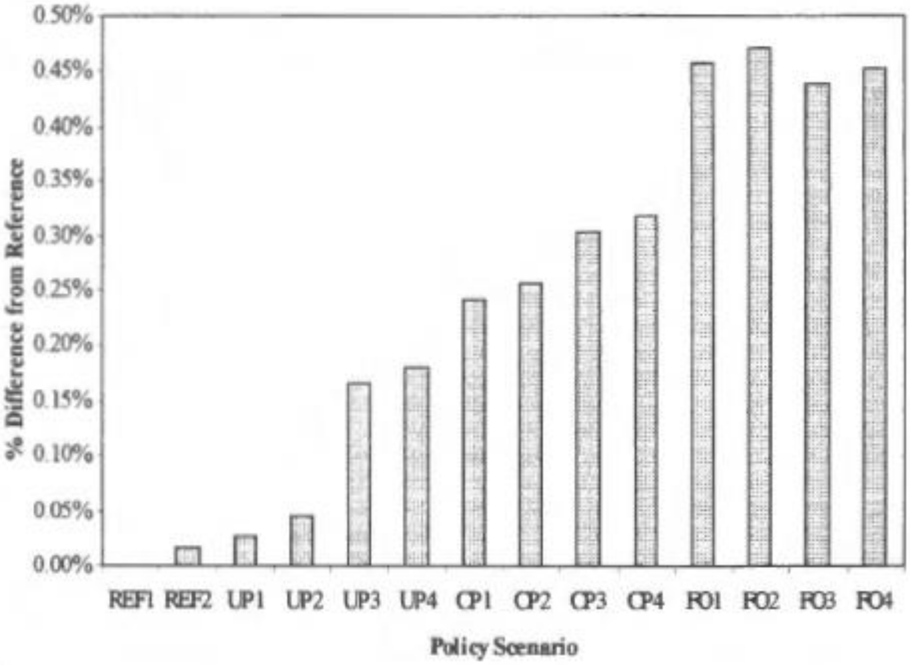

Figure 2. Percentage Increase in Welfare Levels in the 2005 Model.

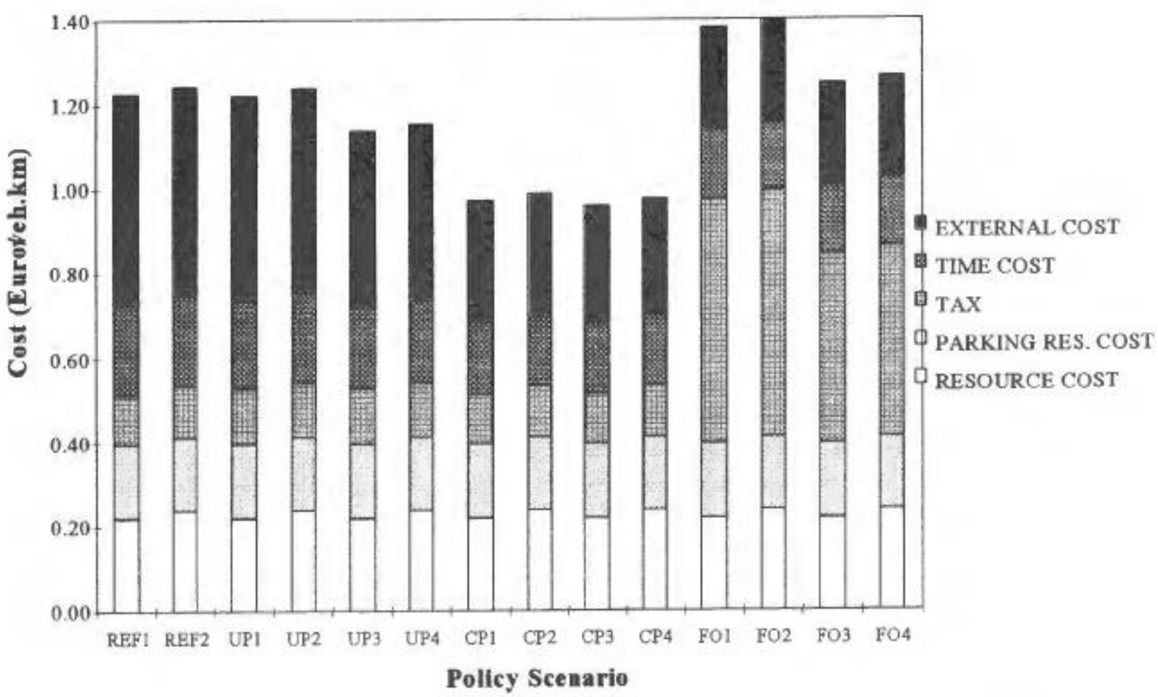

Figure 3. Costs associated with an Inhabitant driving a Small Petrol Car Alone in the Peak Period in the 2005 Model.

The variation in demand for private transport by an inhabitant non-parking payer is represented in Figure 4. The biggest decrease in demand occurs in the full optimum scenario where parking charges are taken into account and vehicles are supplied with improved technology. An increase in demand by an inhabitant non-parking payer occurs in the congestion pricing scenario but this corresponds to the large decrease in demand by commuters as the cost of their journey rises significantly. The greatest changes occur for large and small gasoline cars, driven alone, but this is only to be expected since they are the most common user groups.

With the increase in taxes on public transport in the full optimum scenario, there is a corresponding reduction in demand as illustrated in Figure 5. Demand rises in the uniform pricing and congestion pricing scenarios but this is because public transport prices are constrained to reference year levels while private transport prices rise. The largest increase in demand for commuters using bus is in the congestion pricing scenario.

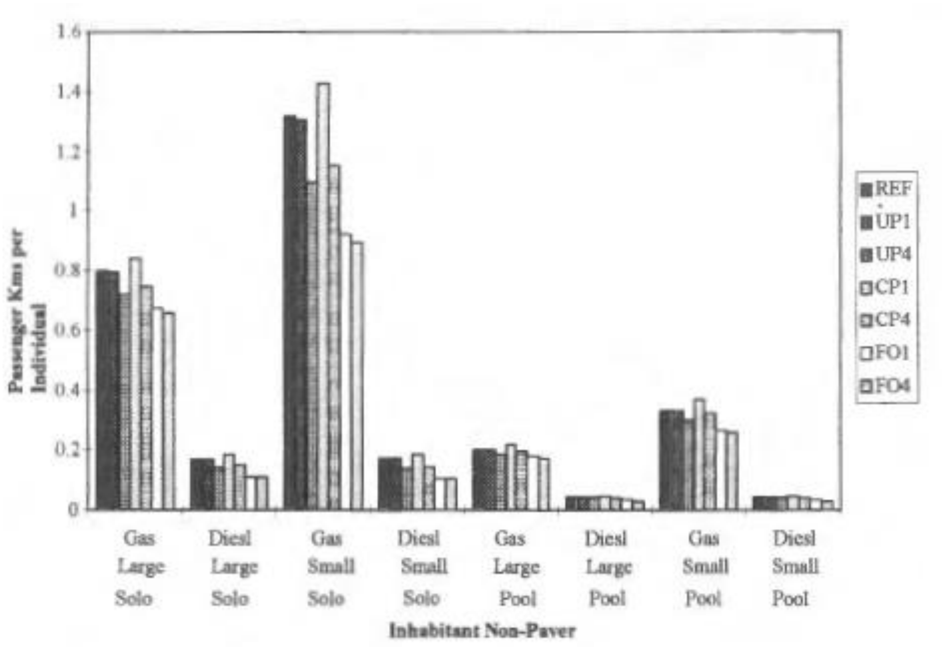

Figure 4. Demand for Private Transport in the Peak Period in the 2005 Model.

