The Implementation and Effectiveness of Transport Demand Management Measures

An International Perspective

Edited by

Stephen Ison *and* Tom Rye

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An International Perspective

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Chapter 1

Introduction: TDM Measures and their Implementation

Stephen Ison and Tom Rye

Introduction

The basic tenet of Transport Demand Management (TDM) is the influencing of individuals travel behaviour. As defined by Meyer (1999) TDM can be seen as 'any action or set of actions aimed at influencing people's travel behaviour in such a way that alternative mobility options are presented and/or congestion is reduced'. Table 1.1 classifies a number of TDM measures aimed at influencing peoples travel behaviour.

Table 1.1 TDM measures

Type	Measures
Economic Measures	* Fuel Tax * Road user charging * Parking charges * Tradable permits (combined with regulation by quantity) * Public transport subsidisation
Land use	* Land use and transportation strategies such as: car free developments and location of new developments * Park and Ride Facilities
Information for Travellers	* Travel Information before a trip is undertaken * Car Sharing
Substitution of Communications for Travel	* Teleworking * E-shopping
Administrative Measures	* Parking Controls * Pedestrianised Zones * Alternative working patterns

The list of measures is by no means exhaustive but is indicative of the types of measures available to transport professionals as a means of bringing about a change in travel behaviour. Clearly with a number of these measures proposed there are issues relating to effectiveness, acceptance and implementation. A TDM measure seeks to manage the demand for travel by drive alone private car, rather than catering for that demand, or managing the road system on which that car travels. TDM measures are aimed at influencing mode choice, trip length, the frequency of trips and the route taken. They can be applied to meeting specific goals, namely to reduce congestion, to improve air quality or to reduce the reliance on energy. In general TDM has been associated with addressing congestion, as a result of commuting and this is the main focus of the book. The book seeks to review the nature of particular TDM measures, their effectiveness and issues relating to implementation and how the barriers to the implementation of the respective measures may be overcome. In this way it is intended to be of use both to academics and practitioners.

TDM measures can be implemented on a nation-wide basis, such as with fuel tax, on an area-wide basis as with road user charging or park and ride, or on a site-specific basis with measures such as parking restraint on a university campus. TDM measures can seek to focus on the short term mitigation of congestion or can seek to take a more long term strategic approach by focusing on land use patterns.

In this introductory chapter we consider the range of TDM measures that are detailed in this book and the reasons for their inclusion. The chapter also provides a summary of the findings from each of the chapters, and analyses the commonalities in these. In particular, it focuses on commonalities in terms of the barriers to implementation, and how these may be overcome. Barriers to implementation is a central theme running through the book.

TDM Measures Considered in this Book

The chapters in this book deal with the following topics:

- Purchase, circulation and fuel taxation.
- Road user charging.
- Using ITS to manage demand through road pricing.
- The land use and local economic impacts of congestion charging.
- Tradable driving permits rights in urban areas.
- Parking on campus.
- A view of parking policy in an Australian city.
- Park and ride in the UK.
- Public transport subsidisation.
- The substitution of communications for travel.
- Travel plans (also known as workplace trip reduction plans or site-based mobility plans).

These topics are not intended to provide exhaustive coverage of all TDM measures. For example, reference to the work of Meyer (1999, p. 577) yields a list of around 44 measures – although some of these are essentially the same measures but applied at different scales (site-based, area-based or region-wide). In terms of the TDM measures detailed in this book it was felt that: first, it was important to consider the role of purchase, circulation and fuel taxation measures, not specifically designed as TDM measures but which undoubtedly impact on travel behaviour. Second, road user charging has been long advocated, particularly by economists as a means of influencing driver behaviour, and as such this book considers that measure. Third, a key consideration for the editors was to ensure that certain measures, that are somewhat neglected in the literature are covered. Therefore, the contents list includes three chapters on aspects of parking, an area of particular interest to the editors (see for example *Transport Policy Journal* 13 (6), a special issue on parking edited by Ison and Rye (2006)) that is relatively under-represented in the literature. Fourth, it was seen as important to include emerging topics, most notably Tradable Permits, and the use of ICT in congestion charging. Fifth, links between land use and transport are a key consideration for the TDM agenda hence a chapter dealing with the way that this relationship is mediated by congestion charging. Finally, issues relating to the substitution of communications for travel and the role of travel plans within a TDM frame are increasingly important measures worthy of detailed discussion. Travel plans are not like the other measures discussed in this book in that they form a means of delivery and not essentially an instrument in themselves. A key consideration was to ensure that contributions were obtained from experts in the field and we believe we have achieved this objective.

Below is a synopsis of each chapter followed by a brief discussion.

Purchase, Circulation and Fuel Taxation

In this chapter, Stephen Potter explores the important issue of how taxation can be used to contribute to TDM objectives. He distinguished between three types of tax: those on vehicle purchase, those on the ownership/circulation of vehicles (for example, annual road tax), and those on fuel, parking and actual road use. He recognises that the effects of the first two taxes on travel demand are likely to be relatively minor, since they mainly influence vehicle purchase.

The chapter briefly reviews the effects of changes in purchase and circulation tax that have been enacted in various northern European countries to stimulate the sales of more environmentally-friendly vehicles, and shows that, where evaluated, these have been associated with significant increases in the proportion of less-polluting cars that have been purchased. A range of changes to company car taxation in the UK in 2002 has led to a reduction of 0.5 percent in total CO_2 road transport emissions (some of these changes affected distance driven as well as choice of car). He also cites evidence that vehicle efficiency in Denmark and Italy is around 20 percent better than in the UK due to their long history of carefully graded purchase and circulation taxes that give major incentives to buy less polluting vehicles.

Interestingly however, Potter argues that in the longer term, purchase and circulation taxes that give incentives to purchase much less polluting vehicles (for example, those with low carbon engines, hybrids) will reduce the average cost of car *use*, thus stimulating travel by car – the precise opposite of a TDM measure.

The chapter then turns its attention to fuel duty. It begins with a comparison of rates of fuel duty in EU countries, noting that certain states add fuel stockpile and/or carbon levies to their duties, and that most vary the rate according to fuel type to stimulate the acquisition and use of particular fuel-types of vehicle. He also notes that it is impossible to charge different levels of fuel duty in different areas for example, more in congested parts of a country and less in uncongested rural areas. Certain modes however can benefit from rebates, such as bus and train operators (as in the UK), although the TDM impacts of such targets vary depending on the conditions attached to the rebate. He cites evidence to show that the UK's fuel duty escalator did indeed slow road traffic growth – it was a successful TDM measure, until abandoned.

Finally, the chapter considers the interactions between (national) road user charging schemes, and fuel duty, arguing strongly that the former cannot completely replace the latter if incentives to acquire more fuel efficient vehicles are to be retained, and if national-scale congestion charging schemes are to be an effective TDM measure.

Road User Charging

In this chapter Ken Button and Henry Vega consider road user charging (RUC) from an economic perspective. They review the economic theory behind RUC, before presenting examples of actual schemes. They also note that the technological barriers to implementing RUC are decreasing and that this may have had a small influence on the increasing number of schemes that are being implemented.

Button and Vega then highlight the distributional impacts of RUC, noting that capitalist economies use markets to allocate most resources and that in many ways the unpriced allocation of road space is an anachronism. They see the distribution of revenues as a factor key to scheme acceptability and accepts that this factor is largely dependent on the policies of public authorities that collect the revenue.

The chapter then summarises the impacts of recent RUC schemes, providing useful data and concludes from these that scheme impacts have generally been positive and achieved their objectives. They point out however that in many cases RUC is implemented as part of a package and that, therefore, it can be difficult to disentangle its impacts from the overall effect of the package. Finally, the chapter makes useful comments about reasons why RUC has not been implemented more widely, alluding to barriers to its implementation.

The Role of Intelligent Transportation Systems (ITS) in Implementing Road Pricing for Congestion Management

David Gillen takes an interesting angle in terms of the consideration of road pricing looking at the role that ITS has in charging schemes, including aiding acceptance. He identifies five public acceptance issues within which ITS can play an important role:

a. Pricing schemes – where, when and the amount to toll;
b. Toll infrastructure – how to toll and how should the infrastructure be managed;
c. Public policy – how to spend the toll revenues and designing transportation alternatives;
d. Public acceptance – how to garner support and overcome resistance from the public;
e. Technology – how technology can be used to improve effectiveness and efficiency.

The chapter notes that ITS when employed in a charging system can be categorised as playing at least one of four roles: communicating information about the scheme; determining the amount that should be paid; enabling payment to be made (expanding the range of payment options); and enforcing the system. Thus, as well as making charging systems more acceptable, Gillen also argues that ITS helps to make them more effective. For example, he argues that closer to (economically) optimal charges can be set, and varied, when using ITS, because ITS has the capability to both measure traffic congestion in real time, calculate charges to reflect these levels of congestion, and to communicate these to users. In another example, the chapter points out how ITS has the capability to manage traffic that might otherwise redirect away from a tolled route when the charge is set at a higher than optimal level.

The chapter concludes with consideration of implementation costs for ITS in charging schemes, and a review of actual schemes, both those planned and those actually implemented, and the role of ITS within these. It notes that most European schemes have, to date, adopted fairly simple ITS technologies without the capability for real-time charging, whilst those in the US (mainly HOT lanes and tolled roads) and in Singapore have used rather more sophisticated technology. The chapter concludes that, in spite of ITS's considerable potential in making pricing more acceptable (as well as in providing an important flow of management information), this potential has not yet been exploited to any great degree.

The Land Use and Local Economic Impacts of Congestion Charging

The use of land use planning as a means to manage the demand for transport and to encourage the use of more sustainable modes is a key interest of transport and spatial planners. This chapter, by David Banister, examines this relationship by considering as it does the possible land use, and local economic impacts, of congestion charging. Banister poses the question of whether congestion charging schemes can encourage land use patterns that themselves further encourage more sustainable travel patterns.

The chapter first reviews the theoretical literature on the land use impacts of congestion charging. In the short term, there might be a slight redistribution of transport-intensive activities away from a charged area, but an intensification of other high-value but less transport-intensive activities within the area, to take advantage of improved accessibility. In the longer term, there would be a number of conflicting pressures: firstly, since transport costs are a low proportion of total costs for many types of firms, there might be only a very small effect; secondly, agglomeration economies might prompt the further concentration of firms in a charged area; and/or thirdly land values might change as developers seek to take advantage of changing patterns of accessibility. The chapter concludes that the theoretical literature is 'ambivalent' about the land use impacts of congestion charging and goes on to look at the empirical evidence from London.

Since the London scheme has been in place for only a few years, it is very difficult to establish any effects on land use, which take place over a longer timeframe. However, Banister conducts a thorough review of the local economic impacts, concluding that they are broadly neutral, with perhaps a minor negative impact on retailing (especially small retailers) and a greater positive effect on higher value-added sectors such as finance. Linking this to the theoretical studies once again, he concludes that there could be small but measurable impacts on land use in the longer term, and that London provides an excellent laboratory in which to study these.

Tradable Driving Permits Rights in Urban Areas

Charles Raux presents this chapter on the concept of tradable driving rights – that is, a permit issued by public authorities to drive a certain number of kilometres in urban areas at no cost, but with a need to purchase more permits from those who have not used their full allocation for those drivers who wish to drive more than their allocated number of kilometres. This then keeps the number of kilometres driven to a set maximum and ensures that those that pay to drive are those that derive the greatest benefit from so doing, thus maximising economic welfare.

Raux explains the situations in which tradable permits may be more or less appropriate, and the ways in which they can be adapted in order to avoid significant welfare losses to society. After considering various types of permit that could be issued to try to address specific 'nuisances' (emissions, land use, or car ownership), he makes the case instead for permits to be issued to consumers – travellers – and highlights two technologies that could be used: one based on roadside beacons or gantries to register trips made, and the other based on satellite tracking to measure vehicle kilometres. Raux argues that the technology for these two types of scheme is at the point where it will be capable of reliable application in practice – although he does later point out the necessity of widespread interoperability of technologies for schemes to function properly, especially for coping with occasional users in a given area.

The chapter then considers some of the practical problems of setting up a scheme to allocate tradable driving rights to travellers or inhabitants. Very usefully, it also outlines some of the key conditions that are required to be satisfied to maximise the chances of a scheme being successfully implemented. A key factor is that at least a proportion of the driving rights should be allocated free of charge, in order to address the equity concerns that are a key barrier to the implementation of congestion charging schemes.

The chapter proposes a scheme run by a public agency that requires drivers to use up driving rights according to the type of car they have (its pollution characteristics) and the approximate level of congestion in the area in which it is driven. Raux tests this scheme using a model of the Lyon conurbation and finds it to be superior in many important respects to a congestion charging scheme for the same area, principally because the surplus resulting from the permit scheme would be redistributed between motorists rather than becoming revenue for the transport authority.

The Politics and Economics of Parking on Campus

Parking is a key element of TDM and also one which is contentious particularly in terms of who can park and where, and the overall price charged. Donald Shoup provides an interesting perspective on TDM by analysing the specific case of US university campus car parking. The US University is a major traffic generator and the chapter seeks to analyse both the political and economic aspects of campus parking drawing lessons of relevance to urban areas. The political approach relies on administrative rules and regulations, while the economic approach is based on market prices.

Shoup details the parking strategy relating to a number of US University campuses. For example, in terms of UCLA he argues that since the price of a parking permit is well below the cost of new parking provision drivers who park in the new infrastructure only pay a fraction of the marginal cost. The incorrect pricing strategy results in an excess demand for permits and thus the need to devise a point system for ranking students' priority which creates 'parking anxiety' and what Shoup calls 'cheating for parking' as students seek to increase their points tally by such means as using false addresses. Excess demand can also lead to the supply of new parking provision and this results in users who formerly walked or vanpooled.

Shoup argues that a performance-based price for parking could address the situation – a performance-based price for parking, being the price at which demand equals the supply of spaces available with a 15 percent vacancy rate. He argues campus parking should not be priced like private parking where the aim is one of maximising private profits not social benefits, but so as to create a few vacancies everywhere – ensuring that the right price of parking is the lowest price that will avoid shortages.

Parking cash out is also put forward as a way of reducing demand for campus parking – a scheme that can achieve almost the same efficiency gain as charging for parking, but without the political pain. Another university policy option is the use of fare-free public transportation.

Shoup argues that the car parking issues at big universities provide important lessons for TDM in cities, with a growing number of universities reforming their pricing policy both in terms of campus parking and public transportation.

A View of Parking Policy in an Australian City

Here William Young considers parking policy in Melbourne, Australia, in order to draw wider conclusions about the conflicting nature of parking policy implementation in many cities worldwide. He first shows how thoughts on parking policy have evolved from a viewpoint where parking is seen as an essentially passive element in the urban mobility system to one where it is now often seen as a means to actively manage mobility and local economic development.

Young then describes the context for parking policy in Melbourne: a decentralising, low-density city divided into a number of municipalities, but with a higher density core at the locus of the public and private transport networks, the central business district, where there is still a very high concentration of activities and thus parking demand. Both state and local policy still tend to see parking as something that must be supplied and its impacts (for example, on streetscape, pedestrian and cycle safety) managed, rather than actively using parking as a means to manage travel demand overall. The only major exception to this is the policy of the central city, Melbourne City Council – but there are 32 other municipalities in the metropolitan region (and no effective regional government). The City of Melbourne has been seeking to limit amounts of public and private non-residential on- and off-street parking for many years, although Young reports that in fact there have been big increases in provision in the last 10 years. Pricing is also not always conducive to the achievement of stated policy goals. As one moves away from the central city, parking policy becomes more orientated towards meeting demand rather than managing it.

Finally Young presents an analysis of the overall impacts of different administrations' parking policies in the Melbourne metropolitan area, and finds that they produce perverse results in some cases. In particular, he concludes, parking policy has a tendency to support trends in the decentralisation of land uses.

Park and Ride in the UK

Stuart Meek presents this chapter on Park and Ride considering both its implementation and the degree to which it is effective in reducing car use. He first looks at the concept of Park and Ride and delineates its various components. He outlines a number of variations on the concept that are used internationally but the chapter draws specifically on the UK's long-standing experience of bus-based schemes, which are typically found on the edge of urban areas and provide access to the urban core of host centres.

Meek then considers the issue of implementation and the circumstances in which Park and Ride is most suitable. After outlining how a changing political climate has influenced both the popularity of Park and Ride and the objectives for which it is used, he goes on to explain that there are a wide range of funding sources available for the significant costs involved in the implementation and operation of schemes. The way in which schemes are designed is then discussed, including the main barrier to their implementation, the construction of Park and Ride sites. This is the case, Meek suggests, because sites are often located on countryside or greenbelt land on which there is limited existing development and sufficient space for sites, which results in concerns over environmental impacts and the loss of countryside amenity.

Despite this barrier, Meek then argues that Park and Ride is a relatively saleable 'carrot' but there are concerns over the degree to which it is effective in directly reducing car use. The chapter outlines that mileage savings from Park and Ride are offset considerably by it encouraging increased trip frequency and length, attracting users of traditional public transport and operating low load factor buses. He suggests that these have arisen as a result of the insufficiently rigorous restraint measures implemented alongside schemes. He concludes that the most suitable instrument to improve the effectiveness of Park and Ride is road user charging.

Public Transport Subsidisation

In this chapter, John Preston considers how public transport subsidies can act as a demand management tool, by influencing demand for car travel. He first notes the economic arguments for public transport subsidisation, in terms of maximising welfare. The existence of user economies of scale or operator economies of scale provides a justification for subsidy if welfare is to be maximised, although he also notes that several authors have argued that operator economies of scale are lower than has previously been thought. In addition to these 'first-best' arguments for public transport subsidy, Preston also considers the use of public transport subsidy as a means to reduce the negative externalities associated with private transport, and also with public transport's role as a 'quasi-public' good such that there is a benefit to its very existence, even to those people who almost never use it. However, Preston also notes that there are arguments against subsidy, such as a possible tendency for it to leak into increased operating costs (although this can be addressed by different means of securing the subsidised service); and also the costs of collecting taxes to pay for the subsidy, and the distortions that taxes introduce into the economy. He then briefly considers the key types of subsidy – capital, operating and user subsidies – and their advantages and disadvantages.

The chapter then looks at England as a case study of public transport subsidy (both bus and rail). Although, as he notes, buses in England outside London are often perceived to be a largely commercial operation, when user subsidy (through concessionary fares for the elderly and other groups) are included, the total amount paid by governments to operators outside London in 2003/2004 was around £1 billion (US$1.9 billion, €1.25 billion). Buses in London, London Underground and national rail were recipients of even larger amounts of subsidy.

The chapter then proceeds to evaluate the effectiveness of different types and amounts of subsidy. Preston first cites work from the UK and the Netherlands to argue that a subsidy paid to operators per passenger carried is a much more cost-effective and welfare maximising measure than reducing fares for specific groups of users. He then goes onto use a model of bus markets in English metropolitan areas to show that, in most, there are strong grounds for small increases in subsidy and increases in service levels coupled with some fare reductions to maximise welfare, and that these would have beneficial TDM impacts. He suggests that the current market in these areas may be monopolised, with 'what might be considered excess profits' for operators, preventing welfare maximisation.

The chapter concludes that in England at least there are sound welfare-based arguments for reducing fares and for paying subsidy on a per-passenger carried basis, not on the basis of mileage-operated or as a concessionary fare to users. Preston finally notes that, as a TDM measure, subsidies are second best, but that they can be shown to have significant benefits, including modal shift.

The Substitution of Communications for Travel?

Glenn Lyons, Sendy Farag and Hebba Haddad explore the prospect of being able to change where an individual participates in an activity so as to reduce or remove 'derived travel'. The basic tenet of their argument is that transport policy makers should think in terms of modes of access rather than modes of transport, with telecommunications playing a central role. The question which they seek to address is whether from a transport demand management perspective communications can be used as a substitute for travel? Hence the title of their chapter being 'The substitution of communications for travel'.

The chapter begins by considering the issues associated with travel and communications and the relationship between them and thus the possibilities for demand management, taking account of the fact that it is inappropriate to consider a single measure in isolation. In terms of communications the chapter focuses on working and shopping and the potential for teleporting and e-shopping and their associated transport demand impacts. The chapter deals with the emergence of the Internet and mobile phones as a major new mainstream communications medium and with it opportunities for substitution. They do stress however that optimism needs to be tempered by the fact that activities such as shopping may serve important goals such as social interaction, something that cannot be provided through e-shopping. Equally, though telecommunications may result in travel being substituted it may also generate new travel opportunities. In terms of teleporting this could have the impact of allowing individuals to live further away from the conventional workplace, with resulting longer commutes. In saying this they present evidence to suggest that teleporting has potential to reduce car travel at peak periods. From a transport demand management perspective they argue that employers have an important role to play as agents for change.

They conclude by stating that teleporting and e-shopping have a role to play in terms of a substitute for travel and increasingly more so as the technical barriers to substitution become progressively less significant. In saying this they suggest that social and institutional barriers will still remain. Interestingly they are of the opinion that travel substitution will dovetail extremely well with road pricing, with an increased cost of travel encouraging more substitution. It is important to state that they question whether transport policy recognises telecommunications as a transport demand management measure but they state that ignoring the role of substitution in terms of TDM is no longer seen to be an option.

Travel Plans

Enoch and Zhang examine the travel plan, which they see as less a specific TDM measure, and more a means of delivering TDM measures in the context of an organisation or site. They define a travel plan and the measures it incorporates, arguing that most 'are not complicated and hence are easy to implement'. They go on to outline the benefits of travel plans to organisations that implement them, to the members and users of those organisations, and to the wider community. They also present a comprehensive review of the literature on travel plan effectiveness, drawing on literature from Europe and North America. They point out that, while individual travel plans have shown some impressive results, the take-up of travel plans (especially in the private sector and amongst SMEs) is quite low, leading to a relatively modest TDM impact at the present time.

The authors examine the reasons for this apparent lack of diffusion of the travel plan, especially in the UK, through an analysis of eight key barriers to travel plan implementation. They then argue, however, that travel plans, in the UK, are moving from being a 'niche' TDM tool to one that is expanding to different segments (for example, from employment to residential uses), in its scope (for example, to new as well as existing developments), and in its scale (from being implemented by individual organisations, to groups of organisations). On this basis, they argue that the role of travel plans may strengthen in the future, in UK transport policy at least.

There are commonalities between the various chapters, particularly with regard to implementation issues and barriers. A unifying theme is the need to 'package' measures, and support for those measures, together. For example, Potter argues that the most effective form of tax from a TDM point of view is the general increase in fuel prices, but points to experience in Britain with the ill-fated fuel tax escalator to show that public acceptability issues can be considerable. He advocates the packaging of fuel tax increases with differential (lower) rates for more environmentally friendly vehicles and user groups (although this risks a re-bound effect, as people can travel further for the same cost), and the earmarking of at least some of the revenue for improved public transport. Button also argues for the possible 'packaging' of support for road pricing amongst different groups, and the earmarking of revenue to increase acceptability. Raux makes a convincing case for the 'package' of tradable driving rights: these have the advantage in that a defined amount of driving and pollution can be set (unlike road pricing); all road users get some free allocation (equity issues); and users also have an incentive to make their behaviour more virtuous – since permits can be sold back to the issuing agency.

Both Young and Meek in their chapters highlight inconsistencies in parking and park and ride policy packages, where different aspects of policy are in clear conflict with each other. Meek offers some solutions to the problems that he recognises, such as careful design, and managing city centre car parking. Preston argues clearly in favour of a package of (carefully selected) subsidy and other TDM measures in order to shift patronage from car to public transport. Finally, Enoch and Zhang see local area travel plan groups as a possible means of integrating all forms of local transport planning in one, to try to move away from a more mode-based approach.

Conclusion

This chapter has introduced and summarised the contributions from the authors in this edited book. The unifying theme of these chapters is their focus on implementation, and barriers to it. They range across the menu of TDM measures but show that impacts can be significant, either at the global level (for example, fuel taxes, or public transport subsidisation) or at the local level (on-campus parking). In many cases a package approach is identified as a means to both improve chances of implementation and to enhance effectiveness. So, with this practical focus on how to implement measures and reduce barriers, this book will be a useful addition to the shelves of practitioners and researchers alike.

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Chapter 2

Purchase, Circulation and Fuel Taxation

Stephen Potter

Introduction: Taxation and Transport Policy

During the last decade, the UK and many other developed nations have reformed existing forms of road transport taxation to address a number of transport policy goals. This has involved modifying the design of purchase, circulation and fuel taxation to promote:

- More fuel efficient vehicles.
- Alternative fuel vehicles.
- Cleaner fuels (lower emissions and/or low carbon).
- Modal shift and traffic volume.
- Congestion reduction.

Of these five groups of objectives, only the last two involve Transport Demand Management (TDM). The first three categories concern policy objectives to influence not the use of vehicles, but their technology, the type of fuel used and fuel economy. The last two objectives do involve TDM, but it is important to specify the aspect of TDM that a tax may influence. Transport demand consists of a group of factors generating the total volume of travel (Potter 2007). These include total number of trips, trip length, mode used and vehicle occupancy. Policies for reducing congestion, as well as considering the total volume of travel, also require a consideration of the location and time of trips (although some congestion reduction policies are only about shifting trips rather than affecting the total volume of trips – an issue of network management rather than TDM).

In many cases, TDM has focused upon choice of mode, but this is just one factor in the traffic/congestion generating mix. It is perfectly possible to have effective TDM without modal shift. For example a tax measure may reduce traffic volume by promoting higher car occupancy, trip linking and trip substitution, but no modal shift away from the car. Equally modal shift may be promoted, but if this is in a context of a generally rising volume of traffic, then impacts such as congestion and emissions will continue to worsen.

Overall, when looking at the role of taxation in transport policy it should be recognised that, (a) some important tax measures are primarily to influence vehicle technology, the type of fuel used and fuel economy, and (b) a comprehensive approach to TDM is needed covering all aspects making up travel demand.

Positioning of Taxation Measures

In developing the design of taxation measures, a crucial point is to position the measure in the transport system where it will have the most direct impact. This positioning relates to whether the objective of a measure is mainly to manage vehicle choice or use. There are three crucial taxation points which relate to user decisions:

- Tax on the initial purchase of a vehicle.
- 'Circulation' Tax on the ownership of vehicles (annual registration tax and company car taxation).
- Tax on the use of vehicles (fuel, tolls, roadspace and parking).

Purchase and circulation taxes will have a strong influence on the choice of vehicle and the technology associated with the fuel it uses. Circulation taxes, although distanced from the point of purchase, also largely have an impact upon vehicle choice rather than use. Taxes on various aspects of the use of vehicles (fuel, road user charges and parking) have the strongest impact upon decisions to use a vehicle once purchased. The latter are therefore the main TDM taxes. Consequently, this chapter concentrates upon the use of road fuel duties, with other user taxes and charges covered by other chapters in this book. However, this chapter will first review purchase and circulation taxes as they have some secondary TDM effects.

Purchase Taxation Measures

In addition to VAT, many countries, and most European Union states, have a specific car purchase tax, although the UK and Germany are notable exceptions. The UK did have a 10 percent Car Purchase Tax, but in 1992 it was replaced by the UK government policy of raising fuel duty.

In a number of EU countries, existing car purchase taxes have been reformed to promote cleaner and low carbon vehicle technologies. For example, as noted in the review of European car taxation by Skinner et al. (2006), the Netherlands have introduced a series of reforms to their original 42 percent car purchase tax that has led, from mid-2006, to the registration taxes being reduced for the most fuel-efficient cars (rated A or B under the national fuel efficiency/CO_2 emissions labelling system[1]). The reductions amount to €1,000 for A-labelled cars and €500 for B-labelled cars, while cars in the least efficient bands (D to G) faced an increase in tax of up to €540.

This tax structure is similar to a trial which ran in 2002. An ex post evaluation of the trial (VROM 2003) found that, compared to 2001, the market share of the A-labelled cars in 2002 increased from 0.3 percent to 3.2 percent, while that of B-labelled cars rose from 9.5 percent to 16.1 percent. This was a much greater increase than had been anticipated (EEA 2005). The loss of the incentive in 2003 resulted in

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1 This is a relative system. The CO_2 emissions of A-labelled cars are more than 20 percent below the average CO_2 value of new cars, while emissions of B-labelled cars are between 10 percent and 20 percent below the average value, and so on.

a drop in market share for these vehicles, but with a lag effect resulting in their share remaining higher than the pre-incentive year.

In Belgium, tax incentives for the purchase of low CO_2-emitting cars were introduced in January 2005. The tax reduction is equivalent to 15 percent of the sale price, up to a limit of €4,350 for a car emitting less than 105 gCO_2/km. For cars emitting between 105 and 115 gCO_2/km the tax reduction is 3 percent of the sale price (up to a limit of €850 and 3 percent). The tax incentive works by the novel approach of reducing the purchaser's personal taxable income rather than refunding the purchase tax (ACEA 2006). Hence non-taxpayers are unaffected by this mechanism.

VAT is, of course a purchase tax, and there is no reason why a variable rate of VAT could not be levied. Italy does this; as well as a registration tax, Italians pay two rates of VAT on car purchases. This is the standard 19 percent on cars with an engine capacity of less than 2000cc (2500cc for diesels), and at 38 percent above this threshold.

'Circulation' Tax Measures

Most developed countries have an annual registration (or 'circulation') tax entitling owners to use the public highway. In many countries this circulation tax is varied by the engine size or power of a car, but some nations have implemented reforms to address fuel efficiency or environmental policy objectives. In Denmark the tax varies with fuel consumption, whereas Germany links tax liability directly to the Euro emission standards, with the least polluting car paying only 20 percent of the rate of the most polluting car, but as the overall tax is so low (about €50 per car), its impact on car choice is negligible.

Britain has had a CO_2 emission-based circulation tax (Vehicle Excise Duty) for cars since 2001. Initially the range of charges was small, but this has gradually been refined and widened such that by 2008 it covered a range from no charge at all for low carbon vehicles in band A, up to £400 (€610) for vehicles in the highest emitting band G (Table 2.1). From April 2009, VED will be totally restructured

Table 2.1 UK Vehicle Excise Duty rates (£ per year) 2007–2008 (for private vehicles registered from March 2001)

VED band	CO_2 (g/km)	Petrol and Diesel cars	Alternative Fuel Cars
A	100 and below	£0	£0
B	101 to 120	£35	£15
C	121 to 150	£120	£100
D	151 to 165	£145	£125
E	166 to 185	£170	£150
F	186 to 225	£210	£195
G*	226 and above	£400	£385

Notes: * Band G is for new cars registered on or after 23 March 2006.

Source: DirectGov, http://www.direct.gov.uk/en/Motoring/ (accessed 12 August 2008).

into 13 narrower CO_2 bands with a new top band of over 255 g/km and the separate 'Alternative Fuel' bands will be phased out by 2011.

Another type of circulation tax is company car taxation. This can be viewed as a sector-specific circulation tax as this is the annual income tax charge where an employer provides employees with a car that is available for private use. In the UK, a major reform of company car taxation took effect in 2002, when the tax charge was related to a car's value weighted by its CO_2 emissions. The charge rises from a base level of 15 percent of a car's purchase price, for cars emitting 165 grams per kilometre (g/km) of CO_2, in 1 percent steps for every additional 5 g/km over 165 g/km. The maximum charge is 35 percent of a car's price. Diesel cars not meeting Euro IV emissions standards incur an additional charge of 3 percent, up to the 35 percent ceiling. There are further reductions for company cars using cleaner fuels and technologies.

An assessment of the impact of this tax change (Inland Revenue 2004) showed that, in the first year of the new system, average CO_2 emissions of new company cars decreased from 196 g/km in 1999 to 182 g/km in 2002. The number of business miles has reduced by over 300 million miles per year and the overall effect has been to reduce the emissions of carbon from the company car fleet; by around 0.5 percent of *all* CO_2 emissions from road transport in UK. It is notable that this tax measure affected both vehicle choice and vehicle use. The TDM effect on business travel was because the old system had tax discounts for high business mileage, which were abolished under the new system.

Other countries are starting to follow the UK's example in reforming company car tax. Skinner et al. (2006), note that in Belgium, from 2005, employers have been liable for a '*Cotisation de solidarité*' if they allow private use of the car by individuals. This is a tax on employers rather than employees, as, in contrast to the UK, commuting is a tax-deductible expense for employees. This tax is based on CO_2 emissions and fuel type. In France, the 'TVS' tax (*Tax sur les Véhicules de Société*) was adjusted from 2006 to take account of CO_2 emissions of the vehicles purchased, to incentivise the purchase and use of lower emission vehicles. Also from 2006, the amount that companies can set against depreciation for tax purposes has also been related to CO_2 emissions.

The positioning of a circulation tax, being as an annual change on ownership, means that it has a less direct impact on the type of vehicle purchased than does purchase tax. It can, however, be a useful complementary measure to car purchase tax and for countries such as the UK and Germany that have no purchase tax, this second-best, indirect alternative may be the only tax available to influence purchase behaviour. However, a notable development is the UK government's plan to further reform its VED circulation tax. As well as widening the range of charges (detailed above), from April 2010, a 'first-year' rate of VED is planned. For new cars with emissions under 160 g CO_2/km the first year rate is no different, but it will be higher than the normal rate for new cars with emissions over 160 g CO_2/km. This is effectively a purchase tax, with the maximum additional VED supplement for the most polluting cars of £495 (€750).

The size of the tax is important. Initially the relatively low rates of VED had little discernable effect, but recent changes with a significant annual charge on high CO_2

vehicles is generating attention and seems likely, along with the rise in oil prices, to result in some shifts in car purchase behaviour. This is following the pattern set by the strong impact of the reform to company car taxation which, being a major cost to users, its reform to be weighted by CO_2 emissions has influenced vehicle choice. A car costing £20,000 (€30,000) used mainly for business purposes under the old system would have cost an employee paying the standard rate of tax about £690 (€1,100) a year. Under the reformed system, it would require a lower level of CO_2 emissions to keep the tax bill the same, and moving to a car with higher CO_2 emissions would result in the tax bill more than doubling to £1,600 (€2,500) per annum.

This substantial tax impact is in contrast to the relatively small tax gains of the VED reforms. The VED reforms before 2007 produced only a saving of about £100 (€65) per annum, which for most purchasers of new cars is too little to influence car choice. Furthermore, the introduction of the new VED structure coincided with the reduction in fuel duties from late 2000 (discussed in the next section), so the small VED reform was counterbalance by the larger tax reduction on fuel. The change to VED in the UK over the past two years, and future proposed changes are now reaching the point where this tax is having an impact on vehicle choice.

Overall, experience indicates that complementary purchase and circulation tax measures can have a significant policy impact on the type of cars purchased. Potter and Parkhurst (2006) note that the combined effect of well-established highly graded purchase and circulation tax systems in Italy and Denmark help explain why their car fleets have a 20 percent better fuel economy than the UK. The extension and refinement of such tax systems can play an important role in the uptake of cleaner vehicle technologies and low carbon fuels.

Purchase and Circulation Taxes and TDM

Well designed purchase and circulation taxes can stimulate cleaner car technologies and fuels, but their position within the tax system means that they are not an appropriate TDM measure. Some have had an incidental TDM impact, the main example being the UK company car tax reform, because of the business mileage weighting aspect.

There is a more strategic way in which purchase and circulation tax reforms could affect transport demand. The economics of low carbon vehicles are such that they have high capital costs and lower running costs. This becomes more extreme for the more radical technologies such as hybrids, electric and hydrogen vehicles. In order to stimulate the uptake of such technologies requires strong purchase and circulation tax incentives to reduce fixed costs, while parallel fuel tax concessions take place on cleaner fuels. The net impact is that the fuel-efficient low carbon cars have very low running costs coupled with tax incentives to cut purchase costs. Extending the use of lower cost, good-fuel economy vehicles will cut the cost of motoring and so will stimulate car use. Historically, the price of motoring has fallen; motoring costs are now 10 percent less than in 1980, while disposable income has risen by 90 percent. In real-terms, over the same period, fares for public transport have risen significantly, with a 42 percent rise for bus and coach and 39 percent for rail.

As will be noted in the next section, fuel price elasticity studies (such as Glaister and Graham 2000, and Goodwin 2002) indicate a short term elasticity of 0.4 (that is, a 10 percent drop in price would increase car use by 4 percent), so a 33 percent drop in fuel cost (about the amount resulting from policy objectives for low carbon cars) might be expected to increase the volume of car travel by about 13 percent. To cut transport's environmental impacts we need low carbon vehicles, but if the tax system only addresses the supply side, then it will raise transport demand, counteracting any savings in CO_2 emissions from the low carbon vehicles. On their own, purchase and circulation tax measures will have a negative impact on TDM. Tax (and other policy measures) need to impact upon both vehicle design *and* vehicle use.

Road Fuel Tax

TDM taxation measures need to be positioned to influence not the type of vehicles purchased, but decisions about the amount of travel and mode used. In the UK, and other developed nations, the main tax on the use of vehicles is upon fuel. In the UK there are other taxes and charges affecting use, including a limited number of road and bridge tolls, plus the London and Durham congestion charging zones. In other countries, motorway tolls are more widespread (for example, in France and the Netherlands). Parking charges are a further significant cost that can be influenced by policy, but are not generally viewed as tax. This chapter concentrates on fuel tax, with further chapters in this book covering other taxes and charges on transport demand.

Fuel tax (or Fuel Excise Duty to use the official term) is a familiar measure that has long provided a useful and steady income to national and (in some federal countries) regional governments. It is important to distinguish fuel duty from standard sales taxes (such as VAT in the EU). Sales taxes apply to all goods and are levied at a percentage of the price. Fuel duty is in addition to any sales tax. It is charged not as a percentage of the sales price, but at a rate per unit of fuel; per litre (or gallon in the US) for liquid fuels and per kilogramme for gaseous fuels. The rate may differ according to the type of fuel (diesel, petrol, low-sulphur or LPG), but remains the same whatever fluctuations occur in the base price of the fuel. So, for example, in the UK the current (2008) road fuel excise duty rates are 48.35p per litre for sulphur-free petrol and diesel, 28.35p for biodiesel and bioethanol and 12.21p per kg for liquefied petroleum gas (LPG).

Some countries have component parts for fuel duty (for example, Belgium has an '*Energy Levy*' as part of its fuel excise duty and the Netherlands also has a carbon and energy levy). In some cases there is also a component to fund fuel stockpiles (for example, in Finland and the Netherlands). Some Scandinavian countries have a CO_2 levy as well as fuel duty, but this is also at a fixed rate per unit of fuel.

Fuel duty rates vary considerably between countries, affecting the overall retail price. Table 2.2 shows this information for the EU-15 states.

Table 2.2 Tax and retail price of premium unleaded petrol, 2008

	Tax as % of retail price	Retail price (Eurocents per litre)
Netherlands	64	1.69
Denmark	62	1.58
Germany	65	1.57
Finland	64	1.57
Italy	61	1.54
Belgium	61	1.53
France	64	1.51
United Kingdom	67	1.51
Portugal	60	1.50
Sweden	63	1.47
Irish Republic	57	1.34
Austria	56	1.33
Luxembourg	54	1.32
Greece	47	1.27
Spain	53	1.23

Note: This data covers all tax on petrol (including VAT).

Source: www.aaroadwatch.ie/eupetrolprices/ (accessed 12 August 2008) and *Transport Statistics Great Britain*, 2007, Table 10.8.

Fuel Duties and Transport Policy

Fuel Duty was never originally intended to be a transport policy measure. It emerged through the twentieth century to become a steady source of government income that fulfilled a series of important principles of taxation. Firstly, it raises large amounts of predictable and reliable income. Secondly, and unusually for a direct tax measure, fuel tax has some progressive characteristics. A progressive tax is where the tax rate increases with income. Income tax is a clear example where the tax rate rises with income. Fuel duty is a proportional tax (the tax rate remains constant as income rises). However, as the UK *National Travel Survey* shows, there is a strong correlation between income and both car ownership (Department for Transport 2006a, pp. 34–6) and the amount of car travel/fuel used/tax paid (See Table 2.3). Consequently this consumption pattern produces an indirect progressive effect, increasing the amount of tax paid by higher income groups, with the top income quintile paying nearly five times more fuel duty than the bottom income quintile.

Finally, fuel tax is administratively simple and cheap to gather, it is easily enforced and evasion is difficult. With most petrol and diesel sold for road transport use, the default position is that it is taxed, with rebates provided for clearly defined other purposes (for example, exemption may apply for agricultural uses, rail and buses).

Table 2.3 Car driver distance travelled per year and fuel duty paid by income quintile, 2005

	Lowest income quintile	Second quintile	Third quintile	Fourth quintile	Highest income quintile	Average
Car driver mileage	1,370	2,324	3,405	4,793	6,574	3,684
Fuel Duty paid*	£93	£158	£232	£326	£447	£250

Note: *Fuel duty paid estimated at 6.8p a mile from the 2005 Fuel Duty rate of 47p per litre and an average UK fuel consumption of 9 litres per 100 km.

Source of mileage data: Table 5.5 (p. 37) Department for Transport, 2006b.

In the last 20 years, as well as providing a reliable and equitable source of government income, fuel duties have come to be adapted to address a number of transport policy objectives, as noted in the first section of this chapter. Fuel duties are a very low cost tool for government; the tax has to be gathered and enforced anyway, and any adaptation to address transport policy goals involves a relatively small additional cost in legislation and administration.

Although fuel duties can be used for transport demand management it is important to realise that they can, and are frequently used for other types of transport policy. As well as seeking to manage transport demand, fuel duties are used to promote fuel efficiency and the use of cleaner and low carbon fuels. In this respect, fuel taxation is used for exactly the same purpose as purchase and circulation taxes. The key way to do this is to have differential rates of fuel duty.

Differential rates of fuel duty are not a TDM measure. They are mainly about fuel switching and promoting low carbon vehicles. For example, a differential duty rate on unleaded petrol was used successfully in several countries in the 1990s to promote unleaded petrol and more recently to speed the transition to low sulphur road fuels. In countries with high duties on petrol and diesel, there is considerable scope to promote new low carbon fuels and transport technologies by offering substantial fuel duty concessions. If fuel tax rates are high then tax concessions can go a long way to compensate for the higher capital cost of low carbon vehicles. All this is a valuable part of addressing transport's environmental impacts, but does not affect the volume and modal distribution of travel – which is what TDM is about. Indeed, as noted in the conclusion to the previous section, this will have a negative TDM impact. To address transport demand requires not a differential in fuel duties, but a policy affecting the overall price of fuel.

In the UK, the adoption of fuel tax as a transport demand measure formally took place in 1992 when the Conservative government replaced the UK's 10 percent Car Purchase Tax with the *Fuel Duty Escalator*. The principle of the Fuel Duty Escalator was that Road Fuel Duty would be increased annually at above the rate of inflation, initially by 5 percent per annum and, from 1997, 6 percent per annum. This was coupled, for example, with the 1996 policy for regulated rail fares to rise at 1 percent *below* the rate of inflation, thus over time increasing the real cost of travel by car and reducing that of rail. Other European countries have also adopted a policy to raise the overall price of road fuels, in some cases with an increase in public transport subsidies to reduce fares and/or considerable investment in public transport capacity. The Netherlands is a prime example of this.

Fuel duty has thus emerged as a policy instrument to promote modal shift. However, by affecting the price of travel, fuel duty also influences other key determinants of the volume of travel, including:

- Trip length.
- Vehicle occupancy.
- Trip linking.

As was observed earlier in this chapter, TDM is frequently viewed as only being about modal shift. It needs to be more than that. Only a minority of the rise in the volume of car traffic is due to trips shifting from public transport, walking and cycling. Increasing trip length (rising in the UK by about 0.15 km every year), declining car occupancy (dropping in the UK by 0.3 percent per annum) and a shift in travel towards car-dominated leisure purposes are more important in generating traffic growth. If these elements are not addressed by TDM, then modal shift alone will have little impact on overall transport demand (Kwon and Preston 2005, Potter 2007). The level of fuel duty will affect all components of transport demand. In addition high fuel duties will also automatically favour cars with a better fuel economy – so fuel duties will have an impact on the type of vehicle purchased as well as the amount of use.

The Impact of Fuel Duty on Travel Demand

Fuel duty has an overall impact on the price of fuel, but it can also be a more targeted measure. As noted above, fuel duty can vary by fuel type, and this kind of targeting works particularly well when differential rates are used to promote fuel quality or a new cleaner fuel, like low-sulphur and low-carbon fuels. This targeting is most effective in promoting the diffusion of a cleaner fuel where the cost of introduction is relatively low (for example, unleaded and low sulphur fuels and, currently, biofuel blends). Where more radical technologies are involved, like electric vehicles and CNG, which involve a substantial increase in capital cost, then more than a fuel duty concession is needed to effectively promote use, for example a combination of purchase and fuel measures (Potter and Parkhurst 2005).

Targeting by fuel type to promote fuel switching is, however, not TDM. The type of targeting needed for TDM involves varying price by geographical area (for example, in city centres where congestion is greatest or where new development is taking place), by parts of the road network (for example, particularly congested roads), by journey types (for example, work and school trips) and by time (for example, congested peak hours). In some cases it is also required to target TDM measures by institutional factors (for example, Travel Plans for a particular employment site or leisure facility). Fuel duties simply cannot be targeted in any of these ways. At best, in federal countries where individual states can set fuel duties, there can be a crude geographical variation, but differentials can produce border effects, with motorists travelling quite some distance to exploit lower fuel prices in adjacent states. This certainly happens in the US and similar border effects occur in the European Union and elsewhere. In Singapore (where fuel duties are high), border controls check motorists driving into Malaysia, who are legally required to have a nearly full tank in order to stop them border hopping to fill up on cheap fuel.

One way that fuel duties can have a targeted TDM impact is for them to vary by type of user. By having a lower rate of duty or an exemption for public transport vehicles, then this will lower operator costs, which could result in lower fares and enhanced services – so promoting modal shift. The impact in this case is indirect and the danger is that a simple rebate or exemption will be absorbed within the cost structure of operators, with little or no TDM policy benefit. As such the design of the rebate/exemption is crucial. This can be illustrated by the case of the rebate mechanism in the UK, where the fuel duty rebate takes the form of the 'Bus Service Operators Grant' (BSOG) where bus operators receive a grant according to how much fuel each operator uses. This design of subsidy has been subject to criticism because it rewards fuel use regardless of patronage. The UK Commission for Integrated Transport (CfIT) has supported research to explore rebate designs that would link more directly to TDM policies. Their studies produced recommendations for a payment per passenger to replace BSOG in order to incentivise operators to grow patronage (CfIT 2002). One CfIT study indicated that if BSOG funding were reallocated to this redesigned system, demand could increase by 4.7 percent, with 20 percent to 40 percent of the newly generated passenger trips transferring from cars (FaberMaunsell 2002). Bristow et al. (2007) notes that an even more targeted approach is possible if some funds from the fuel duty rebate is allocated to support service enhancements specified to achieve TDM impacts, as has happened with the UK 'Kickstart' programme to support bus service enhancements. This targeted investment has produced a growth in patronage averaging over 20 percent in the first year of operation (Bristow et al. 2007), considerably higher than the 4.7 percent estimated by the less targeted design in the CfIT study. Such a programme could include targeting by geographical area and other TDM variables.

Overall, therefore, fuel duty is a general measure applicable at a national level that promotes TDM by raising the level of fuel costs for motorists. It is not really possible to target the TDM impacts of collecting fuel duty, but more targeted rebates to promote TDM policies are possible. In practice most countries that have a rebate for public transport do not target this in any way. Targeting fuel duty rebates according to TDM principles can be important and is a neglected policy area.

The effectiveness of the imposition of fuel duty as a general pricing mechanism will depend on the context in which it is applied. As noted above, some counties have combined a policy to increase fuel duties with subsidies to reduce public transport fares (or the rate of fare rises). So, the TDM impact of fuel duties will very much depend of the overall pricing context. Fuel Duties would be expected to have a stronger TDM impact if there were complementary policies to reduce public transport fares (and also increase public transport coverage) than if such complementary measures were absent.

In the UK, the general context has been one where, compared to other European countries, both fuel duties and public transport fares are high. Even the 1996 policy to limit the increase in (already high) regulated rail fares was reversed in 2002 to increase fares at 1 percent above inflation (coupled with a funding decision to also raise London bus and Underground fares above inflation in order to help finance service improvements) So the UK context is one where the modal shift impact of high fuel duties will be muted, but where other price-related TDM impacts (on the amount of travel, journey length, trip linking and vehicle occupancy) might be expected to be stronger. An examination of changes in traffic growth before and after the introduction of the Fuel Duty Escalator policy indicates that this policy did have a general impact. UK road traffic grew by 18 percent in the six years from 1987 to 1993 (before the Fuel Duty Escalator) and by 13 percent in the six years between 1993 and 1999 when the Fuel Duty Escalator was in operation (Department for Transport 2004: Table 7.1). Of course many factors affect traffic growth, particularly the strength of the economy, however detailed fuel demand elasticity studies (for example, Glaister and Graham 2000; Goodwin 2002) suggest that the tax increases resulted in 10 percent less demand for fuel in 2000 than if the duty rates had only increased at the same rate as inflation. The UK Government (cited in Marsden 2002) estimated that the TDM effects of the fuel duty escalator saved between 1 and 2.5 million tonnes of carbon emissions.

The UK Fuel Duty Escalator was abandoned in 2000. In September of that year, farmers and truck drivers mounted a blockade of oil refineries to protest, ostensibly, at the increase in road fuel duty. The protest exploited a strategic weakness in the fuel distribution system. With all fuel deliveries originating from a few refineries, a relatively small number of people and vehicles were able to blockade the refinery gates. Coupled with panic buying, within days fuel shortages were causing transport chaos. The government capitulated, cut fuel duties and abandoned the fuel duty escalator. From 2000–2007 there have been only two inflation-rate rises in UK fuel duty, meaning that the escalator has been reversed. In the first two years alone, Road Fuel Tax revenue dropped by 13 percent (Department for Transport 2003) and by 2005 all road tax revenues had dropped by over £2 billion (Potter and Parkhurst 2005). The politics behind the 2000 fuel protest were complex. High fuel duties were a catalyst for two groups from whom, paradoxically, the level of fuel duty was in reality a peripheral issue. Farmers in the UK had grievances over a number of agricultural policy issues, but actually benefited from a substantial fuel duty rebate; for truck drivers, overcapacity in the industry and not the price of diesel fuel was their main problem. Both groups, however, found the fuel protest to be an effective way to air wider grievances (Parkhurst 2002). Despite this, the UK fuel duty protests did highlight a weakness in a policy for high increases in fuel duty. It is certainly difficult for any one individual country (or state in a federal system) to have a large difference in fuel duty rates – and fuel prices are an issue amenable to popular political dissent.

What perhaps is notable is that, outside the UK, most other European Union states have had a version of the ‘escalator’, but with annual rises in fuel duty at a somewhat lower rate. The net effect is that they have now reached similar levels of fuel duties and price as in the UK. As shown in Table 2.1, the UK no longer has the highest fuel price (indeed it is in the middle of the range of EU petrol prices). The more gradual escalators used in some other EU states have faced lesser difficulties that the UK experienced. However, in the context of rapidly rising oil prices it is now becoming politically difficult to raise fuel duties any further and there have been protests in a number of European nations and calls for road fuel tax to be cut. If the oil price remains high, it seems that the further use of fuel duty as a policy instrument will be severely curtailed.

Lessons on Fuel Duty for TDM

As a TDM measure, fuel duty has an impact at the national level and its influence is upon the overall pricing context. A policy for high fuel duties provides a foundation upon which other, more targeted, TDM measures can be placed – be they fiscal, regulatory, organisational or infrastructure. Fuels duties have a particular strength in that they exert a broad positive impact upon the full range of traffic generating factors. These include not just modal choice, but also the other structural components determining travel volume, such as trip length, vehicle occupancy and trip linking. However, fuel duties are not a rapid TDM measure. As the 'escalator' experience shows, they need to be applied consistently and with political sensitivity. Their effects build up slowly and their effectiveness will also depend on the pricing context – particularly relative costs to public transport and other travel alternatives. If constantly applied over time, a regime of high fuel duties can result in this becoming a part of user expectations and understanding. High fuel costs become part of the everyday transport landscape, and so people adjust long term behaviour and expectations accordingly.

Targeting the collection of fuel tax is possible for policies to promote fuel switching and the adoption of low carbon vehicles (ideally as part of a mix with other policy measures). Targeting of the collection of fuel duty is not really possible to serve TDM objectives. A rise in fuel duty will affect some trip types more than others, affecting discretionary trips more and those where mode shifting and trip avoidance is most viable. These may, or may not, be the sort of trips that are desirable for TDM policies. The area where some targeting is possible is in rebates to public transport and other users. The careful design of rebates can address TDM goals, but this has not tended to take place. This neglected aspect could be a valuable TDM tool.

Fuel Duty in a Road User Charging World

Over the next decade the road transport taxation landscape could change in a dramatic manner. Road user charges appear to be set to become a major part of the taxation system, both in the UK and a number of other countries. As well as the UK, several other nations and states are exploring or implementing national road user charges. Schemes for freight transport have been implemented first (notably in New Zealand, Germany, Switzerland and Austria), but in Britain, the Netherlands, and in Oregon, US, schemes for country-wide car road user charges are progressing. There are a variety of reasons for road user charges rising up the political agenda, which are explored elsewhere in this book. Among them is the point made in this chapter that, unlike fuel duty, road user charges can be targeted on the places and times congestion occurs and other key TDM factors. An additional point is that the increasing diversity of transport fuels produces administrative difficulties and raises equity issues. How does one justify and enforce the taxation of gas or electricity at one rate for domestic use and at a much higher rate for road transport use? In the longer term this will be even more of an issue were hydrogen to become a major transport fuel. Additionally, in the emerging era of high oil prices, it is politically difficult to increase fuel duties.

The emergence of a new road transport taxation regime centred upon road user charging rather than fuel duties therefore raises the question as to what role fuel duties have, if any, in this new transport taxation landscape. Should road user charges replace fuel duties? Should they be in addition to fuel duties – or some blend of the two? The freight road user charge schemes have replaced previous annual registration taxes either fully or in part. In the Oregon and Dutch proposals for private motorists, road user charges replace fuel duty (with the Dutch proposal advocating the replacement of car purchase tax as well); in the UK this has yet to be decided. For existing city road user charging schemes, such as in London, Oslo and Singapore, the charges are in addition to fuel duties, circulation and purchase taxes.

There are two key points in considering whether any new road user charges should replace or be in addition to fuel duties and other taxes. First there is the point made at the beginning of this chapter that road duties serve important transport and environmental policy objectives other than TDM. If fuel and vehicle excise duties were entirely removed then this would sweep away the existing incentives for fuel efficiency and the promotion of low carbon fuels. Fuel duty inherently promotes fuel efficient vehicles, and a lower tax on cleaner fuels has proved to be a potent and cost-effective policy instrument. A shift to a purchase tax, graded by vehicle fuel efficiency and fuel type could form a replacement measure, but, as noted earlier in this chapter, the top rate charges would need to be high to seriously affect purchasing behaviour. Rebates on road user charges could also form an alternative to retaining fuel duty, similarly graded by fuel efficiency and fuel type. However, retaining fuel duty which can target these factors well, or a combination of fuel and purchase tax measures, would seem a more appropriate approach.

A second point is that studies modelling the impacts of a national road user charge in the UK have suggested that replacing fuel duties with road user charging in a revenue neutral package would fail as a TDM measure because it would result in motoring costs falling in less congested areas where traffic growth is already rising rapidly (for example, rural areas and city fringes). It would also lead to activity patterns redistributing to low charge areas (Wenban-Smith 2006). As detailed in Foley and Fergusson (2003) their modelling work indicates that such a revenue neutral charge (with the road user charge replacing fuel duty) would help to redistribute traffic and ease pressure on congestion hot spots, but would not necessarily lead to an overall decrease in traffic levels or CO_2 emissions. In the context of eliminating fuel duties, and with the real costs of motoring continuing to fall, a revenue neutral road user charge would worsen overall traffic levels and CO_2 emissions.

Conclusions

Purchase, circulation and fuel taxation can be used to promote a variety of transport and environmental policy goals. In exploring the use of these tax measures it is important to distinguish between policy measures to influence vehicle characteristics (technology, the type of fuel used and fuel economy) as opposed to vehicle use. Well designed purchase and circulation taxes can stimulate cleaner car technologies and fuels, but their position within the tax system means that they are not an appropriate TDM measure. Indeed, if successful, of themselves, they will have negative TDM effects.

Road fuel duties are an appropriate and effective TDM measure and one that can be targeted to serve other sustainable transport policy goals. Within this broad context it is appropriate to introduce more targeted measures. These include targeting fuel duty rebates, which is a neglected area of opportunity, and the introduction of complementary TDM measures, such as road user charges. Rather than replacing fuel duties, evidence is mounting that to manage transport demand as well as effectively address other sustainable transport policy goals, any new fiscal measure needs to complement and not replace fuel and vehicle excise duties, although rising oil prices could reduce the need for fuel duty increases. This may be a politically inconvenient truth and the real challenge is now managing the transition towards an effective new transport taxation regime.

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Chapter 3

Road User Charging[1]

Kenneth Button and Henry Vega

Introduction

Anyone who has been to a New Year's sale knows that very low prices can lead to near chaos as large crowds of consumers often physically fight to get what they want. They are not inhibited in their actions by the knowledge that they will have to pay very much for what they get. The same situation, including the physical violence in the form of 'road rage', also occurs in many cities as citizens get frustrated in snarled-up traffic. Just as the mad dash for reduced price china at Harrods' New Year sale leads to queues and crowds, so the low price paid to access a road leads to traffic jams and delays; traffic congestion.

Traditionally the methods of charging for road use have taken one of two forms. There have long been tolled roads, of the type initiated in Britain in the seventeenth century, where users pay a fee for use. These tolls, and the same is true where they are used today, are set to recover the cost of constructing and physically maintaining the road. The tolls are not designed to allocate the road space or to optimize congestion – when the tolls vary it is normally related to the physical damage done by a vehicle to the pavement and not to the impedance that such vehicle may impose on other road users. More widely, road users are charged even less directly for their use of infrastructure through a variety of taxes that may (as in the case of the US federal gas tax) be hypothecated to be spent on the road network or flow into the general coffers of the Treasury to be spent as government wishes. In general, these taxation systems have little to do with making good use of road assets.

The role of an economic price, however, is threefold, (i) to allocate what is available, (ii) to indicate where that capacity needs to be changed, and (iii) to provide the resources for financing that change.[2] Traditional tolls may serve the last of these purposes by recovering investment costs but they seldom meet the other two. Table 3.1 provides some guidance as to the tasks that various forms of road charging are set to perform.

The distortions that result from inappropriate charges for the use of one asset, in this case a road, have also been felt in complementary and competitive sectors. They occur when authorities seek to contain the primary problem with a second

1 The authors would like to acknowledge the US Federal Highways Administration for funding this work under Cooperative Agreement DTFH61-06-H-00014.

2 The acronym A(allocate)I(indicate)R(resource) offers a useful aid memoir should one slip into the simple idea that pricing is only about cost recovery.

Table 3.1 Technical tasks for various forms of road charging

Road Charging Scheme	Facility congestion tolls	Cordon congestion tolls	Weight-distance truck tolls	General distance tolls
Enforcement	●	●	●	●
Payment Billing	●	●	●	●
Data Storage	●	●	●	●
Data Communication	●	●	●	●
Charges Owed	●	●	●	●
Vehicle Class/Weight	○	○		○
Time/Congestion Level	●	●	○	○
Distance Travelled			●	●
Position on Road Network			○	○
Presence in Area		●	○	●
Entering/Exiting Facilities	●		○	

Notes: ● Required for the task, ○ Optimal but not required for the task.

Source: Adapted from Sorensen and Taylor (2006).

best approach involving either restricting the use of complementary services (for example, controls over parking[3]) or stimulating the use of alternatives (such as public transit). This second best approach seldom works. This has demonstrably been the outcome in the context of urban roads where, in many cases, traffic congestion levels have remained little changed for decades.

On the expenditure side, road investments are made for a variety of reasons, often with quasi-economic justifications added as a veneer. Cost-benefits analysis is widely used in one of its variants to provide a social assessment but the technique is far from perfect and subject to political manipulation. More powerful in the age of the car has been the engineering approach of providing capacity to meet demand. While there may be some justification for this in some situations, the fact that there is no direct

3 This is not to say that parking should not also be charged in an efficient manner in its own right (Button, 2006a, Calthrop et al., 2000).

economic price per trip paid by road users for their activities means that 'demand' in this context is nothing like the notion of effective demand used by economists. The outcome is likely to be excess capacity and a geographical maldistribution of roads. The reluctance of citizens to accept the environmental effects of more large scale investments in roads, coupled with the increasing costs of construction as successive projects move down the marginal returns on investment curves, have to some extent stymied this build to meet demand philosophy.

The distortions that result from inappropriate charges for the use of one asset, in this case a road, have also been felt in complementary and competitive sectors as the authorities have sought to initiate second best policies to contain congestion. Attempts to discourage car trips terminating in a congested area by means of parking restrictions and fees leads to higher levels of through traffic as well as additional congestion as terminating drivers seek the limited parking capacity that is available. A significant amount of car movements in many cities involves drivers looking for somewhere to park (Shoup, 2004). Subsidies to public transport reduce the incentive for it to be provided efficiently and at the lowest cost – the X-inefficiency problem.

To reduce urban road traffic congestion, national and local authorities have gradually been turning to policies with a degree of economic rational underpinning them, rather than simply trying to build their way out of problems or providing ever increasing amounts of subsidizes to public transportation (Gomez-Ibanez and Small, 1994). In particular, there have been moves to use Road Pricing as a tool for rationing scarce road space to those who gain most from its use.

The aim of this chapter is not to provide an encyclopedic coverage of all the literature that has been generated on Road Pricing, nor to catalogue all the efforts that have been made, largely failures with a few successes, to adopt Road Pricing. It is definitely not the intension to go into the finer points of obtuse microeconomic theory. Rather, it is to consider some of the challenges that confront the adopting of efficient fiscal policy instruments within the transportation system using Road Pricing as an illustration.[4] In doing this, examples and case studies will be used so that readers unfamiliar with the idea of adopting user charges as a means of improving traffic management will not find it difficult to understand the basic concepts involved.

The Arguments for Economic Road User Charges[5]

The importance of appropriate pricing to make the best use of transportation infrastructure is certainly not new: the principles can be found in the work of French engineering economists of the 1840s (Dupuit, 1844). Unfortunately, for a variety of

4 Some of the issues that are almost completely ignored include, optimum toll locations (de Palma et al., 2004), pricing across multi-modal systems (Arnott and Yan, 2000), charging for mixed traffic flows (Arnott and Kraus, 1998), and partial network charging (Verhoef et al., 1996).

5 To keep the discussion of Road Pricing manageable, the focus of its application to-date will be on urban road schemes. There are a limited number of cases where inter-urban roads have variables tolls that may be used to affect traffic flows but these are outside the domain of the discussion.

reasons, both practical and due to a lack of understanding by many of basic economic principles, road space is seldom priced in a way that optimizes congestion and, as a result, social welfare is not maximized. The modern principles of Road Pricing go back over 80 years to the work of Arthur Pigou (1920), were expanded upon by the Nobel Prize winning economists Buchanan (1956) and William Vickrey (1959), and by the former British Prime Minister, Mrs Thatcher's main economic advisor Alan Walters (1961).[6]

The idea is simple, since roads are not privately owned[7] and access to them is not determined by the market, there is a need, if roads are to be used efficiently, for the authorities to set a user charge that, for any given capacity, ensures that socially optimal flows are attained – the Road Price. There is often confusion about what this means. Road Pricing is solely concerned with making the best use of roads from the narrow perspective of users and is not concerned with third party effects such as pollution that should be treated separately. Congestion may or may not be related to environmental damage; 20,000 solar powered cars per hour on a road may congest it but cause minimal environmental damage whereas 500 old, badly maintained diesel vehicles may cause no congestion but a lot of pollution. Second, as the Nobel Prize winning economist, Ronald Coase, so ably famously demonstrated, policies such as Road Pricing are not market solutions but the most effective way of achieving an externally determined target traffic flow.[8] This flow is independently determined and is not the result of any market-based process.

The standard economic diagram illustrating the basic principles of Road Pricing is that originally found in the works of Walters and Vickrey, and although this is now seen as a gross simplification,[9] it serves well to illustrate the essential aims of congestion charging. In Figure 3.1 we take the basic case of a straight, single lane road with a single entry and single egress point, and with homogeneous traffic entering the road at regular intervals, although the intensity of entry can change. The average cost curve shows the generalized costs (a composite of money and time costs) of using the road for existing traffic, and is the cost observed by a potential additional user. The demand curve represents the utility that potential road users enjoy by joining the traffic flow at different levels of generalized cost. Individuals will join the traffic flow as long as they feel the benefits to be enjoyed exceed the costs. In the diagram, this leads to a traffic flow of F_1.

The problem, however, is that by undertaking the very act of joining the traffic stream a vehicle slows all succeeding vehicles by some small amount unless there is excess capacity on the road. This may only be a few seconds for each vehicle, but when the flow is large this mounts up. This combination of the cost borne by the

6 More technical accounts are found in Newbery (1989; 1990) and Eric Verhoef (1996).

7 The American economist, Frank Knight (1924) made the point that with privately owned, competitive roads, the market would both result in their optimal use and in optimal investment.

8 A brief account of this dinner party held at Aaron Director's where this was initially discussed is found in Stigler (1985).

9 Lindsey and Verhoef (2001) and Yang and Huang (2005) provide a detailed discussion of the issues.

vehicle driver and the cost imposed on other vehicles is depicted as the marginal cost curve in the diagram. If motorists take these combined costs into account then the flow would fall to F_2. The idea of the Road Price is to make them cognizant of the congestion cost element by imposing a charge of $C_2 - C_1$ on each road user; this being the additional congestion costs associated with the marginal user at the optimal traffic flow.

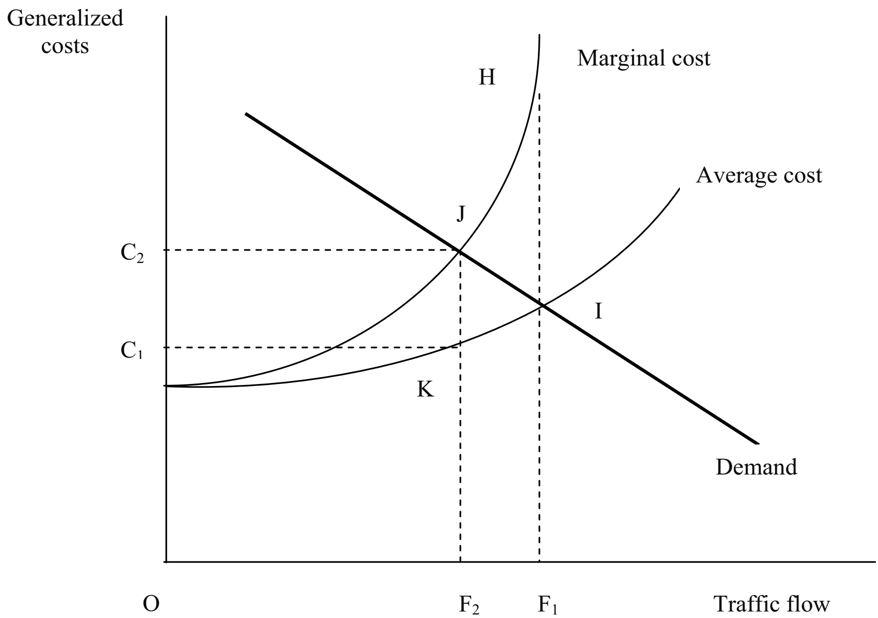

Figure 3.1 Simplified diagram of the effects of road pricing

It takes little imagination to realize that over a complex network with numerous junctions, various road types, different vehicle mixes and so on, the case in the diagram is simple in the extreme and that calculating the optimal charge would be challenging. Indeed, this is sometimes used as a reason for not charging. In reality, however, the pricing of a computer, a car, or any other sophisticated product or service is far from easy but it is done, albeit far from ideally, and companies like Microsoft and Apple seem to be held in much higher esteem than many local politicians and traffic engineers. Private sector companies in western style economies make an educated guess at the appropriate direct price for their products and then adjust them in the light of experience; if there is a large demand for their product then they raise prices and use the revenue to invest in additional capacity that will ultimately reduce costs and prices.[10] They do not charge a low price and then let queues allocate the output.

10 This does not mean that the outcome would be ideal – for example the private sector supplier may be a monopolist – but there are ways of handling this type of situation.

The figure, despite its simplicity, also provides a way of looking at alternatives to Road Pricing as congestion containment policies. Expanding the capacity of a road by adding physical capacity or initiating better traffic management through intelligent transportation initiatives will shift the cost curves down and out and thus reduce the divergence between them at the point where demand equates with the average cost. Such actions are clearly not costless and still leave a divergence between the new actual traffic flow and the optimal flow given the added capacity. Effectively traffic increases to fill the additional road capacity available. Subsidizing public transportation will pull the demand curve for road use to the right but again will still leave, albeit smaller, a traffic flow in excess of the optimum. Limiting or charging for parking will have the same effect.

A Few Examples of Urban Road Pricing

What is so surprising is that the principles of using pricing to allocate scarce resources, indicate where more are needed, and provide revenues to fund expansions, very simple economic ideas, so central in other parts of market economies, have taken so long to be applied to roads. Basically, if there is a shortage of something prices rise to allocate out what you have to those who benefit most from its use. The higher prices indicate that more capacity is needed, and generates the revenue to finance it. Although it seems unlikely that many of the policy-makers who have moved towards Road Pricing as a means of reducing congestion are aware of the finer points of economic theory,[11] a combination of desperation at the failure of traffic engineers to provide solutions to what is an economic issue, combined with a tightening of public funding, concerns about the environmental implications of continued massive infrastructure expansion, and the emergence of new technologies for fee collection,[12] have created settings conducive to congestion pricing. We review some of these here and Table 3.2 offers a few more details.

In 1975 Singapore implemented a cordon-based variable pricing scheme with the aim of reducing congestion in the city's central business district. In 1999, the scheme was extended and now charges are applied to users on certain expressways and outer ring roads as well. Charges are in effect on weekdays, from 7:30am to 7:00pm in the business districts, and from 7:30am to 9:30am on outer roads. Automated electronic road pricing was implemented in 1998 (Willoughby, 2000).

Cordon tolling has been a widely used strategy, with some initiatives that were first intended to finance additional engineering works evolving toward congestion charging (Ieromonachou et al., 2006; Sorensen and Taylor, 2006). The deployment of the cordon tolling, for example, was popularized by their use in a number of Norwegian cities primarily for revenue generating purposes (Tretvik, 2003).

11 An exception is Ken Livingstone, the former Mayor of London, who took up the idea after reading an obscure paper on the topic by Milton Friedman.

12 In fact, charging for road use was common in the past although mainly as a cost recovery tool but largely abandoned in the early part of the twentieth century in favour of earmarked taxation, as with the US gas tax, or financing from general revenues. One reason was simply the cumbersome nature of toll-booths as a way of collecting fees.

Table 3.2 Characteristics of eight major road pricing schemes

City	Electronic system starting date	Entry charge for a small vehicle	Toll ring area (km^2)	Average daily crossings	Annual revenue (million)
Trondheim	1991	$2.40	50.0	74,900	$25.00
Oslo	1991	$2.40	64.0	248,900	$196.00
Bergen	2004	$2.40	18.0	84,900	$36.00
Stockholm	2006	$1.33 to $2.66	29.5	550,000	n/a
Singapore	1998	$0.33 to $2.00	7.0	235,000	$80.00
Rome	2001	$3.75	4.6	75,000	$12.30
London	2003	$15.0	22.0	110,000	$320.00
Santiago	2004	$6.42	n/a	250,000	n/a

Notes: n/a: Not available.

In 1986, Bergen established the first urban toll ring as a supplementary funding mechanism for new roads, public transport, parking space, pedestrianisation, and an environmentally improved city centre. The cordon-based scheme only requires payment in entering the city centre. There are seven toll points around the city with fees collected between 6:00am and 10:00pm on weekdays and approximately 13 percent of the revenue is used to cover operating costs. Enforcement is dependent on digital video control. Because of the level and structure of the charges, there has been little impact on traffic levels and the system is not really a demand management tool in its current form. The toll ring is expected to cease operating in 2011.

A toll-ring scheme was initiated in Oslo in 1990 with the objective of financing additional roads capacity. Charges are in effect seven days a week at all times of the day. Electronic collection started in 1991. The toll ring although expected to cease operations in 2007 has continued to operate and interest persists in having the Oslo system evolve into a genuine congestion pricing scheme. Trondheim introduced an area-wide variable pricing scheme in 1991 again to finance road infrastructure and public transportation. Since its inception, Trondheim has opted for electronic fee collection with differential rates being charged for the morning and evening rush hours and a lower rate between 10:00am and 6:00pm. An innovation to this system that was originally cordon-based only, was the introduction of inter-zone charging in 1998. The pricing scheme, as originally conceived, stopped at the end of 2005.

In 1998 Rome implemented a cordon-based pricing scheme with the aim of preserving its historical areas. Payment is required to enter the city centre and only residents and employees working in the area with a secured parking space are allowed to enter the city centre. Authorized non-residents, about 35,000, are charged a flat rate. Charges are in effect six days a week, from 6:30am to 6:00pm on weekdays, and from 2:00pm to 6:00pm on Saturday. Electronic pricing started in 2001 with 22 toll points around the city.

Santiago de Chile's scheme consists of a network of toll roads that cross the city from north to south and also surround it. In 2004, the first of four major toll road concessions involved the implementation of a pricing mechanism, and in 2006 two additional projects were completed. The main purpose has been reducing air pollution in the city with the alleviation of excess congestion a secondary concern. There are three levels of charge depending on traffic speeds, the lowest being effective when the speeds are above 70 km/h and the lowest when speeds fall below 50 km/h. Payment is required at all times when using any of the roads concessions.

More recently, Central London has been the subject of an area-pricing regime (Leape, 2006; Nash, 2007). The charges apply to vehicles using roads in the city's core area between 7:00am and 6:30pm on weekdays with a 90 percent discount for those living in the area, buses and some other groups. Payment is made through a variety of channels and there is the opportunity for retrospective payment.

During the first seven months of 2006, a full-scale cordon-based road pricing trial was implemented in Stockholm with the objective of reducing congestion and improving environmental quality. This was followed by a referendum in September 2006 to test views on making the scheme permanent: a proposal that received over 50 percent of the vote. Road users were obligated to install a free-of-charge transponder on the windshields and a smartcard could be bought at different locations, recharged, or linked to a bank account to make payments. Charges were in effect on weekdays from 6:30am to 6:00pm, and on Saturdays from 2:00pm to 6pm. A limit of $8.30 was set as the maximum a user could be charged per day. As in other schemes, users were able to make a payment after they used the roads. Violations were considered tax evasion as the scheme was classified as a governmental tax (Stockholmsforsöket, 2006). Because of rising discontent in Stockholm's neighbouring municipalities, the permanent introduction of the congestion tax had to be passed by the Swedish parliament. This occurred on 1 August 2007.

The Technical Problems of Introducing Optimal Road User Charges

Theoretical economics, with its love of abstraction and mathematical exactitude, has long been drifting away from more traditional ideas of political economy. It is easy to show, as seen above, that with a few equations or diagrams, there are benefits to be gained by manipulating road user charges to contain excessive congestion. Implementation of such strategies, however, has been confronted by a plethora of practical and political challenges.[13] In addition, these have not always been independent of each other with opponents to Road Pricing using technical imperfections of any scheme as justification for attacking the concept in its entirety.

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13 Jones (1998) provides a listing of the reasons for public opposition to Road Pricing that is more extensive than the items covered here, although the substance of the main items is the same. In addition to the items listed by Jones, in the US there is the added problem that since many roads have been paid for through ear-marked taxation there is a common view that any further pricing would just be a tax on users.

Calculating the Road Price and its Impact

This topic has, to some extent, already been touched upon, but given the small industry that has grown up seeking to calculate optimal road prices in different contexts some additional comment is needed. It is clearly difficult, perhaps impossible, to calculate the optimal Road Price. To begin with, the Road Price is simply the efficient way of attaining a traffic related objective – particular flow, speed, or traffic density. This objective is set by the authorities, often based on the views of traffic engineers who take into account such things as safety and road wear in their estimates. It is largely a subjective indicator of the type of performance that is wanted from the road. The Road Price is then set to limit traffic to attain the objective.

What this charge will need to be will depend on the costs perceived by motorists of using the road; and this is largely a combination of direct costs and the implicit money costs of travel time. In practice neither is easy to calculate. The problem is that people's demand elasticities depend on their perceptions and not on objective measures. Hence, while the money costs of a trip will embrace such things as fuel costs and wear-and-tear on the vehicle, because these involve infrequent outlays, the road user tends to ignore most of them when deciding on a particular journey. Travel time poses a different sort of problem because, although it is recognized that 'time is money' to adopt the old saying, exactly how much money a minute of travel time saved is worth is open to some debate.[14] There are a variety of techniques available for putting a valuation on time savings (Jara-Díaz, 2000) but issues arise about such things as the appropriateness of the methods used (generically between stated and revealed preference techniques) and whether one can sum the value of many small savings to get the value of a large savings.

Technology

The pioneering Singapore area licensing scheme was simple and just involved vehicles having to display a card to show the driver had paid to enter the core area during designated times. From an economic perspective, this procedure had low transactions costs – the production and sales of permits was cheap and enforcement at entry points to the city became part of normally policing – and provided drivers with prior knowledge of potential costs upon which to base decisions regarding entering the city. It did not, however, provide any direct link to the congestion caused by a vehicle once in the city, and its application elsewhere in urban areas with far more entry and exit points would make enforcement more difficult and costly.

Manual charging systems also inevitably lead to 'steep tolls' in the sense that you either pay or you do not pay, and even when there is payment the price goes up in discrete jumps. The academic evidence (Arnott et al., 1993) is that there are considerable efficiency losses when such crude charges are imposed.[15]

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14 Indeed, on a related topic of evaluation of the London Road Pricing scheme one can get entirely different results depending on the values used (Nash, 2007).

15 These may be reduced if there are multiple zones with different charges or the charges vary at different time, albeit not continuously. Such options, however, add to the complexity of the system and the administrative costs.

The Smeed Report (1964) recognized the limitation of this type of simple fee collection over 40 years ago and discussed various electronic options, the technology of the day was, however, limited and expensive. Things have changed and now a variety of alternatives are available and many have been adopted.

One early concern that emerged with experiments using hypothetical electronic fee collection involved confidentiality of the information gathered. The issue is still a sensitive one. Keong (2002), for example, argues that the issue of privacy is inevitable when implementing electronic road pricing. The Hong Kong experiment, for example, from 1983 to 1985, while successful in showing that the technology used was reliable and that real time adjustments to charges were possible, also raised concerns that the information collected could infringe on personal liberties (Hau, 1990). The electronic congestion charging schemes in Stockholm, London, and elsewhere that have been initiated since that time have taken care to minimize the possibility of them being used for 'tracking' with powerful legal protections being built into the institutional structures in which they operate.

The London system makes use of off-the-shelf camera-based automated number plate recognition technology to enforce speed limits. Video recognition close circuit television cameras target optical characters on the number plates of vehicles at a rate of one per second even if the vehicle is travelling up to 100 mph. Charging is automated through computerized systems that deduct funds from the smartcards or through billing. The systems now deployed in Stockholm, Norway, and Santiago use automated vehicle identification involving the installation of a transponder and a smartcard that are detected by beacons installed at toll-booths and other check points. The exchanges of information between the tag and radar are possible using simple radio frequency identification technology. Regular users have their vehicles fitted with an electronic tag while visitors can make cash payments using specific lanes. Violators are identified through camera-based recognition of the vehicles' license plates and charged a retrospective fee.

Singapore's scheme does not require a centralized computer system to keep track of vehicle movements since all charges are deducted from an inserted smart-card at the point of use with records of transactions kept in the memory chip of the card belonging to the individual. As a further step to assure the public of privacy, all records of transactions required to secure payments from the banks are erased from the central computer system once this is done – typically within 24 hours.

In a sense, these types of device are often just more efficient ways of cordon charging. While it is possible to develop these types of technologies to provide real time charging, that reflects the actual levels of congestion when a vehicle is using a particular part of the road network, they suffer from a major economic drawback.[16] Consumers should know the price of something before coming to the purchase

16 This is also true to the on-vehicle technologies of the type proposed for Cambridge, England in the early 1990s (Ison, 1998). The idea, subsequently aborted, would have entailed each vehicle having a self-contained charging unit installed that when in the city would run down a pre-charged smart card as the vehicle encountered slow traffic or stopped for a short period. Again, this is ex post charging.

decision. The problem is that the drivers' own actions affect the price that should be paid and this makes real time charging extremely difficult in practice.[17]

Efforts at circumventing this problem have been made. One approach is to provide advanced information on local traffic conditions so that a driver has more insight as to the likely Road Price to pay. Modern technology facilitates the provision of real time traffic information on relevant parts of the network. Another approach is the one that has been deployed in the Interstate 15 scheme in California. In this case, the toll varies with traffic to maintain a target traffic speed with the road users being given the option of a 'free' road alongside the priced one. Information on average tolls for various times of the day is made available to help in route choice decision making.

Distributional Effects

Technically, in economic terms, road pricing leads to a Hicks-Kaldor societal welfare improvement. What this means is that overall, while some people will be worse off as a result of the price (if they were not it would be a Pareto improvement), those that benefit would be in a position to compensate them and still retain some gains from the scheme. In the case of road pricing, it is the authority that imposes the charge that benefits from the revenues collected (represented C_2JKC_1 in Figure 3.1) with the average road user being worse off. This leads to two related issues; defining exactly which road using groups lose and by how much, and second if and by how much should the authorities provide compensation. The first of these issues is dealt with here, and the second in the sub-section that follows.

All forms of pricing inevitably lead to differential consumption patterns that are to some extent influenced by income levels. Western style economies accepts this partly because it prioritizes what people want to consume but also because income is itself seen as reflecting the endeavors of individuals. If there are concerns about the income distribution this is treated as a normative issue that should be handled through redistribution as part of a political process. Road Pricing is no exception to normal pricing principles. Much of the debate about the distributional effects of congestion charging centres on the ability of poorer individuals to be able to buy road space, but the poor have inabilities to buy many things. Thus the problem is really one of income distribution *per se*, rather than of the price mechanism.

There is a second area of distributional interest, namely how the impacts of road pricing are spread over geographical space. In some cases there is a clear link between this and the income distribution issue because of the correlation between land use patterns and household incomes. In another context, however, there are concerns

17 Although this issue of prior information is a difficulty, it should not be seen as entirely damning of real time electronic pricing. Many urban road users make regular trips and there can be a strong learning experience. Additionally, there are few markets where consumers have full information when they make a purchase. Equally, in many markets, the price may be known but the quality of the product uncertain until actually consumed; the real time Road Price case is just the reverse of this with the speed on the system known because it is the policy target but the price to be paid is uncertain.

that Road Pricing will penalize businesses in areas where road users have to pay for their congestion effects as opposed to those that do not.[18] The evidence on this is limited, but a study of the London road charging scheme by Quddus et al. (2007) found that although individual stores were adversely impacted by the Road Price, it did not affect overall retail sales in Central London. Isolating the implications of the congestion charge is, however, not easy because of a failure of the Central underground line during the initial period of its introduction, the heightened fear of terrorism at the time, and the on-set of a general macroeconomic downturn.[19]

Expenditure of Revenue

Technically, the underlying cause of congestion is a lack of property rights; there is no real market for road space. Road Pricing does not fill that void but rather lets the authorities determine what the socially desirable level of road traffic is and then adjusts prices to produce this. This would normally mean that road users would pay more than they do now, but this is not universally true. Work by Newbery (1989) and Graham and Glaister (2006), for example, take a wider geographic perspective of Road Pricing and look at the entire UK road network. Although their results differ in detail, the studies find that while Road Pricing in urban areas would increase the revenues enjoyed by the relevant road authorities, revenues would fall on other parts of the network that are far less used.

A distinctive outcome of the Road Price is that the revenue does not go to a private company that then makes commercially oriented decisions on how to spend it, but rather to a public agency that has less clear-cut criteria regarding using the revenue flow (Button, 2006b).[20]

This issue was first highlighted by Sharp (1966) who suggested a variety of ways in which the money may be spent, none of them without problems. Examples include reducing other road user charges, which has an intuitive appeal provided that they are not being used to fulfill other policy objectives, such as reducing CO_2 emissions from carbon fuels or acting as a sumptuary tax to finance other, socially approved expenditures. There are also practical problems because fuel and other motoring taxes may be poor tools for congestion amelioration[21] they do indirectly impact on

18 Tied to this, but a slightly different topic, is a concern that freight transportation, and in particular collection and delivery, costs will rise due to Road Pricing. Much will depend on how the revenues of a congestion charge will be spent, but given the high premium that companies place on reliability as part of their overall supply-chain logistics it seems that freight activities would actually benefit from time savings and the ability to reap some of the benefits enjoyed by retailers, and so on, who would require lower inventory holdings.

19 A study by Carmel (2003) indicates the economic downturn began before the charge was introduced.

20 The link between a Road Price and optimal investment in road capacity is not a simple one and much depends on whether roads enjoy constant long-run costs or not. Keeler and Small (1977) provide a useful discussion of these issues.

21 Higher fuel taxes, although affecting trip volumes in the short term, have little impact on rush hour traffic flows in the longer term as car owners switch to more fuel-efficient vehicles.

congestion and reducing them will have some form of 'buy-back effect' as road users effectively enjoy additional spending power. Other options that reduce the buy-back implications, such as giving the revenues to those who make less use of roads – for example, the sick and old – are seen to have wider social benefits.

From a more pragmatic, political economy perspective of forming coalitions of interests that would endorse Road Pricing, Goodwin (1989) and Small (1992) looked at spreading the expenditure of revenues across different interest groups including road users (in the form of investment in additional capacity and intelligent transportation technology to better manage what there is), public transport authorities (in the form of capital and operating subsidies), and the general public (in the form of reduced taxation or increases in public endorsed non-transportation expenditures). The trick, of course, would be to find the appropriate balance of this redistribution between the various groups that would carry local political opinion. This has proved difficult in many cases.

A number of efforts have been made to ask those affected how they would like to see the revenues from Road Pricing spent. Verhoef et al. (1997) did an extensive survey in the Netherlands, and found that, in decreasing order, the preferences were for investment in more road capacity, reduction in vehicle taxation, reduction in fuel taxation, investment in public transportation, subsidies for public transportation, investment in car pooling facilities, general taxation cuts, and expansion of other forms of public expenditure.

In practice, most Road Pricing schemes do involve a high degree of earmarking of revenues either because the local authority has needed to do this to get policies through or because central government has mandated it as part of its wider policy agenda. In the case of the toll roads in Norway, although not strictly a Road Pricing scheme, the revenues were specifically earmarked for local transportation expenditures on roads and buses. In the UK, the revenues from London's congestion charging must, by national law, be spent on transportation in London; in fact much of it goes to subsidize bus services.

The Outcomes of Road Pricing Implementation

There are numerous academic and official studies that have examined the potential effects of using road user charges of one form or another to reduce urban traffic congestion. Rather than rehash these, or try to produce some meta-analysis of their statistical conclusions, here we look briefly at what has actually transpired when Road Pricing has been adopted. One thing is clear, the evidence from the various road-pricing schemes that have been initiated, and heavily studied, to date shows that drivers do respond to prices and that traffic congestion can be controlled through direct user charges. Besides the direct traffic effects on congestion, the initiatives have exerted a number of secondary influences, many that were generally anticipated but not on the scale that they have occurred.

There are inevitably problems in assessing the pure impacts of Road Pricing. All the schemes that have been introduced to date have been part of larger packages and isolating the effects of any element is difficult. The Singapore Area Licensing, for example, was accompanied by additional bus capacity and investments in park-and-ride facilities as well as exemption for high-occupancy cars. Also the charges themselves have inevitably embraced political compromise that, for example, in the London case resulted in significantly lower charges for residents and some types of road users such as taxis, trucks, and two-wheeled vehicles. Added to this, can be particular circumstances that affect the system, such as the closure for a period of the main underground railway line in London at the time congestion charging was initiated.

The world is also not static and traffic growth takes places over time. Consequently, there is a need for the level of congestion charges to change with circumstances. However, this makes it hard to estimate anything but very short term *ex post* elasticites because of the problem associated with allowing for these background growth trends.

Table 3.3 provides details of the outcomes of some of the major urban Road Pricing schemes in terms of the direct effects on automobile traffic, on the traffic situation more generally, and on public transport. The pattern that emerges is pretty clear and does not need much in the way of elaboration; Road Pricing, where it has been employed has reduced the use of cars, improved traffic flows, and led to a modal shift toward public transportation during peak periods. There have also been secondary benefits, such as reduced traffic generated environmental pollution, although this is difficult in practice to quantify and evaluate because people allocate their time saved from not being held up in traffic in a number of ways that in themselves can result in adverse environmental consequences.[22]

Of course not all outcomes have been exactly as predicted. In many cases, the authorities have underestimated the power of pricing and the reduction in traffic has exceeded forecasts, and the revenue collected has been less than expected. Equally, public transportation has generally been found to be a more popular substitute than expected once travellers are aware of the congestion costs of using cars. This poses some operational challenges in terms of budgeting and in the provision of public transportation, but has not seriously brought any scheme into difficulties.

Enforcement has posed challenges to the authorities responsible for some schemes, although there seems to have been a learning process. Transport for London (2006), for example, reported that the number of penalty charge notices fell throughout 2005 with 21 percent fewer charges overall. Nussio (2007) reports on Rome that violations to the zone resulting in fines have fallen from an initial 22 percent of the overall access flow to about 7 percent of those registered in 2005–2006. Reductions in traffic flows were actually mainly achieved through this reduction of illegal traffic entering the limited traffic zone. Better monitoring was made possible by the installation of electronic gates in 2001; illegal traffic decreased from an estimated 36 percent before their activation to under 10 percent after a year and a half as reported by the Progress Project (2004).

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22 Just as an example, it has been estimated that the Stockholm scheme reduced CO_2 by 10–14 percent in the inner city area and by 2–3 percent in the surrounding area, although there was little impact on noise levels, while the London charging scheme produced an annual \$6 million benefit in terms of reduced CO_2 emissions, and \$30 million in lower accident costs.

Table 3.3 Effects of road pricing

City	Traffic effects	Congestion effects	Public transport effects
Singapore, 1975–1998[1]	- 44%; -31% by 1988	Average speed increased from 19 to 36 km/h	Modal Shift, from 33% to 46% trips to work by city bus, 69% in 1983
Trondheim, 1991	-10%	n.a.	+7% city bus patronage
Singapore, 1998[2]	-10 to -15%	Optimized road usage, 20 to 30 km/h roads, 45 to 65 km/h expressways	Slight shift to city bus
Rome, 2001	-20%	n.a.	+ 6%
London, 2003	-18% 2003 vs 2002, 0% 2004 versus 2003	-30%. 1.6 min/km typical delay 2003, 2004 versus 2002 (2.3 min/km)	+18% during peak hours bus patronage 2003, +12% in 2004
London, 2005[3]	Small net reductions - 4% 2005/2006	- 22%. 1.8 min/km typical delay	bus patronage steady
Stockholm, 2006	- 30% 2006 versus 2004	-30 to -50% journey time	+ 6%

Notes: [1] Although called Area Licensing Scheme, the system was a cordon toll rather than an area license (Santos, 2005). [2] Electronic fee collection introduced. [3] New rate introduced.

Sources: Keong (2002), Rye (2006), Santos (2005), Hoven (1999), Tretvik (2003), Nussio (2007), Progress Project (2004), Transport for London (2005; 2006), Stockholmsforsöket (2006).

Why is Road Pricing not Used More?

Despite the adoption of a number of more economically based road charging systems in recent years, Road Pricing is not the norm. There are many reasons why this is the case; some of which have been explored in detail by academics, but others that remain speculative. We have also dealt with some of the issues, such as those associated with distributional impacts and the expenditure of revenues, when discussing the rationale for the systems that are now being used. The topic is a large one, however, and some surface scratching is attempted here regarding several of the other factors that have proved impediments to improving the way roads are used. Additionally, there is no single, ideal way of implementing Road Pricing, and the rejection of some schemes that have been put forward in the past may also have related more to their particular details than to the acceptability of the concept itself.

Reluctance to adopt economic pricing principles may in part be due to a feeling that individuals have some form of inalienable right to mobility and that pricing would restrict this. Matters of ‘inalienable rights’ are complex, and this is not the place to discuss them in any detail. What is perhaps germane, however, is that rights are not free goods; there is an opportunity cost involved in acquiring and retaining them. The costs of providing ubiquitous mobility are high and, while some may see ubiquitous mobility as desirable, the opportunity costs of achieving it are opaque in a world where there are inappropriate signals of the wider economic and social costs involved. Nevertheless, notions such as the 'freedom of the King's Highway' still persist and many are reluctant to pay for the use of roads irrespective of the economic consequences of current and future generations of excessive congestion.

In some ways related to this notion of a right to mobility, is the position taken in some countries that once a road has been built using public money, normally financed by taxation, then the public have the right to freely use the facility. This, for example, is a common argument voiced in the US and one of the reasons why Road Pricing in California has been limited to new facilities offering a better quality of service to the existing public roads; hence the charging regime is called 'Value Pricing'. The argument that once paid for, a facility should be open to all runs against the basic ideas of economic resource allocation has emotive appeal. In reality, unless there is optimal capacity whereby user charges just reflect up-keep costs, then there is a need to somehow ration the scarce road space so that its benefits are not diluted, and pricing is the way this is normally done in market economies and seems to work well.

At a more pragmatic level, even if road pricing is seen as the most efficient way of allocating road space, there are transactions costs involved in its adoption and enforcement can be high. Manual charging at cordons normally leads to severe local congestion at collection points. Until recently, electronic systems have been expensive and their reliability in question. The schemes that have been initiated over the past decade or so vary in their implementation costs (Button and Vega, 2007) as well as their effectiveness to improve traffic conditions. From a technical perspective, however, they are now highly reliable and the costs of implementation are relatively low, especially once capital costs have been amortized.

In all societies there are vested interests that seek to maximize their own welfare. This is not meant as a normative statement, but rather one of fact, and one long explored by the Chicago School of Economists[23] and, in a different way, by institutional economists interested in decision making within bureaucracies. Indeed, it is the premise that the economics of Adam Smith is based upon. In the context of road supply and use, there has been a domination of engineering thinking and engineering professionals largely staff most major governmental agencies. Construction companies are large and the engineering profession is organised and powerful. The interest of this group from a career perspective is largely in expanding systems and investing in capacity, any interest in making efficient use of existing capacity runs almost counter to this. Additionally, the training of most engineers does

23 Much of the focus of the Chicago School was initially on the capture of regulatory systems by both the regulators and the regulated to the detriment of society. Stigler's (1971) conveys the general ethos of the argument that is also applicable to many other contexts such as policies governing road provision and use.

not involve extensive analysis of economic allocation problem.[24] While this does not mean that additional capacity is not needed in many cities, the efficient allocation of existing road space has seldom been treated in a rational and unbiased way.

That changes are occurring partly reflect improved technologies for implementing Road Pricing and partly are a default resulting from the successive failures of policies involving road construction, public transport subsidies, and physical traffic management. This does not mean these other policies are irrelevant for optimizing road traffic, but each has its particular role that in the absence of Road Pricing it cannot fulfill efficiently. It has taken time for this realization to sink in because Road Pricing does involve payment for opportunity costs and this is unpopular leading to other, less immediately painful but very second best options being adopted.

Conclusions

It has taken a long time for the 'scribblings' of some French engineers to permeate the policies of transportation policy-makers, and even today there is reluctance on the part of many to accept that treating roads as we do most other goods and services in modern economies yields immense social benefits. But the trend is towards change and towards a more rational approach to the way we use our transportation systems. Time is a scarce resource for all of us and to waste large amounts of it sitting in lines of traffic is neither productive nor enjoyable for the majority.

The interesting issue from the perspective of political economy, rather than abstract economic theory, is why Road Pricing is not the norm but rather exists in a few isolated locations. The technology exists. It clearly works as a mechanism for reducing congestion, indicating where more capacity would be socially beneficial, and generates revenues that can be used to increase capacity. While some analysis has been done on this, the answer as to why society tolerates such waste is still eluding us. Surveys have posited some reasons, ranging from a general mistrust of government to ideological notions that roads, despite manifestly being the opposite, are public goods, but these hardly offer a full explanation. Perhaps the grip of populist Peronism extends beyond the borders of South America as far as roads are concerned.

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24 One way of looking at this issue is in terms of a comparison. Civil engineers design and construct hospitals but are seldom consulted about the way beds should be allocated to patients; that is seen as a medical matter. But engineers who design and build roads have largely been those who have been responsible for traffic policies; an economic matter.

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Chapter 4

The Role of Intelligent Transportation Systems (ITS) in Implementing Road Pricing for Congestion Management[1]

David Gillen

Introduction

Road pricing as a mechanism for demand management has been in the theoretical literature for near 100 years starting with Pigou in 1920.[2] Numerous academic articles appeared in a broad range of transportation and economics journals and provided a compelling case for the use of this instrument to manage congestion and optimize system and network investment.[3] It was not until the early 1990s that countries began to look at implementing road charging schemes. For the last decade the EU has been actively studying the use of the application of marginal cost pricing in transportation. They have funded research projects as well as demonstration schemes (see Gillen, 2000). The application of road pricing principles has included pricing for infrastructure financing as in Norway and for congestion management as in Stockholm and London.

It was not until passage of ISTEA (Intermodal Surface Transportation Efficiency Act) in 1991 in the US that there was a shift from discussions of the principles of demand management and pricing in particular to introducing the practice through demonstration projects. Further progress was made under the Transportation Equity Act for the 21st Century (TEA-21) of 1998. TEA-21 authorized the Value Pricing Pilot Program (VPPP) to fund innovative road pricing actions for easing congestion, and permitted limited tolling on Interstate highways. In many cases these demonstration projects were the introduction of High Occupancy Toll lanes (HOT lanes) which is the sale of excess capacity in HOV lanes to single occupancy vehicles (SOV), or vehicles which would not meet the HOV criteria for numbers of riders in the vehicle.[4] In the case of the I-15 HOT lanes real time pricing has been introduced where the price to use the HOV lanes will vary with the level of demand, measured

1 I am indebted to Kelly Loke for excellent research assistance in developing this chapter.

2 See Pigou (1920) while some have argued that Dupuit (1849) was the originator of efficient pricing for public services.

3 For an excellent survey see Lindsey (2006).

4 See Lindsey (2005) for a list of the various projects.

by speeds and volume/capacity ratios.[5] The development of private toll roads has also been an impetus to the move from theory to practice. Canada has lagged behind both the EU and US. The only 'priced' roadway is a private toll road running north of Toronto, Canada's largest city.[6]

The implementation of these pricing measures have been possible through the use evolution of relatively rudimentary labour intensive licensing schemes such as Singapore in 1975 and more recently the elements of Intelligent Transportation Systems (ITS), specifically the use of electronic tolling hardware with both on-vehicle and off-vehicle methods. There does not appear to be the use of other components of ITS infrastructure such as real time information on speeds and flows and providing users with options through information signage. This chapter examines the role that ITS has and can play in implementing demand management techniques, specifically road pricing. The following section describes the characteristics of congestion pricing schemes and distills these differing features into five basic design criteria. The purpose of this section is to understand the common elements of road pricing schemes. In the next section, the differing types of ITS investments and strategies are examined with the purpose of identifying those features of ITS which are able to meet the design criteria of road pricing schemes. The question to be answered are which ITS investments facilitate the introduction of road pricing. The final section of the chapter provides a description of several road pricing schemes around the world and illustrates how ITS investments have facilitated their introduction.

Road Congestion Management

Congestion represents one of a handful of externalities that plague urban environments. Others include air pollution, accidents and noise (May, 1992; Toh and Phang, 1997). Road congestion problems in particular, have been studied extensively for decades. It is broadly accepted that there is no single solution to these problems and that a package of transport and land use policy measures is needed (May, 1991; 1992). Economists for example focus on road pricing strategies while engineers tend to rely on supply side techniques of increased capacity, better design or modal alternatives and planners rely on land use planning.

Congestion management is understood to be the use of a variety of techniques and actions aimed at shaping the travel behaviour of urban road users, especially commuters. These techniques and actions can include the use of incentives as well as penalties, aimed either at modifying the supply of transport (for example, curbing the number of vehicles owned and increasing absolute road capacity) or modifying the demand for travel. May (1992) advocated that improvements in the supply of transport alone would not be able to meet the demand for travel. Some means of controlling that demand is also needed, that is, Travel Demand

5 I-15 is the Interstate highway running from Los Angeles to San Diego.

6 Priced means prices vary by time of day and vehicle and so has a similarity to marginal cost pricing. There are several toll roads in the country but the tolls are for financing not demand management.

Management (TDM). TDM refers to a variety of techniques and actions aimed at managing the demand on transportation facilities by encouraging commuters to change their commuting patterns and behaviours (Turnbull, 1995).

One of the most widely studied TDM techniques is road pricing. The literature dates back at least to and perhaps beyond Pigou (1920) but interest in it accelerated in the 1990s as policy makers began to realize a growing or anticipated shortage of revenues for financing, replacing and expanding infrastructure from fuel taxes and other traditional sources, and an increasing willingness to consider direct user charges such as tolls. The advancement in reliable electronic tolling technology spurred governments' interest and support for road pricing (Lindsey, 2006).

The Smeed Report (UK Ministry of Transport, 1964; Thompson, 1990; May, 1992; Hau, 1992) listed twelve criteria for a successful road-pricing scheme design:

a. Charges should be closely related to the amount of use made of the roads.
b. Prices should vary for different areas, times of day, week or year and classes of vehicles.
c. Prices should be stable and readily ascertainable before road users embark upon a journey.
d. Payment in advance should be possible although credit facilities may also be permissible.
e. The incidence of the system upon individual road users should be accepted as fair.
f. The method should be simple for road users to understand.
g. Any equipment should possess a high degree of reliability.
h. It should be reasonably free from fraud and evasion, both deliberate and unintentional.
i. It should be capable of being applied to a wider vehicle population or geographical area.
j. System should allow occasional users and visitors to be equipped rapidly and at low cost.
k. System should be designed both to protect individual users' privacy and to enable them to check the balance in their account and the validity of the charges levied.
l. System should facilitate integration with other technologies, and particularly those associated with driver information systems.

What is important to note from these twelve criteria is they cover a broad array of pricing principles as well as implementation criteria and needs and not simply ensuring, for example, that prices charged approximate marginal congestion costs. There are the added needs of meeting user's expectations, fairness and public acceptance, for example. Thus the role of ITS goes beyond simply getting the price right and includes broader public acceptance issues. These criteria can be grouped into five key aspects (see Figure 4.1). Although comprehensive, none of these criteria considers the role of public policy which is an important factor in implementation.

a. Pricing scheme – where, when and the amount to toll.
b. Toll infrastructure – how to toll and how should the infrastructure be managed.
c. Public policy – how to spend the toll revenues and designing transportation alternatives.
d. Public acceptance – how to garner support and overcome resistance from the public.
e. Technology – how technology can be used to improve effectiveness and efficiency.

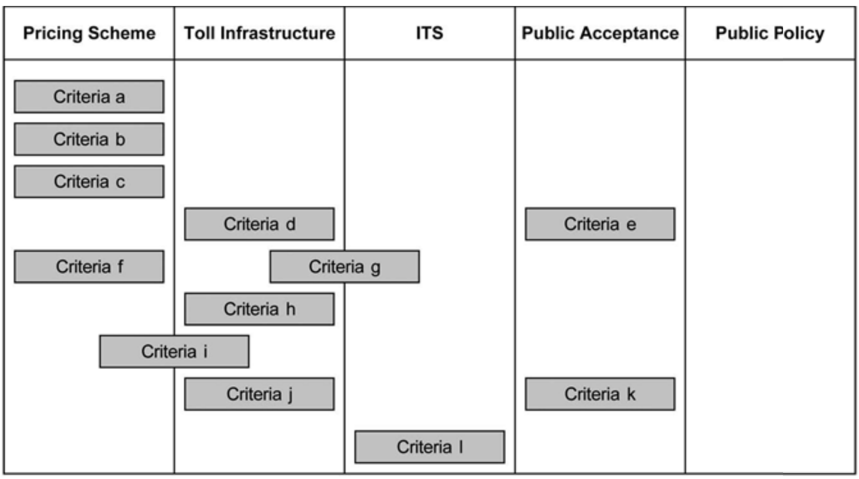

Figure 4.1 Grouping road-pricing scheme design criteria

Designing the Pricing Scheme

There are many different types of congestion management pricing schemes. Some are more direct than others in managing the demand for road use. Instituting taxes such as a carbon tax, fuel tax and car ownership tax are examples of indirect pricing schemes that aim to reduce or modify travel demand on certain transportation facilities. But there has been much debate over their effectiveness. For example, the Hong Kong car ownership taxation scheme yielded more car reduction in the New Territories, where incomes were lower but congestion less serious in those areas where congestion was worse (Lindsey, 2005). Atkinson and Lewis's (1975) evaluation of fuel taxation schemes also indicated that off-peak and leisure journeys tend to be forgone first. Given this evidence, as well as others, we have the advocacy for more direct road pricing schemes.

Road-pricing schemes generally have three key objectives (May, 1992):

a. Increasing the efficiency of congested road networks (such as Singapore's ALS and ERP and Hong Kong's ERP).

b. Reducing environmental impacts of congestion (for example, London, Dutch Rekening Rijden proposals for the Randstad, Stockholm, Edinburgh).
c. Generating revenue (either for public sector or private sector) (for example, Bergen, Oslo and Trondheim toll rings in Norway).

Regardless of their objectives, road-pricing schemes can be classified into three key types (Lindsey, 2006; 2007).

Facility-based schemes These include single lanes and individual roads or highways. Examples include High Occupancy/Toll (HOT) lanes (such as that in Houston, Texas and San Diego, California) and individual highways (such as the Electronic Road Pricing (ERP) scheme in Singapore). The charges in these schemes can vary by time or by vehicle type. In Houston for example, to use the HOV lanes during periods normally restricted to vehicles with three or more occupants, vehicles with two occupants pay a $2 toll and a $2.50 monthly fee. These schemes are ideal candidates for resolving congestion problems that are localized on major routes.

Area-based schemes These cover a broader geographical area and include cordon, whereby vehicles are tolled when they cross the cordon; and area charges, which are imposed for moving into, out of or within an area. Examples include toll cordons (such as that in Fort Myers in Florida and the charging scheme in London, UK), area licenses such as the Area Licensing Scheme (ALS) in Singapore for the Central Business District) and urban parking fee structures. Charges in area-based schemes can vary by time and vehicle type. In the case of Singapore, there are two types of ALS licenses: Whole-Day at S$1 for motorcycles and S$3 for all other vehicles and Part-Day at S$0.70 for motorcycles and S$2 for all other vehicles. Emergency and police vehicles and scheduled buses are exempted. Area-based schemes are therefore ideal candidates for resolving congestion that are concentrated in areas where demarcation is possible such as city centres.

Network-based schemes These include highway networks (such as the Trans-Texas Corridor project and the Japanese network of tolled highways) and systems that encompass all road travel such as GPS-based distance pricing. Networks of toll roads are appealing schemes because they provide scale economies for the users in terms of multiple possible origins and destinations within the network and for the operators in terms of toll collection (Lindsey, 2006). It may also be the case that political approval might also be easier to gain than for single facilities insofar as spatial equity is promoted by providing a common type of service across multiple regions. Nevertheless, toll-road networks face design challenges and obstacles such as setting of fair tolls (or at least be perceived so) for highways that have different construction costs and level of congestion.

Regardless of the type of schemes, determining the optimal toll amount has been and still is a topic of debate.[7]

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7 Road pricing is a simple concept that extends the common practice whereby prices are used to reflect scarcity, and to allocate resources to those that value them most. Economists

Toll Infrastructure

So how should tolls be charged? There have been proposals and actual cases of the use of toll booths, electronic road gantries, electronic metering of road use with bills sent to users at the end of the month and so on. Each has its advantages and disadvantages in terms of flow efficiency, billing accuracy, capital and collection costs and enforcement challenges.

The next question is: should toll infrastructures be managed as a public property or as a private investment? From a public sector perspective the main goal in harnessing the private sector is to attract private funding and/or operation of tolled facilities while avoiding both heavy subsidization and exploitation of monopoly power. It is also designed to bring private sector incentives of efficiency and customer service to the provision of road services.

Although the private sector plays a leading role in toll-road development in Europe, Australia and other parts of the world, in part because this is facilitated by government policy (Orski, 2005), most existing road-pricing schemes are managed publicly. One exception is the case of Highway 407 in Canada which has been owned and operated by a private entity, 407 ETR Concession Company Limited. The company is required to comply with provincial safety and environmental standards and to relieve congestion to alternative public highways. Tolls are not regulated but the company is subjected to financial penalties if annual traffic thresholds set out in the contract are not met; Mylvaganam and Borins (2004) provide a more detailed account.

Earmarking Toll Revenues

A longstanding question that goes beyond transportation is whether revenues from user charges should be earmarked for specific purposes (Lindsey, 2005; 2006) such as providing new transportation alternatives to using the priced road or area, improving existing infrastructures and park and ride arrangements and so on. Arguments against earmarking contend that it hampers budget control because priorities change over time. Many recent studies of road pricing however, support earmarking as necessary to gain political or public approval. Other advocacies include its consistency with the beneficiary principle, facilitation of long-term planning, potential in preventing political abuse of funds and enhancing public acceptability. Although there has been advocacy that the way in which the government allocates revenues will determine both the equity and the political acceptability of a road-pricing scheme, real-life practices vary. For instance, earmarking is the rule for Value Pricing Pilot Projects and the US Highway Trust Fund is earmarked in principle if not in practice. Earmarking however is not practiced in countries like Singapore and Hong Kong.

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now accept short-run marginal cost as the appropriate basis but there remains residual support for average-cost pricing to cover long-run costs. However, in all practical sense, the simpler the calculation of the charge, evidence suggests, the more readily the public will accept it.

The Importance of Public Acceptance

Public support is necessary in any road pricing scheme design (May, 1992; Small, 1992; Jones, 1998; Lex Services, 1998; Odeck and Brathen, 1997; 2002; Ison, 2000; Harrington et al., 2001; Santos and Rojey, 2004). Garnering public support has been challenging for three reasons. First, it is simply difficult to convince people that they should pay for something they once received seemingly for free (Harrington et al., 1998; Jones, 1998; Santos and Rojey, 2004); a lack of feasible transit alternatives (in some cases) only makes road-pricing feel more like coercion and the exploitation of the monopoly taxing power of government. Second, many view road prices as simply another tax, a way for urban government to raise monies in ways they would not be able to do otherwise and use them in ways not related to congestion or transportation problems.

Third, road tolls are perceived as deadweight losses whose effect on reducing congestion is questionable and any net benefits from the scheme are unfairly distributed. The equity arguments are probably the most difficult to refute (May, 1992). Several authors have argued (Richardson, 1974; Wilson, 1988) that road pricing is regressive, in that it will bear more heavily on poorer car users. In fact, the problems of regressivity and general opposition have typically prevented the introduction of road pricing (Morrison, 1986; Giuliano, 1994; Verhoef et al., 1997; Jones, 1998; Richardson and Bae, 1998). But there are others who have also pointed out that the lowest income travellers, who typically travel by bus or on foot, are most likely to benefit (GLC, 1974). In practice, it will be a small group of lower income car users who will be more seriously affected, as they are already by parking charges. Although there have been proposals to provide exemptions for this small group of lower income car users, there are strong arguments against them because of the potential enforcement and administrative problems which they generate (May, 1992). Therefore, the key is probably not in eliminating all inequities but to keep them to a minimum.

Many studies have also found that earmarking toll revenues can enhance the public's acceptance of road pricing schemes. For example, Odeck and Brathen (1997) found that public acceptance of the toll ring in Oslo, improved from 28 percent in 1989 to 40 percent in 1995 because during this time, several road investments were carried out in Oslo with tolls collected. Ison (2000) also found that acceptability increased from 11.3 percent to 54.6 percent after an explanation was given as to how the toll revenues will be used. Harrington et al. (2001) also found between 7 percent and 17 percent increase in support to congestion pricing when the use of toll revenues are specified. A study in London (NEDO, 1991) found that the acceptance of road pricing rose from 43 percent to 62 percent when it was known that the revenues would be used for improving London's transport system. Another UK-wide survey by Jones (1991) found that the percentage of supporters rose from 30 percent to 57 percent when revenues from road pricing was to be used to improve public transport and conditions for pedestrians and cyclists, and to reduce accidents.

The attitudes of the decision makers are therefore crucial. If they present road pricing as a positive means of improving the quality of the city centre and they are likely to encourage economic activity; if they present it as a means of restricting mobility and freedom of choice, they may well have the contrary effect (May, 1992).

In summary the successful implementation of road pricing requires a set of mechanisms that will facilitate pricing on a facility, network or over a broader geographic area. The mechanism must also be capable of varying the level of tolls and the structure as well. Public acceptance requires not only transparency but visibility of choice. This means that there must be choice to substitute away from higher priced roads if users wish to choose an alternative. This investment in alternatives should be transportation based. This would also include technologies that improve facility or network efficiency and effectiveness. Therefore, next the characteristics of ITS investments and the role and which types of investments can play a role in facilitating road pricing implementation are identified.

The Role of Intelligent Transportation Systems (ITS)

ITS refers to the application of a wide range of advanced and emerging technologies (such as computers, sensors, control, communications and electronic devices) aimed at improving the efficiency, mobility, productivity, safety and utilization of the overall transportation system. It also aims to mitigate the environmental impacts of transportation (Turnbull, 1995).

The application of ITS in road pricing can be classified into four key segments based on the process of a toll charge transaction. Regardless of the type of pricing scheme, a typical toll charge transaction will involve essentially four steps: (1) communication, in the form of advanced notification and detection as well as alternatives choice, (2) determination of toll amount and pricing structures, (3) payment of toll and (4) enforcement of system. The potential use of ITS in each of these steps are briefly introduced below.

Communication

Communications in road pricing schemes concerns mainly that between roadside and vehicle. There are two key objectives for deploying ITS in this stage of the toll charging transaction. The first objective is to equip the road user with real time and accurate information so that he/she is able to make an informed decision whether or not to use the tolled facility and what alternative options are available to them. For example, in order to influence commuters to change from driving alone to using some form of high-occupancy vehicles, this information needs to be provided in advance of the first mode selection (Turnbull, 1995). The second objective is to initiate the toll transaction by detecting the user vehicle accurately for subsequent steps in the toll process.

Determination of Toll Amount

ITS offers potential for improving both the accuracy and efficiency of toll calculation. As indicated earlier, there are many ways of determining the optimal toll amount. However, the simpler the calculation, the more easily the public will accept it. In a typical road-pricing scheme, whether it’s a facility-based, network-based or area-based, the tasks of detecting and calculating the toll amount are being performed on a moving vehicle. As such, in order to ensure that inefficiencies (if any) in these tasks do not create its own congestion, ITS can be applied to maintain the speeds of vehicles as they pass through the charge point.

Payment of Toll

ITS can potentially simplify toll payment methods while expanding the number of payment options at the same time. There are two main types of payment systems. The off-vehicle recording system involves the use of an electronic tag on the vehicle. May (1992) argues that the off-vehicle recording system is only really suitable for cordon (that is, area) or point charging, were the vehicle type, time of day and appropriate charge, are recorded.

The on-vehicle recording system on the other hand, involves the use of a smart card (Thompson, 1990; May, 1992) and an in-vehicle unit, into which the smart card is inserted. The on-vehicle recording system has the potential to accommodate a range of charging regimes and also the advantage of maintaining individual user's privacy. In addition to their pay-per-use design, these smart card devices are also able to provide an immediate indication to the driver when a charge has been incurred. They can therefore be used for other transport services such as parking and public transport (van Vuren and Smart, 1990; May, 1992).

Enforcement of System

Unless enforcement action can be readily automated, there is a serious risk that the system will breakdown and violations will increase (May, 1992). Having the ability to detect the right vehicles and implement the right charge is not enough. Any road-pricing scheme should also be designed in such a way that fraud and evasion can and are kept to a minimum or totally eliminated. Compared to a manual system of monitoring, ITS can definitely be applied to ensure that all vehicles passing by the charge point are detected and their characteristics accurately recognized and toll charges accurately applied, more efficiently and effectively. Because of its information capturing and retention capabilities, ITS can also allow and enable after-the-fact enforcement of fraud and evasion incidents.

As a final point in each case, information is being gathered. The off vehicle system gathers information at a point in time and space while an on-vehicle system [can] collects information on a continuing basis. The on-vehicle system provides superior information to manage a network and area as well as a facility, while an off-vehicle system provides information only for managing a facility. Certainly, the information generation feature of ITS should not be overlooked. Even though it appears ancillary to the prime purpose to implement road pricing, it has an important role in managing demand in subsequent time periods and in the case of on vehicle system in different areas. A key value of on-vehicle sensors is it gives mobility to ITS and overcomes a significant drawback and oft cited criticism, of vehicle ITS systems simply move the congestion to the next bottleneck.

Intelligent Transportation Systems (ITS)

While the principle of road pricing has a long and distinguished literature, it is relatively recently that the practice of road pricing is taking place. Implementation is much more than simply getting the price right it also includes the potential for evasion or diversion, the security of information about people's travel and the degree of public understanding and their perception of the fairness of any pricing scheme. With rapid advancement in information technology especially in the realm of ITS technologies, the critical components of a successful road pricing scheme implementation now include the careful tactful deployment of ITS technologies.

ITS are based upon the concept of using advanced communications, computers, sensors, and information processing, storage, and display techniques to improve the efficiency and safety of the surface transportation system and to reduce its harmful

Table 4.1 ITS technology classification

Functionalities	Scheme 1 Categories	US DOT Scheme Categories
Information and guidance (for decision making)	a. Advanced Traveler Information Systems (ATIS)	b. Pre-trip travel information c. En-route driver information d. En-route transit information e. Traveler services information f. Route guidance g. Ride matching and reservations h. Personalized public transit i. Emergency notification and personal security j. Impairment alert
Controlling and directing	k. Advanced Vehicle Control Systems (AVCS)	l. Traffic control m. Longitudinal collision avoidance n. Lateral collision avoidance o. Intersection crash warning and control p. Vision enhancement for crash avoidance q. Pre-crash restraint deployment
Automation and efficiency enhancement	r. Advanced Public Transportation Systems (APTS) s. Commercial Vehicle Operations (CVO) t. Advanced Rural Transportation Services (ARTS)	u. Travel demand management v. Electronic payment services w. Commercial vehicle pre-clearance x. Commercial vehicle administrative processes y. Commercial fleet management z. Public transportation management aa. Fully automated vehicle operation
Surveillance and monitoring	bb. Advanced Traffic Management Systems (ATMS)	cc. Incident management dd. Onboard safety monitoring ee. Automated roadside safety inspections

environmental effects (Branscomb and Keller, 1996). Turnbull (1995) discusses two different classifications schemes for ITS technologies. The first divides ITS into six broad categories based on their general applications. The second classification scheme is developed by the US Department of Transportation and it also groups ITS technologies based on their general applications, into 27 categories, but it is done more from a user's perspective.

An alternative approach, to which we subscribe, is that, in order to identify the potential of various ITS applications in achieving the seemingly different dual objectives of road pricing – (1) revenue generation/financing and (2) efficient use of and investment in transportation infrastructure, ITS applications should be classified or looked at based on their key purpose/functionalities. Based on the two previously mentioned classification schemes, four key functionalities emerge; these are illustrated in Table 4.1.

The four primary functionalities are providing information, directing vehicles and people, providing an efficient method of pricing and monitoring use. We consider each in turn.

Providing information and guidance This refers to the ability of the ITS application to collect, analyze and transform (if required) and disseminate data and information in a way and form that can be used for decision making by the transportation user, service provider or infrastructure/system governor. For example, traveller information programs using variable message signs and highway advisory radio have been used to capture and disseminate current traffic information to guide drivers in making better decisions about route choice. Studies have shown that such programs have produced benefits in reducing travel times and delays and consequential benefits in reducing emissions and fuel consumption are also predicted (US DOT, 1996).

Controlling and directing movement of vehicles and/or people This refers to the ability to capture real time information, automate decision making based on pre-set rules and criteria and disseminate that information/decision in an effort to influence the behaviour of vehicles and/or people. For example, the use of flexible traffic signal control systems have been reported to generate benefits in areas including travel time and delay reduction, travel speed improvement, vehicle stops reduction, fuel consumption and emissions reduction (US DOT, 1996).

Automating and enhancing the efficiency of the delivery of the road-pricing effort This refers to the ability of the ITS application to computerize tasks so as to reduce the need for human and time resources. For example, the use of electronic toll collection has automated the calculation and payment of toll charges, thereby greatly improving the throughput of vehicles on a per-lane basis compared with manual lanes.

Monitoring the use and functioning of the road-pricing effort This refers to the ability of the ITS application to observe and track activities, capture that information and disseminate it in a real time manner for quicker problem prevention, response and resolution. For example, the use of vehicle location systems such as GPS technologies coupled with computer-aided dispatching systems, have enabled public transit operators and commercial vehicle fleet operators to more effectively and efficiently determine the demands for their transportation assets and allocate their resources and services accordingly. The use of these ITS applications are producing benefits in travel time reductions, improved security and service reliability and cost-effectiveness. This contributes to road pricing implementation by making alternatives more attractive substitutes.

ITS Components and their Characteristics

The US Department of Transportation (DOT) has identified nine first-level ITS components as part of the intelligent transportation infrastructure (ITI) (Turnbull, 1995). The US DOT ITS national program seeks to achieve goals in four areas, namely safety, productivity, efficiency and environmental impact. It is envisioned that these components, which can be implemented over time, will form the platform for numerous ITS products and services provided by both the public and private sectors. Gillen and Gados (2006) also provide a comprehensive listing of 35 ITS components and their characteristics.

Table 4.2 Re-classifying ITS components based on their primary functionalities

Functionalities	US DOT	Gillen and Gados (2006)
Information and guidance (for decision making)	a. Regional Multimodal Traveler Information Centers b. Transit Management Systems	c. Traveler Information d. Route Guidance e. Ride Matching and Reservation f. Traveler Services and Reservations g. Automated Dynamic Warning and Enforcement h. Non-vehicular Road User Safety i. En-route Transit Information j. Weather and Environmental Data Management k. Archived Data Management
Controlling and directing	l. Traffic Signal Control Systems Railroad Grade Crossings	m. Traffic Control n. Travel Demand Management o. Automated Dynamic Warning and Enforcement p. Demand Responsive Transit q. Emergency Vehicle Management r. Vehicle-based Collision Avoidance s. Infrastructure-based Collision Avoidance t. Sensor-based Driving Safety Enhancement

Table 4.2 continued Re-classifying ITS components based on their primary functionalities

Functionali ties	US DOT	Gillen and Gados (2006)
Automation and efficiency enhancement	u. Electronic Fare Payment Systems v. Electronic Toll Collection Systems	w. Operations and Maintenance x. Automated Dynamic Warning and Enforcement y. Public Transport Management z. Electronic Payment Services aa. Commercial Vehicle Electronic Clearance bb. Automated Roadside Safety Inspection cc. Commercial Vehicle Administrative Processes dd. Automated Vehicle Operation
Surveillance and monitoring	ee. Incident Management Systems ff. Transit Management Systems gg. Freeway Management Systems hh. Emergency Response Providers	ii. Incident Management jj. Travel Demand Management kk Environmental Conditions Management ll. Non-vehicular Road User Safety mm. Multi-modal Junction Safety Control nn. Public Travel Security oo. On-board Safety Monitoring pp. Inter-modal Freight Management qq. Commercial Fleet Management rr. Emergency Notification and Personal Security ss. Hazardous Material Planning and Incident Response tt. Disaster Response and Management uu. Safety Readiness vv. Pre-collision Restraint Deployment

Based on their primary functionalities, the ITS components identified by both the US DOT and Gillen and Gados (2006) can also be re-classified according to the four key functionalities identified above – (1) information and guidance provision, (2) controlling and directing, (3) automation and efficiency enhancement and (4) surveillance and monitoring; these are provided in Table 4.2.

Analysis – ITS Application Framework

Figure 4.2 below illustrates the divide between the two primary objectives of road pricing schemes and the primary means of achieving them. Traditionally, in the absence of ITS technologies and applications, the road pricing objectives of effective congestion management and revenue generation are almost mutually exclusive.[8] Although a pricing scheme such as the Area Licensing Scheme (ALS) in Singapore has proven to yield significant benefits such as reducing traffic entering the central area by 44 percent, solo car journeys in the controlled period by 60 percent, improving speeds into and within the area by 20 percent (May, 1992), there have been arguments that this is not optimal because the prices that have been set were focused on achieving a traffic flow set exogenously. Also effective revenue generation for financing does not necessarily tolerate a complex pricing structure and complicated enforcement requirements. This is because a road-pricing scheme that takes too much effort and resources to maintain and monitor defeats the original purpose of generating finances for other public endeavors that contribute to demand management.

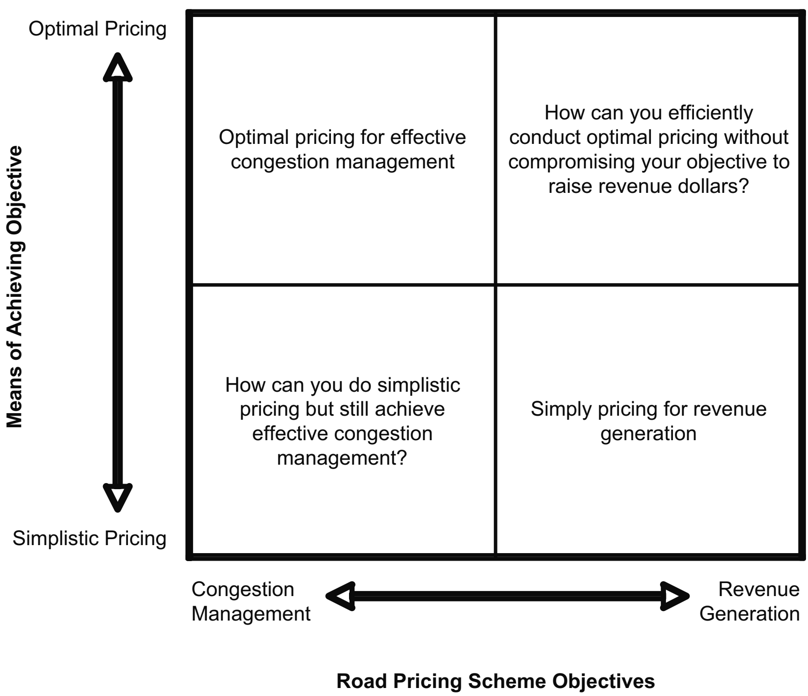

Figure 4.2 Illustration of the gap between the two primary objectives of road pricing

Based on the Gillen and Gados (2006) classification of ITS components which is centred on their key functionalities, it is straightforward to see how various ITS applications and capabilities can be applied to different parts of the road pricing

8 This is in the sense of their application only. The reason is the objective functions differ. If a short run marginal cost pricing scheme was followed while maximizing economic welfare, it is well established that such a pricing scheme will lead to short run optimal capacity allocation and long run capacity investment levels.

process/transaction in order to achieve the dual objectives of a road-pricing scheme (see Table 4.3 below), that is:

a. How can effective congestion management be achieved with only simple pricing scheme?
b. How can efficient revenue generation be achieved with a complex pricing scheme aimed at effective congestion management?

Table 4.3 Matching ITS applications' functionalities with steps in toll process

Key Steps in Toll Process*		ITS Functionalities Required
1	Communication – Notification	Information and guidance
	Communication – Detection	Controlling and directing/Surveillance and monitoring
2	Determination of toll amount	Automation and efficiency enhancement
3	Payment of toll	Automation and efficiency enhancement
4	Enforcement of system	Surveillance and monitoring

Notes: * see Section 1.5.

How can effective congestion management be achieved with only simple pricing scheme? Complex toll charge calculation can be made easier by using ITS applications that has the capability to automate the calculation of toll charge and present them in a simple manner to road users far in advance enough to allow them the opportunity to decide whether or not to use the tolled road or enter the tolled area. To achieve this, several ITS technologies will have to be used as an integrated system. For instance, a toll calculation program that is capable of dynamically calculating the amount of toll charge based on real time usage condition of the road facility or area or network will have to be put in place together with an electronic toll collection infrastructure. A traveller information system can be added to provide early notification to drivers of the potential toll charge to allow them the time to make route decisions. As well such information systems can provide accurate estimates of journey time on the tolled facility. Infrared or microwave technology can be used for a higher rate of information transfer. Therefore, the combination of a dynamic toll calculation program, early traveller information and notification system and an electronic toll collection infrastructure can, in principle, be used to simultaneously achieve economically efficient congestion management and efficient toll operations to maximize revenues from road pricing schemes, given tolls have been optimized. The difficulty is in practice revenues are maximized or there is a target value such that tolls are set to achieve this value rather than the other way around.

Setting higher than optimal toll charges may be effective in reducing congestion on the road facility, area or network but may as a consequence shift the demand for alternative road facilities, areas and networks out of equilibrium. If this is to be done, the key is therefore to deploy ITS technologies that have the capabilities of controlling and balancing traffic, or more aptly, the demand for alternatives. In this case, ITS applications and technologies with information and guidance provision capabilities and controlling and directing capabilities can be deployed to simultaneously achieve the objectives of profit maximization and effective congestion management. For example, an en-route transit information system can be put in place to monitor the road and weather conditions from fixed sensors. The information collected can be disseminated real time to road users at points when they are still able to make route selections or multi-modal trip decisions for a particular destination. Traffic control systems such as flexible traffic signals can be added to influence and control the expected travel times and thereby influencing road users' choice of alternative routes.

As stated above, reducing the costs of administering the toll scheme can also maximize toll profits. In the absence of higher than optimal toll charges, the use of ITS technologies with automation and efficiency enhancement functionalities can potentially maximize the profits from toll schemes. For example, the use of electronic payment services can improve the efficiency of toll collection, violator detection and administering penalties while reducing the time, labour and monetary resources required.

In Table 4.4 the unit costs of capital and operating and maintenance are reported (all costs are reported in 2006 US$s). Although not all of the elements of ITS technologies described earlier are available, nonetheless it is possible to piece together the incremental cost of increased use of ITS technologies. For example, to inform driver choice a variable message sign capital cost is anywhere between $48,000 and $119,000 with annual operating and maintenance costs of $2,300 to $6,000. Such an ITS application would be location specific and cover at most a few routes. To move to a network level information system would move capital costs to $3.77 to $5.4 million depending on the size of the urban area and annual operating costs to $538,000 to $807,000 depending on size. A move to road pricing would entail installing capital and IT components (see listings under 'Toll Plaza' in the table); total capital costs would range from $25,000 to 45,000 and annual operating costs between $600 and $1,300 per reader; a seemingly modest amount when compared with variable message signs. However with multiple readers and adding in 'Toll Administration' costs capital costs increase by $45,000 to $86,000 range and annual costs increase by $4,300 to $8,200. The use of ramp meters is expensive as it is capital intensive; capital costs range from $131,000 to $221,000 with annual operating costs in the area of $5,300 to $10,300. What is not possible to calculate is the gain in economic efficiency achieved as more intensive use is made of ITS technologies. There is some anecdotal evidence on reduced delay and emissions from some applications of ITS technologies.[9]

9 See http://www.itscosts.its.dot.gov/ for more complete information.

Table 4.4 Cost components of ITS

Subsystem/Unit Cost Element	IDAS No.	Lifetime* (years)	Capital Cost ($K)		Adjusted From Date	O&M Cost ($K/year)		Adjusted From Date	Description
			Low	High		Low	High		
Roadside Telecommunications (RS-TC)									
DS0 Communication Line	TC001	20	0.5	0.9	1995	0.6	1.2	2003	56 Kbps capacity. Leased with typical distance from terminus to terminus is 8–15 miles, but most of the cost is not distance sensitive.
DS1 Communication Line	TC002	20	0.5	0.9	1995	4.8	9.6	2005	1.544 Mbps capacity (T1 line). Leased with typical distance from terminus to terminus is 8–15 miles, but most of the cost is not distance sensitive.
DS3 Communication Line	TC003	20	2.7	4.6	1995	22	67	2001	44.736 Mbps capacity (T3 line). Leased with typical distance from terminus to terminus is 8–15 miles, but most of the cost is not distance sensitive.
ISP Service Fee	TC007					0.17	0.6	2004	Monthly service fee ranges from $15 per month for regular dial-up service to $50 per month for DSL.
Conduit Design and Installation – Corridor		20	50	75	2005	3		2005	Cost is per mile. Includes boring, trenching, and conduit (3 or 4 inch). Cost would be significantly less for an aerial installation. In-ground installation would cost significantly less if implemented in conjunction with a construction project.
Twisted Pair Installation		20	11	15.7	2004	1986.54		2004	Cost is per mile.
Fiber Optic Cable Installation		20	20	52	2005	1	2.5	2005	Cost is per mile for cable and in-ground installation. Cost would be significantly less for an aerial installation. In-ground installation would cost significantly less if implemented in conjunction with a construction project.
900 MHz Spread Spectrum Radio		10	9.1		1999	0.1	0.4	2004	Cost is per link.
Terrestrial Microwave		10	5	19.1	2005	0.5	1	2005	Cost is per link. Cost could be higher depending on tower/antenna installation.

Table 4.4 continued Cost components of ITS

Subsystem/Unit Cost Element	IDAS No.	Lifetime* (years)	Capital Cost ($K)		Adjusted From Date	O&M Cost ($K/year)		Adjusted From Date	Description
			Low	High		Low	High		
Roadside Telecommunications (RS-TC) (continued)									
Wireless Communications, Low Usage	TC004					0.12	0.2	2003	125 Kbytes/month available usage (non-continuous use).
Wireless Communications, Medium Usage	TC005					0.5	0.6	1995	1,000 Kbytes/month available usage (non-continuous use).
Wireless Communications, High Usage	TC006	20	0.5	0.9	1995	1.1	1.7	2002	3,000 Kbytes/month available usage (non-continuous use).
Roadside Control (RS-C)									
Ramp Meter	RS006	5	24	49	2003	1.2	2.7	2003	Includes ramp meter assembly, signal displays, controller, cabinet, detection, and optimization.
Software for Lane Control	RS011	20	24	49	1995	2	5	1995	Software and hardware at site. Software is off-the-shelf technology and unit price does not reflect product development.
Lane Control Gates	RS012	20	78	117	1995	1.6	2	1995	Per location.
Fixed Lane Signal	RS009	20	5	6	1995	0.5	0.6	1995	Cost per signal.
Roadside Information (RS-I)									
Roadside Message Sign	RS010	20	39	58	1995	2	3	1995	Fixed message board for HOV and HOT lanes.
Wireline to Roadside Message Sign	RS013	20	5	8	1995				Wireline to VMS (0.5 mile upstation).
Variable Message Sign	RS015	10	48	119	2005	2.3	6	2005	Low capital cost is for smaller VMS installed along arterial. High capital cost is for full matrix, LED, 3-line, walk-in VMS installed on freeway. Cost does not include installation.
Variable Message Sign Tower	RS016	20	26	126	2005				Low capital cost is for a small structure for arterials. High capital cost is for a larger structure spanning 3–4 lanes. VMS tower structure requires minimal maintenance.

Table 4.4 continued Cost components of ITS

Subsystem/Unit Cost Element	IDAS No.	Lifetime* (years)	Capital Cost ($K)		Adjusted From Date	O&M Cost ($K/year)		Adjusted From Date	Description
			Low	High		Low	High		
Roadside Information (RS-I) (continued)									
Variable Message Sign – Portable		14	18.6	24	2005	0.6	1.8	2005	Trailer mounted full matrix VMS (3-line, 8" character display); includes trailer, solar or diesel powered, and equipped with celluar modem for remote communication and control. Operating costs are for labour and replacement parts.
Highway Advisory Radio	RS017	20	15	35	2005	0.6	1	2005	Capital cost is for a 10-watt HAR. Includes processor, antenna, transmitters, battery back-up, cabinet, rack mounting, lighting, mounts, connectors, cable, and license fee. Super HAR costs an additional $9–10K (larger antenna). Primary use of the super HAR is to gain a stronger signal.
Highway Advisory Radio Sign		10	5	9	2005	0.6	1.0	2005	Cost is for a HAR sign with flashing beacons. Includes cost of the controller.
Roadside Probe Beacon	RS020	5	5	8	2001	0.5	0.8	2001	Two-way device (per location).
Toll Plaza (TP)									
Electronic Toll Reader	TP001	10	2	5	2001	0.2	0.5	2001	Readers (per lane). O&M is estimated at 10% of capital cost.
High-Speed Camera	TP002	10	7	10	2003	0.4	0.8	1995	Cost includes 1 camera/2 lanes.
Electronic Toll Collection Software	TP003	10	5	10	1995				Includes COTS software and database.
Electronic Toll Collection Structure	TP004	20	13	20	1995				Mainline structure.
Information Service Provider (ISP)									
Basic Facilities, Comm for Large Area	IS019		5380		1995	538	807	1995	For population >750,000. (stand-alone) Based on purchase of building rather than leasing space. Communications includes communications equipment internal to the facility such as equipment racks, multiplexers, modems, etc.

Table 4.4 continued Cost components of ITS

Subsystem/Unit Cost Element	IDAS No.	Lifetime* (years)	Capital Cost ($K)		Adjusted From Date	O&M Cost ($K/year)		Adjusted From Date	Description
			Low	High		Low	High		
Information Service Provider (ISP) (cotinued)									
Basic Facilities, Comm for Medium Area	IS020		4304		1995	538	646	1995	For population <750,000 and >250,000. (Stand-alone) Based on purchase of building rather than leasing space. Communications includes communications equipment internal to the facility such as equipment racks, multiplexers, modems, etc.
Basic Facilities, Comm for Small Area	IS021		3766		1995	538	565	1995	For population <250,000. (Stand-alone) Based on purchase of building rather than leasing space. Communications includes communications equipment internal to the facility such as equipment racks, multiplexers, modems, etc.
Information Service Provider Hardware	IS001	5	23	34	2004	0.5	0.7	2004	Includes 2 servers and 5 workstations. O&M is estimated at 2%; could be higher for responsive and preventative maintenance.
Systems Integration	IS017	20	86	105	1998				Integration with other systems.
Information Service Provider Software	IS002	20	267	535	1995	13.4	26.7	1995	Includes database software (COTS) and traffic analysis software.
Map Database Software	IS003	2	10	29	2005				Software is COTS.
Information Service Provider Labor	IS004					254	363	1995	Description is based on 1995 data: 2 Staff at 50K to 75K and 1 staff at 75K to 100K. Salary cost are fully loaded prices and include base salary, overtime, overhead, benefits, etc.
Toll Administration (TA)									
Toll Administration Hardware	TA001	5	5.4	8.1	2004	0.27	0.41	2004	Includes 2 workstations, printer, and modem. O&M estimated at 5% of capital costs.
Toll Administration Software	TA002	10	39	78	1995	3.9	7.8	1995	Includes local database and national database coordination. