EVALUATION OF TRANSPORT POLICY OPTIONS USING WELFARE AS AN INDICATOR[1]

Eithne Gibbons, Margaret O'Mahony and Donal O'Sullivan
Department of Civil, Structural & Environmental Engineering
Trinity College Dublin

Abstract

The relationship between transport, energy and the environment is the main focus of a research project currently underway at Trinity College Dublin. The TRENEN model which was developed by the Catholic University of Leuven is the tool by which strategic transport policies will be ranked in the case of Dublin and Ireland using consumer welfare as an indicator. This research is funded under the EU Transport Programme.

The model is hierarchical by nature and models the average consumer's demand for transport allowing for substitution between various options using a set of price elasticities. If the model is allowed to optimise without constraint it outputs a series of taxes to cover the total cost of transport and in particular the external costs. The optimum chosen is the first-best solution in terms of internalising the external costs of transport and could only be translated into the real world if a very sophisticated pricing mechanism was in place to charge precisely for these costs on a real-time basis. Given the difficulty of setting up this ideal situation, this optimum can be used as a benchmark against which second-best policies can be measured on the basis of consumer welfare.

The network model of Dublin has been supplied by the Dublin Transportation Office to help in the calibration of the reference situation for Dublin which is the first stage of the calibration process. The reference situation illustrates the external costs of transport expected in the year 2006 before any new policies have been implemented. When the reference situation is complete, optimisation runs will be conducted with various sets of constraints to allow a wide range of transport policies to be examined.

1. INTRODUCTION

The TRENEN project involves the development and calibration of two models which deal with the interfaces between transport, energy and the environment. The models optimise to an equilibrium which incorporates the marginal external costs of transport in addition to the marginal private costs of transport. One model deals with the interregional transport market while the other deals with the urban transport market. The urban model is currently being implemented in various cities across Europe for the purposes of the TRENEN project which is funded under the EU Transport Programme. The cities involved in the project are Amsterdam, Athens, Bologna, Brussels, Dublin and London. This paper deals solely with the progress to date on the implementation of the urban model for the Dublin case study.

[1] This paper is produced and circulated privately and does not constitute publication. It may be subject to revision before publication.

2. THE TRENEN MODEL

Externalities arise whenever the costs associated with a particular activity are not entirely borne by the individual involved. In the case of road transport these extra costs might include air and noise pollution. The individual road user does not take these factors into account in deciding how many journeys to make, either because they are unaware of them or because they are unwilling to do so (Maddison, Pearce et al, 1996). The TRENEN Urban model is a model for numerical simulation and optimisation of pricing policies which address this issue. The model is more aggregate in its approach than conventional transport models in that the network is treated as a single representative area-wide link. It is considerably simpler than network models but in many cases can benefit from the use of data extracted from a network model.

Reference year data on prices, quantities, network characteristics and elasticities of substitution are input to the model. Calibrating the model means that undetermined parameters, such as congestion and pollution levels, are calculated using the information available for the reference year. The underlying assumption in this process is that the reference situation is in equilibrium. When calibrated the model can simulate or optimise various scenarios by considering alternative policy instruments. Policy scenarios are based on the principle of charging travellers for the external effects of their activities. The model deals with different types of policies ranging from fuel tax to more sophisticated forms of road pricing, as well as regulation of technology.

The effects of the policy instruments imposed are reflected in the consumer and producer surplus, tax revenues and external costs. These are then aggregated into social welfare effects. The basic idea of the model is to look for the optimal combination of pricing and regulatory mechanisms in the control of transport demand to maximise the welfare of society. This optimum will be implemented as a market equilibrium with different types of taxes, public transport prices and environmental standards. In general, the optimum situation is where the difference between the total benefits and the total costs is maximised (Van Dender, Proost, Ochelen, 1997).

The mathematical framework of the model is based on economic theory and it is written in the GAMS suite (Brooke, Kendrick and Meeraus, 1992). Consumer demand is derived from the optimisation of a nested Constant Elasticity of Substitution (CES) utility function (Keller, 1976). The CES function is easy to calibrate and requires a minimum of behavioural information: prices and quantities in a reference equilibrium together with substitution elasticities at each level. The nested CES utility function that has been used contains seven levels of decision making. The elasticity of substitution is chosen assuming that the lower down the tree, the easier it is to substitute between the alternatives. The nested structure of the model is illustrated in Figure 1. The assumption of separability which underlies the nested tree structure plays a role in determining the order of the levels of the tree. All goods located on the same branch of the tree will react identically to a price change of a good that is situated on another branch of the tree.

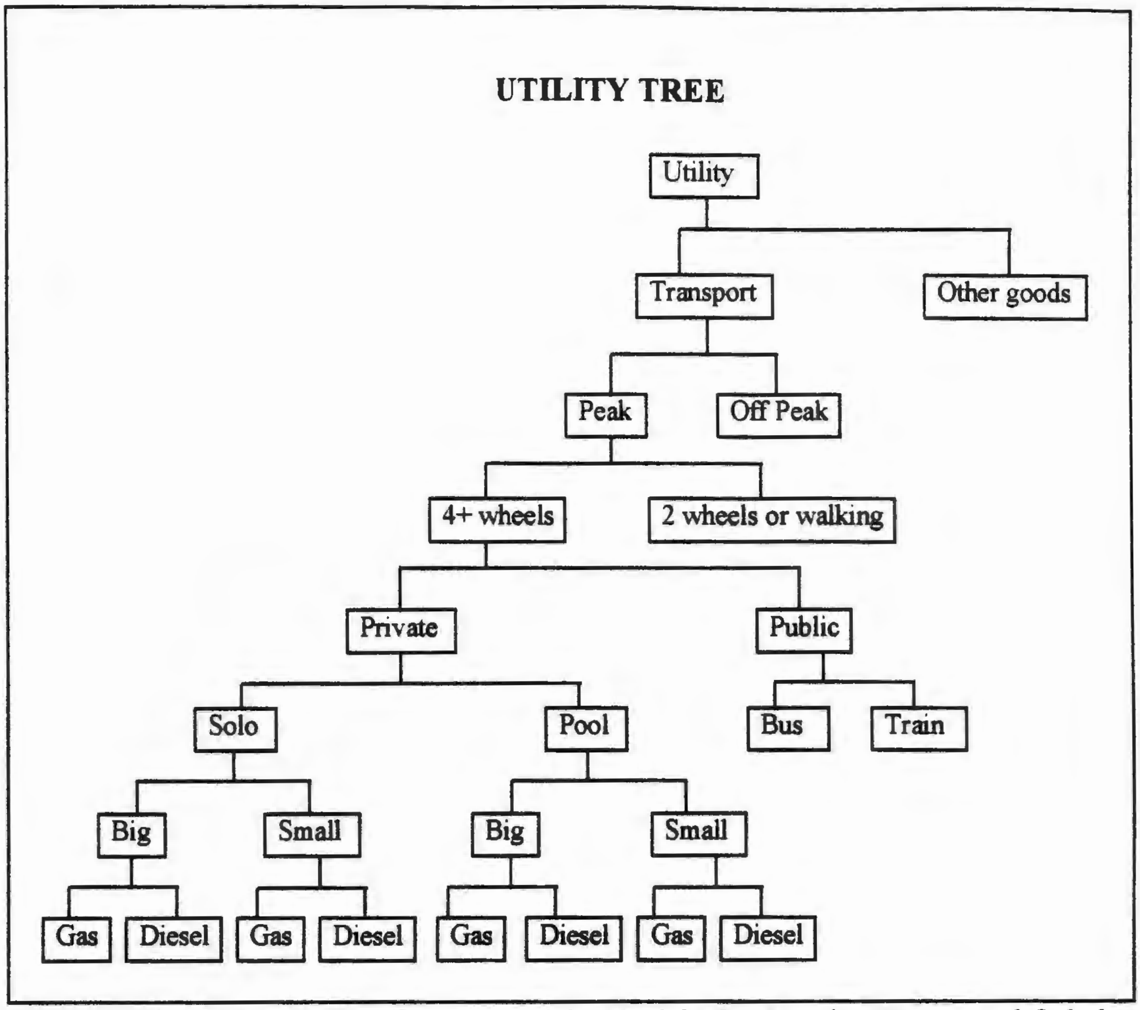

Figure 1: Nested Utility Tree Structure of the Model (Van Dender, Proost and Ochelen, 1997)

The main function of the supply part of this model is to represent the resource costs of alternative transport modes. For the most part, there is no real substitution possibility on the supply side except for the emission technology of cars. The producer can be forced by regulation to supply a particular car technology. The assumption of perfect competition for the private transport modes ensures that producers will minimise total costs. For example, in the absence of pollution regulation or taxation, producers will typically supply vehicles without catalytic converters in deference to vehicles with catalytic converters. Producer prices will thus equal marginal resource costs. 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. Tax revenues from transport are calculated as well as tax revenues from indirect taxes on non-transport goods. It is assumed that all tax revenues are redistributed to the consumer. The extra revenue from improved transport taxation can be used to decrease other, more distorted taxes (e.g. labour taxes). This is taken into account by attaching a positive weight, called the shadow cost of public funds, to tax revenues in the welfare function (Van Dender, Proost, Ochelen, 1997).

3. THE EXTERNAL COSTS OF TRANSPORT

Transport impinges on the environment in a number of ways. Adverse environmental effects are associated with all forms of transport. However, land transport is seen as particularly intrusive because of its proximity to environmentally sensitive areas. Land transport causes a variety of forms of environmental damage which vary in their intensity according to the surroundings in which the transport activity is undertaken (Button, 1993). The 'external cost' of transport refers to the cost that is imposed for which there is no compensation made. The external costs considered within the TRENEN model are: congestion, air pollution, noise, accidents and road damage.

3.1 Traffic Congestion

Congestion is an ever increasing problem within the urban environment. Every additional motorist entering a busy road is slowed down by other road users, and in turn slows down all other road users. Due to motorists differing values of time the time lost due to congestion does not impose an equal cost on all. Bus transport, which is a more efficient means of transport than cars, is also delayed. Bus journey times become less predictable only to further lower their level of attractiveness as an option to the private car user. Congestion reduces the general efficiency of the transport infrastructure, which has implications for the overall performance of the economy (Barrett, Lawlor, Scott, 1997). The marginal external congestion costs are calculated endogenously in the TRENEN model by means of a congestion (or speed-flow) function. The congestion function computes the time loss suffered by other road users if an additional Passenger Car Unit (PCU) joins the traffic flow. This is combined with information on the value of a marginal time saving in order to calculate the marginal external congestion cost of an additional PCU km.

3.2 Air Pollution

Transport is now considered to be the biggest source of air pollution in Ireland (EPA, 1996). It impacts directly on human health, building damage and adds to global warming. Noise is of particular concern in urban areas especially on roads which suffer to a large degree from through traffic. Table 1 provides an overview of the full extent of damage caused by these two by-products of transport. The external air pollution costs used in the TRENEN model are extrapolated from the EXTERN-E consortium results for power plants (ETSU, 1997). Information on the transport of pollutants have been added to these values. The results obtained by EXTERN-E refer to the external costs of air pollution on human health, materials, crops, ecosystems and global warming.

3.3 Accidents

Accidents impose considerably on society. Where road transport insurance is compulsory, the road user takes account of the average private accident costs. However, there are other costs involved. For the purposes of the TRENEN project, the difference between the marginal social cost of an accident and the average private accident cost is the marginal external accident cost. The marginal external accident cost arises in a number of situations: (1) where transport users are not adequately insured, (2) where the insurance system does not deal with all costs related to accidents and (3) where insurance spreads the cost of accidents among all motorists. Other considerations include the risk that car occupants themselves are involved in an accident and the increased risk for car users and other road users due to an additional car on the road.

4. THE NETWORK MODEL OF DUBLIN

The network model of Dublin plays an integral role in the calibration process of the TRENEN model. The network model was developed during the Dublin Transportation Initiative (DTI). The DTI is the result of a major transportation study carried out over four years in the city of Dublin and its hinterland. The DTI was a new and innovative approach to transportation planning in the Greater Dublin area. The technical analysis for the DTI was done using a transport modelling system of Dublin. The computer platform was a combination of two software suites, SATURN and SATCHMO. The transport network of Dublin was replicated on the computer model, with all significant road links, bus routes and rail lines present. The model made predictions for future mode and route choice, thereby providing forecasts of future public transport usage and the number of vehicles on each road.

In 1995, the Dublin Transportation Office (DTO) was set up to co-ordinate and monitor the implementation of the DTI Strategy. The DTO took over the DTI traffic model to ensure that it is maintained and updated regularly so that the model can still be used as a strategic transportation planning tool for the study area.

5. DERIVATION OF A SPEED - FLOW RELATIONSHIP FOR USE IN THE TRENEN MODEL

In order to quantify the external costs of congestion it was necessary to obtain a function describing the relationship between average speeds within the urban network and the overall level of demand for car travel. To derive the congestion function for Dublin the SATURN network model for Dublin was used to calculate average traffic delays and flows resulting from varying levels of demand.

The model runs were straightforward SATURN assignment runs where the demand matrix was assigned to the relevant network. The matrix used in the assignment was the relevant peak or off-peak, all-vehicle trip matrix in PCUs. In previous work carried out on the derivation of a speed - flow relationship for Dublin (Kirwan, O'Mahony, O'Sullivan, 1995) the changes in demand levels were simulated through the manipulation of the matrices. However, in this case demand variations were simulated by changing the parameter GONZO in the list of parameters at the start of the network file. All elements in the trip matrix input to the assignment program within SATURN (SATASS) are factored by GONZO and so changing this parameter had the same effect as factoring the matrix. The 2006 (Do Strategy) network with GONZO = 1 was used as the base network for the subsequent networks. The 'Do Strategy' network for the city includes all highway improvements due to be carried out by 2006. The changes to the base network were made to produce a series of peak and off-peak demands with the parameter GONZO ranging from 0.6 to 1.4 in steps of 0.2. A series of assignment runs was conducted at each of these steps and the 'total travel distance' and 'unit travel time' data were extracted from the results of the assignment runs (SATLOOK). An exponential function was fitted through the data points to produce the relationship between 'unit travel time' and 'total travel distance' for both the peak and off-peak periods as shown in Figure 2.

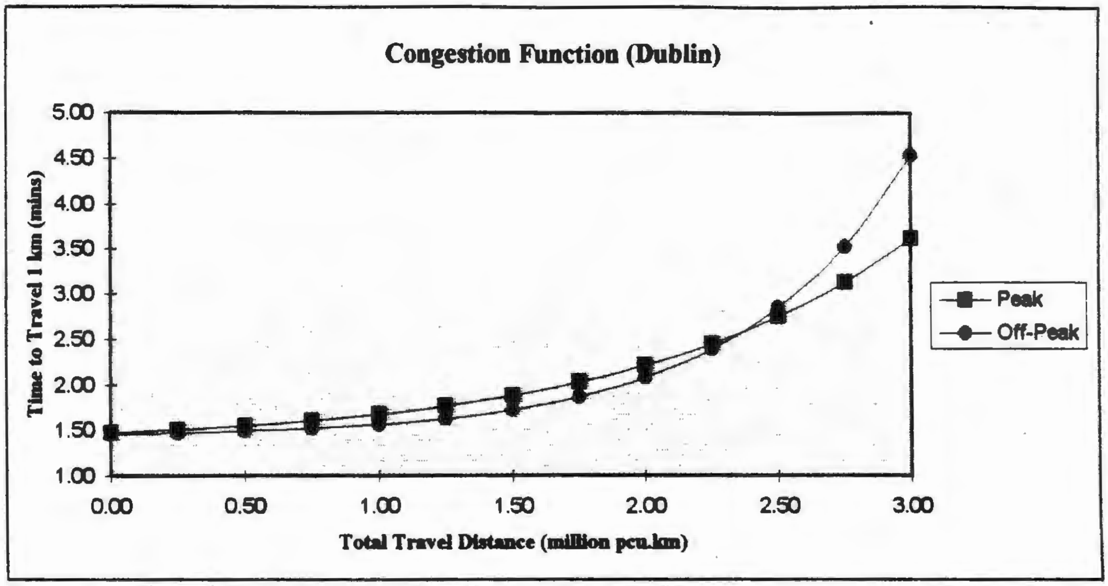

Figure 2: Speed Flow Relationship Derived for Dublin

The relationships are very similar at low levels of demand but the difference becomes more pronounced when demand exceeds 2.5 million pcu.kms. This difference may be attributed to the variation in demand distribution between the peak and off-peak matrices. Demand in the peak-hour includes a large proportion of commuting trips whereas demand in the off-peak hour is more business and shopping related. As a result peak-hour traffic is concentrated on inbound radial routes and on low capacity city centre streets. Off-peak demand is more widely distributed with a higher proportion of flows on higher capacity suburban routes.

The next stage in the process was to assign a mathematical function to the speed-flow relationship. The format of the function had been determined from work by Kirwan, O'Mahony and O'Sullivan (1995) and is as follows:

$$T = A + B\exp^{cx}$$

where T is the time taken to travel 1 km on the network (mins) and
x is the total distance travelled in million pcu.kms.

Through the use of a non-linear curve fitting routine two relationships were derived for the peak and off-peak periods respectively:

Peak Period	$T = 1.34977 + 0.12499\exp^{0.96699X}$
Off-peak Period	$T = 1.43378 + 0.02782\exp^{1.57181X}$

An intermediate level between the peak and off-peak period which is to be used as an all-day congestion function was established from averaging of the peak and off-peak period relationships as shown in Figure 2 and is of the following form:

$$T = 1.41846 + 0.07492\exp^{1.18338X}$$

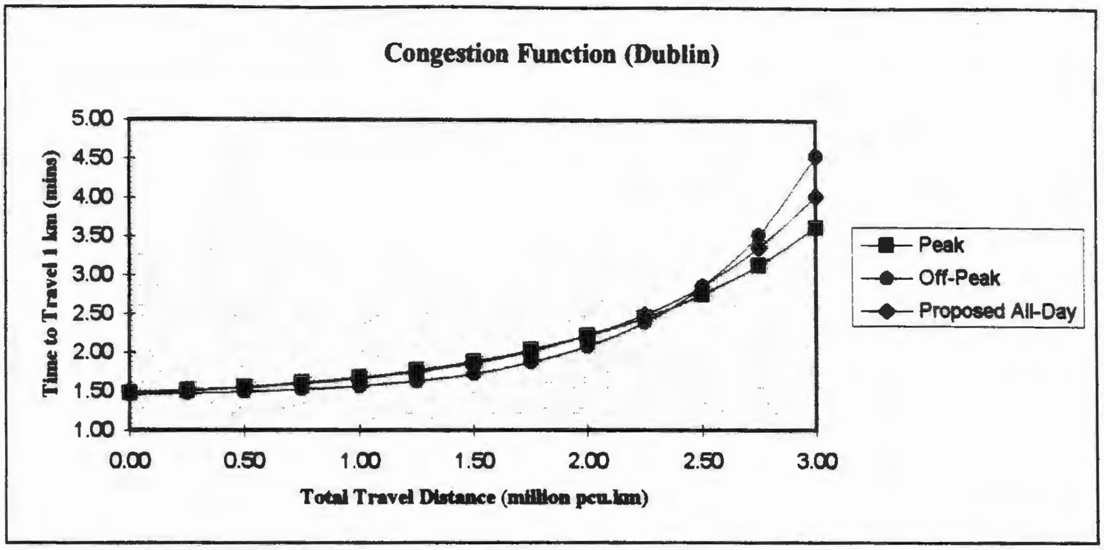

Figure 3: Speed Flow Relationship Derived for Dublin

6. DATA COLLECTION FOR DUBLIN

6.1 Transport Demands in 2005

The TRENEN model distinguishes between four types of consumers on the basis of two characteristics. Residents within a close proximity of the city centre are classified as 'insiders', whereas residents of the peripheral area of Dublin city are classified as 'outsiders'. The zoning system in the SATURN network model of Dublin was used to categorise the consumer type according to 'insider' and 'outsider'. Trips originating in the zones which lay more or less within the canal ring of Dublin were classified as 'insider' trips. The 367 zone trip matrices were compressed into two zone matrices - one zone representing total trips generated by 'insiders', the other zone representing total trips generated by 'outsiders'.

However, demand in the TRENEN model is based on the passenger kilometres travelled by a representative individual per period whereas demand in the network model is based on the number of trips made per hour. To overcome this difference the total number of passenger kilometres travelled in each of the modelled hours was obtained by taking the dot product of the 'insider' and 'outsider' trip matrices (in terms of number of persons) for each mode and the corresponding in-vehicle distance matrix (in terms of kilometres). The in-vehicle distance matrix is a matrix of distances between zones along the minimum generalised cost path. (Generalised cost comprises monetary and time costs). In-vehicle distance matrices for public transport were obtained during the generation of generalised cost matrices. In-vehicle distance matrices for private and freight transport were extracted from the loaded network file by creating a distance skim matrix (matrix of minimum 'cost' routes, where cost is some criteria such as time, distance, monetary cost etc.) for the specified user class. Within SATURN skimmed matrices may be obtained as part of a matrix building option within SATLOOK. Total demands for 'insiders' and 'outsiders' by each mode in both modelled hours in person trips and passenger kilometres are summarised in Table 1.

Mode	TRIPS INS	TRIPS OUTS	Passenger Kms INS	Passenger Kms OUTS	Avg. Trip Length (kms) INS	Avg. Trip Length (kms) OUTS
Peak Hour						
Car	49,080	163,215	412,407	2,579,426	8.40	15.80
Bus	14,913	33,306	96,817	397,806	6.49	11.94
Rail	12,151	29,591	61,917	355,752	5.10	12.02
Off-peak Hour						
Car	41,114	59,188	383,443	841,720	9.33	14.22
Bus	14,423	16,996	87,501	144,202	6.07	8.48
Rail	8,502	7,205	55,920	68,239	6.58	9.47

Table 1: Travel Demands from Network Model

The next step was to convert the peak and off-peak hourly demands of the network model into the peak and off-peak period demands of the TRENEN model. In the TRENEN model an average weekday is considered to be of 13 hours duration containing 2 hours representing an AM peak hour and PM peak hour. The remaining 11 hours are considered to be the off-peak period. It was assumed that travel demand in both peak hours is equal to the demand in the modelled morning peak hour. Similarly demand during all off-peak hours was assumed to be equal to that in the modelled off-peak hour. The travel demands for a representative individual within each period were obtained by dividing total demand within that period by the study area population. The study area population forecasts for 2006 for 'insiders' and 'outsiders' were extracted from the DTI Trip Attraction Generation Model (TAGM) and were found to be 275,371 for 'insiders' and 984,629 for 'outsiders' respectively. The travel demand data for a representative individual is given in Table 2.

Mode	Peak Period INS	Peak Period OUTS	Off-peak period INS	Off-peak period OUTS
Car	2.995	5.239	15.317	9.403
Bus	0.703	0.808	3.495	1.611
Rail	0.450	0.723	2.234	0.762

Table 2: Estimated Travel Demands for a Representative Individual

6.2 Transport Demand by Vehicle Type

The TRENEN model requires further classification of travel demands for the car mode by car size, occupancy rate and fuel type. This data is not directly available and so was derived from data taken from a number of sources. A breakdown of the Irish private vehicle fleet by cubic capacity was obtained in the Irish Bulletin of Vehicle and Driver Statistics (DoE, 1995) and is shown in Table 3.

Classification	Cubic Capacity	Number	Proportion
Small	800 - 1100	205,801	20.8 %
Small - Medium	1101 - 1400	389,930	39.4 %
Medium - Large	1401 - 1700	195,520	19.7 %
Large	1701 - 2000	170,958	17.3 %
Subtotal		962,209	97.2 %
Grand Total		990,384	100.0 %

Table 3: Breakdown of Vehicle Fleet

As can be seen from Table 3 these vehicle sizes account for 97% of the total private vehicle fleet. The distribution of the vehicle sizes are used as the basis for the TRENEN model vehicle classifications

A breakdown of private vehicle ownership according to fuel type is also available in the Irish Bulletin of Vehicle and Driver Statistics (DoE, 1995). Gasoline private cars accounted for 86.3% of all private cars in 1995. This included 898 vehicles using both petrol and LPG. The remaining 13.7% of vehicles were run on diesel. The proportion of vehicles using other fuels was negligible.

It was considered that the classification by size for diesel vehicles should be different to that for gasoline vehicles because a diesel vehicle would rarely, if ever, fall into the small category as specified above. In fact, the 'Recommended New Passenger Car Price List - January 1997' produced by the Society of the Irish Motor Industry (1997) indicates that the number of diesel vehicles with a cubic capacity below 1300cc is very low. In summary therefore, the proportions of gasoline vehicles are based on the actual fleet composition, as shown in Table 3, whereas the proportions of large and small diesel vehicles are based on the assumptions that all diesel vehicles have a capacity between 1300cc and 2100cc and that 50% of these vehicles have a capacity below 1800cc. The classifications and fleet proportions used for the TRENEN model are shown below.

TRENEN Classification	Cubic Capacity	Proportion
Small Gasoline	800 - 1400	61.9 %
Large Gasoline	1400 - 2000	38.1 %
Small Diesel	1300 - 1800	50.0 %
Large Diesel	1800 - 2100	50.0 %

Table 4: Vehicle fleet proportioned according to classification

To account for the demand for car travel in solo or pooled vehicles it is assumed that 20% of all vehicles are pooled. Using the information on vehicle classification the proportions of total demand per person were found and are shown in Table 5. It is assumed that the proportions of total demand do not vary between peak and off-peak periods. These proportions are then applied to the total peak and off-peak period travel demands for a representative individual.

Vehicle Classification	Gasoline	Diesel
Solo Small	42.7 %	5.5 %
Solo Large	26.3 %	5.5 %
Pool Small	10.7 %	1.35 %
Pool Large	6.6 %	1.35 %
Total	*86.3 %*	*13.7 %*

Table 5: Proportions of Demand per Person

The issue of parking is considered by further distinguishing consumers according to those who pay for parking and those who do not pay for parking. The parking cost is assumed to be charged at the destination of city-centre bound trips, not at the consumer's home. 'Payers for parking' incur the resource cost of parking whereas 'non-payers' do not . This implies that 'non-payers' do not take account of parking costs in their travel decisions. For the purposes of the TRENEN model it is assumed that the government bears the resource cost of parking for 'non-payers' which means that 'non-payers' receive a subsidy from the government equal to the resource cost of parking.

6.3 Vehicle Occupancy Rates

Demand in the TRENEN model is represented as passenger kilometres for a representative individual per period by each mode. The equivalent vehicle kilometres is determined by dividing the total demand in passenger kilometres by the average occupancy rate of the vehicle. The average occupancy rate for private vehicles used in the DTI Study was 1.37 persons per vehicle and this is used again as shown below. In the TRENEN model it is assumed that 20% of all private vehicles are pooled and it is necessary therefore to calculate the average occupancy rate for a pooled vehicle. The average occupancy rate of pooled vehicles is given by:

$$VOR_P = \frac{VOR_A - P_S}{P_P} = 2.85$$

where: VOR_P is pooled vehicle occupancy rate
VOR_A is average vehicle occupancy rate
P_S is proportion of solo vehicles (80%)
P_P is proportion of pool vehicles (20%)

The average bus occupancy rates used are based on information from the bus company, Dublin Bus. Average occupancies in the peak and off-peak periods are estimated as 37 and 20 persons respectively.

The average occupancy rates for rail transport are based on average figures for the urban railway line, DART. The capacity of the DART is approximately 180 per carriage. During the peak period there are six carriages per train while in the off-peak period there are four carriages per train. This rail service has proved very popular since its implementation in 1984 and during the peak period the average occupancy is 1080 persons per train. During the off-peak period the occupancy rate averages around 120 persons per train.

6.4 Substitution and Price Elasticities

The assumptions on the way people behave in their transport choices are reflected in the elasticities of substitution since they only have to do with preferences and not with market conditions - the larger the substitution elasticity meaning the more willing people are to substitute one option for another. Price elasticities on the other hand depend on the observed market outcomes. They represent the % change in demand as a consequence of a 1% change in the money price of that particular good. Price elasticities for goods may be derived from substitution elasticities using the relationship between price and substitution elasticities (Keller, 1976):

$$EL_{AA} = \left(-SE_{AB} + W_A\left(SE_{AB} - 1\right)\right)\frac{MQ_A}{Q_A}$$

where EL_{AA} is the price elasticity of demand for transport mode A
SE_{AB} is the elasticity of substitution between mode A and mode B
W_A is the expenditure share on mode A
MQ_A is the money price of mode A
and Q_A is the generalised price for mode A.

The last term is needed because the substitution elasticities are expressed in terms of generalised prices, whereas the price elasticity is expressed in terms of money prices. Cross price elasticities are a measure of the effect of a change in the fares or rates of one operator on the demand for services of another. It can take place between transport modes and also within modes as seen below. A high cross price elasticity would reflect a market which is very responsive to price. An essential service will have a relatively inelastic demand e.g. peak hour commuters; for non-essential trips, demand will be relatively elastic. This is also the case if substitute modes are available.

The most common price elasticities are the own and cross price elasticities of peak car, off-peak car, peak public transport and off-peak public transport. The estimates of these elasticities are summarised in Table 6 (De Borger, Mayeres, Proost, Wouters, 1993).

	Peak Car	Off-peak Car	Peak PT	Off-peak PT
Peak Car	-0.3	0.049	0.708	0
Off-peak Car	0.05	-0.6	0	0.578
Peak PT	0.03	0	-0.35	0.036
Off-peak PT	0	0.02	0.03	-0.87

Table 6: Price Elasticities from literature (De Borger, Mayeres, Proost, Wouters, 1993)

The substitution elasticities used are the same as those applied in the Brussels case study. It is intended that all partners use the same elasticities of substitution (see Table 7) so that a realistic comparison of results may be made between the various case studies in each of the cities.

SL1	Transport and other goods	0.6	
SL2	Peak and off-peak transport	0.8	
SL6	Big and small cars	1.5	
SL7	Fuel types	1.5	
SLA	Freight and other inputs	0.2	
SLB	Peak and off-peak freight	1.2	
SLC	Big and small trucks	1.0	
		Peak	*Off-peak*
SL3	Motorised and non motorised travel	0.3	0.3
SL4	Private and public travel	1.05	1.95
SL5a	Solo and pooled travel	0.6	1.6
SL5b	Bus and rail travel	1.1	1.65

Table 7: Substitution Elasticities

6.5 Private Vehicle Acquisition Costs

Annual acquisition costs for the four types of vehicle classified in the TRENEN model were calculated based on the method presented in Mayeres (1993). The 'Recommended New Passenger Car Price List - January 1997' published by the Society of the Irish Motor Industry (1997) provided the starting data for the calculations. The costs shown were derived from prices for a sample of 37 vehicles. All estimates are based on the following equation (Mayeres, 1993):

$$A_{cash} = \frac{p(1+i)^n - R}{(1+i)^n - 1} i$$

where:

A_{cash} represents the sum one has to save annually when the car is bought for cash in order to be able to buy the same car after n years, taking into account the residual value of the car
P is the purchasing price of the car
R is the residual value at the time of sale
I is the return on savings (in % per year) one has to forfeit
n is the age of the vehicle at the time of sale

In the calculations it is assumed that the actual purchase price is typically 8% lower than the recommended retail price (Revenue Commissioners, 1995). A return on savings, based on the rate of return of a five year government bond, of 5.68% was provided by the National Treasury Management Agency (1997). It is assumed that a new car stays with the original owner for 5 years. In the sixth year it is sold at a price that is 20% of the original catalogue price exclusive of taxes. The process was carried out both including and excluding VAT and VRT (at a rate of 21% and 23.2% respectively) for the purposes of carrying the figures forward to the consumer price and resource cost calculations.

Vehicle Class	Size	Average Retail Price	Actual Purchase Price	Residual Value	Annual Acquisition Cost	
	cc	IR£	IR£	IR£	IR£/vkm	ECU/vkm
Small Gas	800 - 1400	10,251	9,431	1,422	0.1347	0.1840
Small Diesel	1300 - 1800	14,323	13,177	1,987	0.1113	0.1521
Large Gas	1400 - 2000	15,542	14,299	2,156	0.2042	0.2790
Large Diesel	1800 - 2100	16,531	15,209	2,293	0.1285	0.1755

Table 8: Annual Acquisition Costs including VAT&VRT

6.6 Private Vehicle Operating Costs

The calculation of other operating costs incorporates all other non-fuel costs for the privately owned vehicle. For Ireland these were assumed to include motor taxation, insurance and general maintenance costs. To obtain the costs per car-km the annual costs were divided by the average distance travelled in a year by a passenger car. The data was taken from a report on motoring costs published by the Automobile Association (1996) and are presented in Table 9.

Vehicle Class	Car Tax	Insurance (excl Claims)	Licence	Others	Total	Total
	IR£p.a.	IR£p.a.	IR£p.a.	IR£p.a.	IR£p.a.	ECU/vkm
Small Gas	144	260	4	659	1067	0.0999
Small Dsl	216	417	4	1273	1910	0.1058
Large Gas	251	522	4	811	1587	0.1486
Large Dsl	331	571	4	1419	2325	0.1288

Table 9: Operating costs including tax

6.7 Values of Time

The cost of travel time can be regarded as having two distinct elements, an opportunity cost reflecting the value of the activity which the individual would otherwise be engaged in and a disutility element reflecting the characteristics of the journey itself as experienced by the traveller including waiting time, walking, discomfort, etc. The value of time savings to drivers and passengers depends therefore on how the opportunities made possible by the time saving are used.

Studies of the value of time generally distinguish between travel for business and working purposes as opposed to travel for non-working purposes. The values of time employed in the TRENEN model were based on those used in the DTI Study and are presented in Table 10.

	Peak		Off-peak	
	IR£/hour	ECU/hr	IR£/hour	ECU/hr
Private Vehicle	3.06	4.181	3.72	5.083
Public Transport	1.20	1.640	3.72	5.083
Slow Modes	2.40	3.279	7.44	10.165
Freight	11.02	15.057	11.02	15.057

Table 10: Values of Time

7. POLICY SCENARIOS

Testing of transport policies using the TRENEN model is currently underway and results are expected early in 1998. However, the scenarios to be examined are outlined below. All cities involved in the TRENEN project are required to examine the reference, full optimum, uniform pricing and congestion pricing scenarios. These are explained in more detail below.

The 'reference scenario' is that result from the optimisation model in which money prices, road capacity and public transport conditions are unchanged with respect to the reference situation. This means that prices and consequently demands are constrained to their reference year level. The outputs from this run are used as a reference point against which welfare changes may be measured when future year or policy scenarios are tested.

The 'full optimum scenario' is a policy study assuming that sophisticated pricing systems can be used to charge users on a precise basis for the full marginal social cost of travel. It also assumes that vehicle emission technology can be regulated through the mandatory requirement of the installation of catalytic converters.

The 'uniform pricing scenario' is a policy study where fuel costs equal the resource cost of fuel plus the EU proposed level of excise duty and VAT. In this case, the price of public transport is constrained to equal the resource cost of public transport.

The 'congestion pricing scenario' is another scenario which will be tested on all cities involved in the project. For this model run, fuel prices are constrained to their reference level and public transport prices are maintained at resource costs. This results in the model producing toll levels which could be used for determining the levels of congestion pricing. The results of this scenario will be used in another EU funded project, EUROPRICE, currently underway at TCD where the levels suggested will be tested in a congestion pricing trial.

In addition to the above, it is proposed to test policy options for Dublin which reflect different pricing and regulation combinations. These include

- parking restrictions within the city centre
- incentives for car pooling
- restrictions on freight transport within the city centre
- promotion of cycling and walking modes
- promotion of smaller more energy-efficient cars

Work is continuing on the calibration of the model and the analysis of these different scenarios. Results are expected in January and will be published next year.

REFERENCES

Automobile Association - Technical Services (1996), *Motoring Costs - May 1996.*

Barrett, A., Lawlor, J., Scott, S. (1997), *The Fiscal System and the Polluter Pays Principle: A Case Study of Ireland.* Ashgate Publishing Ltd.

Brooke, A., Kendrick, D. & Meeraus, A. (1992), *GAMS - A User's Guide: Release 2.25.* The Scientific Press.

Button, K. (1993), *Transport, the Environment and Economic Policy.* Edward Elgar Publishing Ltd.

De Borger, B, Mayeres, I, Proost, S and Wouters, S. (1993), Social Cost Pricing of Urban Passenger Transport - with an illustration for Belgium. *Public Economics Research Paper No.34. CES Leuven.*

DoE, 1996. Department of the Environment - Vehicle Registration Unit (1996), *Irish Bulletin of Vehicle and Driver Statistics 1995.* Department of the Environment.

EPA (1996). Environmental Protection Agency. 1996.

ETSU (1997) EXTERN-E Project.

Keller, W.J. (1976), *A Nested CES-Type Utility Function and its Demand and Price Index Functions.* European Economic Review, Vol 7, pp. 175-186.

Kirwan, K.J., O'Mahony, M., O'Sullivan, D. (1995), *Speed-flow Relationships for Use in an Urban Transport Policy Assessment Model.* Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Maddison, D., Pearce, D., et al (1996), *Blueprint 5 - The True Costs of Road Transport.* Earthscan Publications Limited.

Mayeres, I. (1993), *The Private Car User Costs.* Centre for Economic Studies, Catholic University Leuven.

National Treasury Management Agency (1997). Personal communication.

Revenue Commissioners (1996), *Statistical Report of the Revenue Commissioners - Year ended 31st December, 1995.* Government Publications.

The Society of the Irish Motor Industry (1997), *Recommended New Passenger Car Price List: Issue 1 - January 1997.*

Van Dender, K., Proost, S., Ochelen, S. (1997), *TRENEN II STRAN ST-96-SC-116 Deliverable D8a - New Model Developments Urban.* Centre for Economic Studies, Catholic University Leuven.