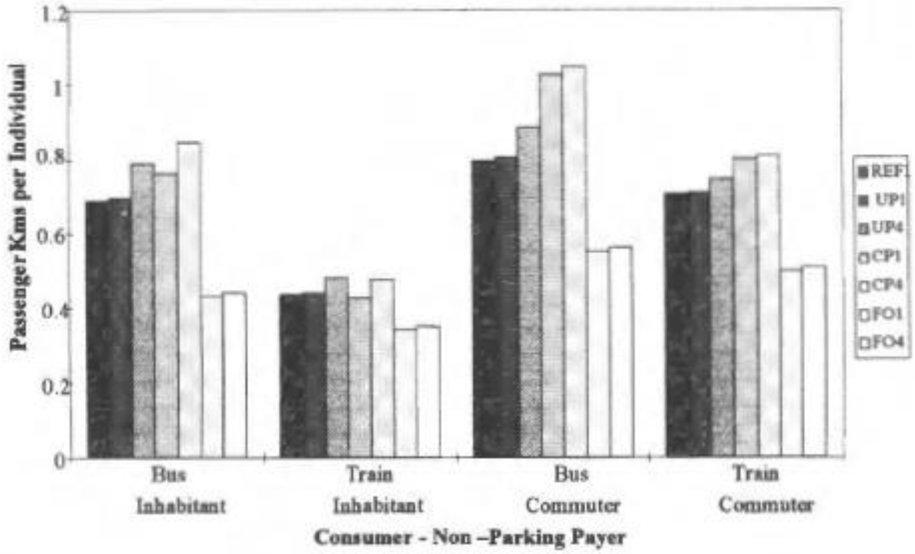

Figure 5. Demand for Public Transport in the Peak Period in the 2005 Model.

The variation in the composition of generalised prices (for an inhabitant driving a small petrol car alone who does not pay for parking) in four of the pricing scenarios considered is presented in Figure 6. There is a correlation between the increase in welfare and the reduction in time cost as a proportion of the generalised price. In the reference scenario, the time cost makes up 38.5% of the generalised price whereas in the full optimum scenario, the time cost makes up only 16.7% of the generalised price (in the peak period). A higher welfare gain means a greater reduction in traffic level. This leads to lower levels of congestion, higher speeds on the network and lower time costs.

An increase in taxes increases the money price as a proportion of the generalised price (from 61.5% in the reference scenario to 83.3% in the full optimum scenario). The resource cost as a proportion of generalised price is higher in the congestion pricing scenario than in the reference scenario; 42.9% compared with 39.5%. This is due to the fact that the generalised price decreases for the inhabitant in the congestion pricing scenario as a result of a reduction in time costs. Also, there is no increase in taxes for inhabitants in the congestion pricing scenario. Tax as a proportion of money price is 35.8% in both the reference and congestion pricing scenarios but more than doubles in the full optimum scenario to 72.8%.

In the off-peak period, the changes in composition of the generalised price move in the same direction as those observed for the peak period. Tax increases are, however, lower in the off-peak period. Tax as a proportion of money price in the full optimum scenario is almost 9% lower in the off-peak period than in the peak period. Since time cost is less significant in the off-peak period, the resource cost as a proportion of generalised price is greater than in the peak period in all pricing scenarios considered.

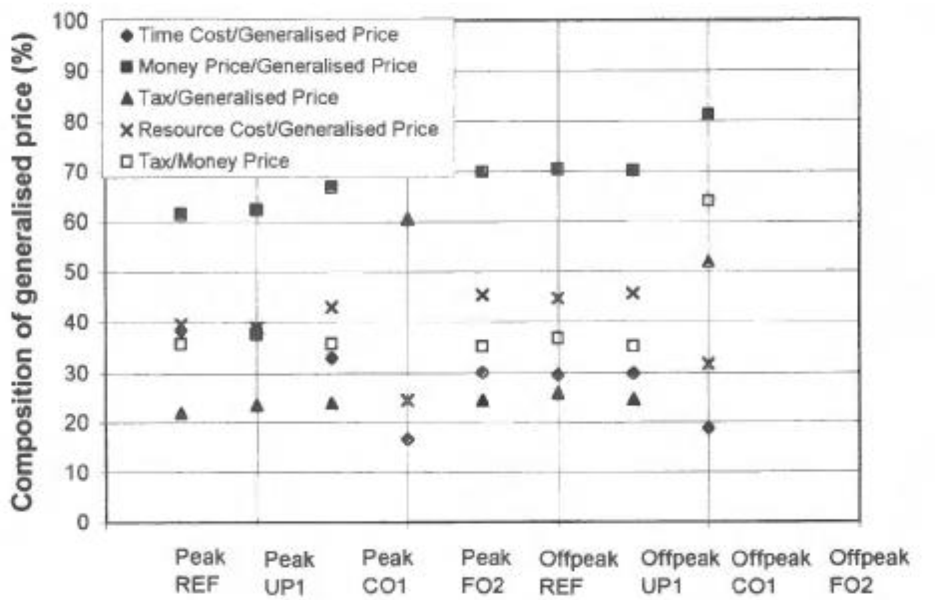

Figure 6. Composition of generalised prices.

It is worth noting when examining the results that the TRENEN model is aggregate and static by nature. There is scope for development of the model to a model more closely aligned to a network model and such development is currently underway at the CES, KULeuven. Although the TRENEN model has some drawbacks in its current form, there is no doubt that such a tool which can give indications of how well second-best policies can perform compared with first-best and with each other is useful for preliminary policy testing by authorities. Needless to say, testing pricing policies using TRENEN would only be a first and indicative stage for policy makers before tackling the more problematic issues surrounding on- street implementation, charge level selection. enforcement. acceptability, political will and public acceptability. Unfortunately, these issues are likely to present similar difficulties in Dublin as elsewhere.

The test results were presented to some of the authorities in Dublin with mixed reaction. TRENEN suggests for a typical commuting work trip that the road use charge level be set at 5-6 E per trip. Such a level is considered too high for acceptability and charge levels are likely to be lower if road pricing were to be introduced. In a recent trial in Dublin involving a small number of participants the charge level suggested by TRENEN was used and resulted in a reduction in car trips in the peak period of the order of 20%. The results of the field trial are to be published elsewhere.

Conclusions

Regulatory policies are incapable of tapping all the mechanisms required to solve transport problems since they overlook human behaviour and do not influence the decision to travel directly. Car running costs tend to be poorly perceived by car owners and appear to have little effect on travel decisions. By making all transport users more aware and more accountable for the full cost of their actions, individuals will be able to make more informed judgements about the costs and benefits of the transport alternatives open to them. There is considerable scope for improvement by bringing prices in line with social costs as current taxes do not represent the full external costs of the different transport modes. The tax on vehicle purchase and the annual motor tax are not well related to the external cost generated by vehicles and although fuel taxes differ according to fuel type they do not always favour those which are least harmful to the environment. Transparency of costs and prices is important so that users can see that the price paid for a given journey is fair in relation to the costs generated and not merely a source of government revenue. Since costs often vary across space, time and modes, there is also a need for differentiation in prices.

The TRENEN model was developed to provide a framework for the evaluation of economic policy instruments. The results for Dublin indicate that the success of policy measures depend upon the consumer being charged an overall higher price for transport and the degree to which that price may be differentiated over space and time. The resulting rise in welfare indicates that the reduction in congestion and pollution combined with reimbursement of tax payments outweighs the utility loss due to the price increases of transport services.

The TRENEN case study of Dublin shows the greatest reduction in traffic level and external costs would occur if it were possible to introduce a highly differentiated and sophisticated pricing system. There would be a large increase in the current level of taxation on the private car user, especially in the peak period. Free parking would be eliminated and taxes on public transport would increase. However, public transport would remain a cheaper option than private transport and would thus encourage a slight transfer to this mode.

A system whereby only taxes on commuters were increased would not produce the same level of benefits as those described above. The demand for private transport by commuters would increase. This would lead to a slight increase in the demand for private transport by inhabitants but the main focus would be the larger increase in demand for public transport. The impact of fuel taxation is clearly related to the charge levels imposed but as fuel cost is only indirectly related to congestion its impact on reducing the total marginal external cost is limited given that the congestion externality is such a large component.

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