The Delivery and Consequences of Transport Solutions

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Abstract

The conflict between transport demand and the environment is a well-documented issue and one that is particularly pertinent to Ireland at the present time. The result of our recent economic growth has seen a significant increase in car traffic levels during which time car ownership levels have risen from 238 per 1000 in 1991 to 350 per 1000 in 1999. Although still some way off the European average of 454 per 1000, the rapid increase, with associated increased demands on road space, has put increasing strain on the existing road infrastructure. Although one should generally draw a distinction between car ownership levels and car usage, there is evidence to suggest that there is a strong correlation between the two in cities/countries where public transport options are not attractive and where there are limited constraints on car usage.

The aim of the paper is to first of all examine the costs that society and the environment are being subjected to as a result of transportation and secondly to give a broad overview of the solutions being adopted to deal with increased transport demand in Ireland and to comment on their likely impact on the environment and their ability to reduce social costs. It is important perhaps to indicate that environmental problems tend to be associated more with car transport than public transport and although the latter cannot be neglected (particularly with the use of diesel buses) the cost to the environment per person is considerably lower than in the case of car transport (relating to occupancy of vehicle) and hence car transport is seen to be the worse of two evils. In this paper, the emphasis will tend to be on policies focusing on use of the car. Topics to be examined include:

- public transport
- enhancements in vehicle technology to reduce air pollution
- traffic demand management measures
- the potential for using intelligent transport solutions

1. Background

Car ownership is continuing to rise across Europe and there are indications that this has also meant an increase in car use. Ireland’s car ownership levels are considerably lower than that of other EU member states as can be seen in Figure 1 but Ireland is second only to Denmark in terms of the highest car usage levels, presented in Figure 2 in units of person.kms. One distinctive feature, when one examines Figures 1 and 2
more closely, is how countries like Germany, Belgium, Austria and Sweden combine higher car ownership levels with lower use. This can partly be attributed in some cases, such as in Germany, to different household structures – smaller than in Ireland – and also perhaps more sustainable transport trends in terms of modal split but surprisingly traffic levels in Germany have not been reduced.

Figure 1. Number of passenger cars per 100 inhabitants (European Commission, DG Transport figures for 1997)
Figure 2. The distance travelled in kms per person per year (European Commission DG Transport figures for 1997)

There exists only one example where the authorities have won the struggle with traffic congestion and that is Singapore but its success is supported by a political regime which backs car ownership controls. The other important elements supporting its success include its land use policies where 85% of the population live in high-rise apartment blocks, mainly owned by government, a metro system, high taxi levels per capita and traffic management techniques which include congestion pricing. The ultimate transport solution therefore would appear to lie in a combination of policies all focused on reducing the use of the car. The difference between Singapore and Ireland is not in the type of policies being used, because Ireland is adopting many of the policies used in Singapore, but the degree to which the policies are imposed (or allowed to be imposed).

Looking more closely at the environmental impacts of traffic, it has been calculated that 380 people died from causes related to pollution in London last year compared with 226 fatalities from road accidents (Focus, 2001). It is thought that transport emissions are also reducing life expectancy, knocking 34,000 years off London residents' lives every year. A half a million people suffer from minor respiratory complaints in London as a result of transport-related pollution. Although these statistics indicate serious problems, a somewhat surprising finding is that the number of days when air pollution was recorded as moderate or higher fell to 16 days on average per site in 2000, compared with 33 days in 1999. Different analysts of these data have different views. One suggestion is that the levels of nitrogen dioxide pollution is reduced due to the introduction of catalytic convertors. Although individual vehicles are cleaner, more traffic means more pollution.
In summary, there are significant costs associated with transportation: monetary costs, health costs, quality of life costs and environmental costs. A more detailed examination of the costs is presented here.

2. **The Social Costs of Transportation**

The costs on other road users and on society of transportation include the following.

- Congestion costs
- Damage to infrastructure
- Noise
- Accident costs
- Emissions

2.1 **Congestion costs**

External congestion costs are a function of the total value of time losses that transport users impose on each other. O'Mahony, et al (1997) determined the marginal external costs of congestion in Dublin using estimates of volumes and corresponding delay from SATURN model runs. Some of the work presented in Gibbons (1999) suggests marginal external costs of £5 per peak period trip. The function type derived was used to estimate the marginal external costs of congestion in the TRENEN model development (Proost et al, 1998), a model developed to prioritise transport policies on the basis of welfare. It is sometimes argued that road traffic congestion is not a genuine externality but this argument is considered to be incorrect in economic welfare analysis.

2.2 **Infrastructure damage**

Damage to infrastructure refers to the costs of wear and tear caused by vehicles to road infrastructure. These costs are imposed upon the operator of the piece of infrastructure. Not all users impose the same level of damage to transport infrastructure. In terms of road usage, damage is normally related to the weight on the axle under the vehicle in a relationship commonly referred to as the Fourth Power Law. This law states that damage increases with increased axle weight to the power of four. If the infrastructure is built on a particularly weak subgrade (soil is weak), a power of six is used. If one examines the theory more fully, passenger cars cause very little damage to road infrastructure whereas heavy goods vehicles (HGVs) with few axles cause significant amounts of damage.

2.3 **Accident costs**

External accident costs are those costs which motorists impose upon each other in accidents. They may include damage to vehicles, transport infrastructure, personal property, costs incurred by legal, policy-related and emergency services, financial costs of injuries and fatalities, such as medical and funeral costs, psychological costs of pain and suffering, values associated with lives and production losses. Small (1992) suggests that accident costs appear to be higher than those of pollution and are comparable with those of congestion costs. Newbery (1988) estimated total 1984 accident costs in UK at £26 billion. Valuing safety improvements is now done by
means of aggregating the individual's willingness to pay to reduce the risk of injury or death from accidents (Small, 1996). Kahn (1986), Jones-Lee (1990) and Viscusi (1993) have reviewed the empirical measurement of willingness to pay, particularly for death risk reduction. Estimates range from $1.5 – $9.0 million per statistical life.

The problem with accident costs is identifying what part of accident costs are externalities. The relationship between traffic volumes and accident rates is difficult to determine. It may be a simple relationship or a complex one, depending on the interaction of vehicles in the traffic stream. The other important issue relates to how much of accident costs are borne by non-motorists. Pedestrians and cyclists appear to account for more than half of motor-vehicle deaths in UK (Jones-Lee, 1990). Governments normally pay for some medical expenses. This represents an externality if the motorist is not made to pay the costs.

2.4 Noise

Noise is considered to be an important external cost, especially in urban areas. Determining the marginal value of external noise costs is inherently difficult but is exacerbated by the fact that when a car is added to a road on which there is already a high volume of traffic, that car may cause less extra noise annoyance than when the same car is added to a road where there is no traffic. Monetary valuations of the hedonic housing market is the most widely used method for evaluation of the social costs of noise. The idea behind this method is that the value of a house depends not only on its intrinsic characteristics but is also a function of accessibility, proximity to schools, shops and pollution. It is reasonable to expect that houses in noisy locations are of less value than those in quiet areas. Pearce and Markandya (1989) provide a detailed description of the method used. Mayeres (1993) conducts an evaluation of the marginal external costs of noise for transport in Brussels.

2.5 Emissions

The marginal cost of emissions is exhibited in terms of health and the environment. Pollutants emitted by the internal combustion engine include NOx, CO, VOC's, CO2, SO2 and particulate matters. Different methods are available for evaluating the external costs of pollutants. Mayeres (1993, 1994) found the marginal social costs of NOx, VOC and SO2 emissions by road transport were determined on the basis of revealed preference of policy makers. Small and Kazimi (1995) used a direct damage approach. There are three steps to the latter method. The first involves establishing a relationship between a change in the emissions and the resulting concentration of pollutants requiring information from dispersion models. The second step involves relating the change in the concentration level to its effects on health, vegetation, materials, visibility and ecosystems. The EC DGVII ExternE project (Bickel et al, 1998) gives an overview of the required dose-response relationships required at this stage in the process. Finally, a monetary value for the different effects of air pollution is required and is obtainable from the ExternE project (Bickel et al, 1998).

3. Transport Policy Solutions to Offset Costs to Society

In one way or another, the transport policies proposed today for Ireland have at their core the reduction of costs (monetary or otherwise) e.g. journey time costs, traffic
congestion costs, environmental costs etc. A review of some of the policies in use are presented below.

### 3.1 Public Transport

The Dublin Transportation Initiative (DTI) in 1995 recommended a future strategy for Dublin with a high priority given to public transport policies and much less emphasis on new roads. The public transport solutions proposed encompass improved suburban rail, three Light Rail Transit (LRT) routes and eleven Quality Bus Corridors (QBCs). Two of the LRT lines are currently under construction - one from Tallaght to Abbey St and the other from Sandyford to St. Stephens Green. For the purposes of this paper and in light of the fact that the QBCs have already been implemented, it is worth looking at enhanced public transport options and how they impact on transport demand.

In summary, the impacts include reduced journey times by bus and increased journey times by car; an expected outcome. The difference in travel times between the two modes and the increased frequencies are noted as being the key elements in the success of the QBCs. Increases in passenger numbers in the peak periods are of the order of 150%. Passenger facilities have been improved although there is further room for improvement. Although timetables are available at the stops, no real-time information is provided at present although this issue has a high priority and hopefully will receive attention in the near future. Priority at traffic signal intersections would also improve the bus service. Although some priority currently exists where buses are allowed enter the traffic stream a few seconds in advance of the car traffic in parallel lanes, more sophisticated technical options exist in terms of lengthening the green time or initiating the green phase sooner when a bus approaches, whichever is the most appropriate, and these solutions should be considered in more detail.

If one examines the bus travel times and compares them with parallel car journeys, some interesting results can be seen in Figures 3 and 4. The bus travel time is shorter in the peak periods both in the inbound and outbound directions compared with car journeys but car trip time tends to be shorter in the off-peak period. These findings would suggest that the traffic congestion that exists in the parallel car lanes and the fact that QBCs have dedicated road space are important factors in ensuring that the QBCs perform. This is an interesting finding and requires further research to investigate the relationship and gain a more detailed understanding of the balance to be struck between road based public transport and car transport and environmental implications.

### 3.2 Enhancements in Vehicle Technology to Reduce Air Pollution

There have been significant achievements in reducing air pollution per vehicle by means of the catalytic convertor. Although there are further enhancements to be made in diesel technology, some researchers suggest that further tightening of low legal emissions may not accomplish much in the face of increasing car congestion levels. Small and Gomez-Ibanez (1996) suggest that the problem of the remaining emissions are dominated by three main factors that are and will continue to be missed by enforcement measures. Firstly, a substantial proportion of total emissions now comes from a relatively small number of vehicles, known as 'gross polluters'
(malfunctioning vehicles). Secondly, large quantities of emissions arise from brief episodes in ordinary driving. Thirdly, although the recent introduction of car testing is likely to ensure reduced emissions, anecdotal evidence would suggest that not all polluters are eliminated.

![Figure 3 Inbound bus and car travel times on Stillorgan QBC (Dublin Bus)](image)

3.3 Traffic Demand Management Measures

The management of transportation demand, even in cities where public transport options are of a high quality, is a difficult issue. The subjective nature of why individuals choose to use their car makes it difficult for researchers to measure how that decision is made and in some cases the actual variables used in the decision. Useful methods incorporating generalised cost are currently available but modal choice remains one of the most difficult issues to model within the transportation field.
The EU has recognised and wishes to deal with two issues relating to transport demand - the fact that transport users do not pay all costs and the increasing problems of congestion and associated environmental impacts. The EU Green Paper entitled ‘Fair and efficient pricing in transport’ (1996) provides a sound basis on which policy change within the EU and member states should develop.

A few of the more practical methods currently available for managing transport demand are as follows:

• Charging for a use of a particular piece of infrastructure
• Parking charges
• Public transport fares and subsidisation
• Fuel taxes

All of the above methods are examples of what are generally referred to by economists as second best pricing methods i.e. they attempt to address the internalisation of the marginal external costs but cannot by their nature internalise those costs precisely. A measure capable of doing the latter would be referred to as a first best pricing method.
3.3.1 Charging for use of a particular piece of road infrastructure

There are many existing examples of charging for use of infrastructure throughout the world. Generally there are two objectives for the implementation of such a measure; revenue generation and management of traffic congestion. Most existing examples focus on the former where typically a private operator agrees to build a piece of infrastructure on the condition that the operator is awarded the franchise for a predefined number of years and the operator tolls the infrastructure to retrieve the funding originally invested in the construction. This type of arrangement is normally referred to as a public private partnership (PPP). Usually, an arrangement exists between the government and the operator governing the charge levels that can be applied.

Managing congestion is the other objective of charging for infrastructure use. In theory, this idea has existed for many years but due to the difficulties of implementing the policy there are fewer full-scale examples in existence. In the USA, the use of High Occupancy Vehicle (HOV) lanes and High Occupancy Toll (HOT) lanes are used to manage congestion on particular routes. The electronic road pricing (ERP) system in Singapore is another good example of charging for infrastructure use as a means of managing congestion. Many other cities aspire to introducing road use pricing but have had difficulties, mainly due to political and public acceptability. The more recent proposals for road pricing in the UK are being closely watched by other European cities.

3.3.2 Parking charges

Parking charges are another useful means of applying marginal social cost pricing. If a parking charge is paid on a day-by-day basis, such charges can be quite effective in that the charge usually forms part of the cost of the trip which the car driver uses in their mental model when they decide between using their car or public transport for a trip. However, if the parking charge is applied on a yearly basis, the charge is normally considered by the car driver as a sunk cost and is therefore not included in their decision making when they choose between modes for their trip. A study of Los Angeles commuters found that employer-paid parking significantly increases the probability that an employee will drive to work and furthermore will drive alone (Wilson, 1992). Parking spaces have a value and free provision is a transfer of a benefit from an employer to an employee, a privilege not extended to public transport users. If a parking charge is applied on a yearly basis or if free parking is in some way treated as a benefit-in-kind for tax treatment, the user sees this charge as a sunk cost and there is no daily incentive not to use their car. In fact, such a sunk cost is likely to encourage higher levels of car usage, as indicated by Wilson (1992).

A daily charge is likely to be the only means by which parking charges can impact on car usage. Scott and Feeney (1998) recommend that a daily charge for spaces could be implemented relatively easily using the local business rates to do so. The part of the business premises allocated to parking could be assessed separately for rates. The rates for this parking area should reflect the cost of parking infrastructure generally and should, in the absence of road use pricing, cover the external costs of transport. The businesses would then be encouraged to pass on the charges to the car users using the parking spaces in their company. Kelly and Clinch (2001) are
currently conducting interesting research on Dublin's recent innovative parking policies.

3.3.3 Public transport fares and subsidies

Subsidisation of public transport is not generally considered to be an efficient transport policy. However, while private car users do not pay for all of their costs, some governments choose to subsidise public transport to encourage its use. Another argument commonly used to justify subsidies is that because motorists do not pay the full marginal social costs of transport, public transport subsidies are necessary to ensure that the choices between public and private transport are not distorted. If it is not possible to apply road use pricing, then subsidisation may be another alternative to include for the marginal external costs. Fares set at marginal cost are normally not sufficient to cover total cost (Small, 1996). A third argument is the benefit which such subsidies offer to the socially disadvantaged, given that generally they are more dependent on public transport than the rest of the population.

3.3.4 Fuel taxes

Fuel taxes may be efficient for the regulation of environmental externalities although only if the taxation policy is not place or time dependent. However, they tend to perform poorly for the regulation of congestion (Verhoef et al, 1997). Koopman (1995) evaluated fuel taxes and compared them with car ownership taxation policies. Taxes on car ownership were found to reduce car ownership. When car taxes and other fuel taxation policies are used, car ownership and usage were found to fall by only 3.3% and 4.3% respectively. Households tend to respond to fuel increases by buying more fuel-efficient and smaller vehicles to reduce the cost per kilometre.

3.4 Potential for using Intelligent Transport Solutions

The advances in information technology are having a significant impact on the transport sector and are likely to continue doing so. Optimising traffic signals to reduce average delay is one area in which there have been advances although there is room for improvement e.g. traffic signal cycle times in Dublin in the off-peak period are leading to unnecessary queuing and associated air pollution. There are also likely to be new advances in this area as telecommunications technology improves – knowing the whereabouts of various vehicles in advance of particular junctions may allow for optimisation of the timings on a closer to real-time basis rather than using data from previous cycles.

Advances in electronic tolling now offer the opportunity to vehicles to travel through toll collection points at relatively high speeds. Excellent working examples of this include the ETR407 in Toronto and the tolling booths in the Singapore road pricing cordon. There has been some recent evidence that National Toll Roads are running a pilot action for the East and West link using this technology. However, they are not offering the benefits of the quicker service by providing a dedicated lane for electronic payers and without those benefits there is little inducement for customers to take up the electronic pricing method. Given the excessive levels of congestion on the toll bridges there is a strong case to introduce electronic pricing with dedicated lanes to reduce the queuing and associated pollution.
Providing real-time passenger information as a means of enhancing public transport service delivery is an issue currently under review by the relevant government departments and agencies. The required technologies and architecture are currently available to enable such systems to provide a high level of information service to the public.

Advances in e-commerce (B2B and B2C) are providing individuals with different methods of shopping and doing business, the main impact of which will be changes in mobility patterns and changes in how product suppliers deliver to their customer. There have been many suggestions as to what impact increased e-commerce will have on transport demand but there have been very few studies to date to examine in detail the impacts.

Conclusions

The aim of the paper is to provide an overview of how the transport policies, in use and proposed, offset the costs of transport demand to society and the environment. Most policies in use and new technologies coming on stream focus on limiting use of the car to reduce traffic congestion and environmental impacts. The struggle between on the one hand trying to supply enough of infrastructure and services to match required transport demand and on the other limiting impact on the environment is a common problem for countries across the world. The enhanced service that transport by car provides in terms of comfort and convenience means that the mobility requirements of many people can be dictated by the fact that they own a car. Taking this point further, there are many parts of the US where life styles have evolved around the car and at this stage in their development existence in those areas is impossible without having a car. The aim of many authorities is to try to break this cycle but in recent times it has been an uphill struggle. The recent increase in property prices in urban centres and the fact that high density living is not particularly popular has meant that many people are choosing to live long distances from their work places. Balancing mobility requirements and impacts on the environment requires compromises between authorities and transport users, significant changes in attitudes, improved public transportation services and traffic demand management measures.

References


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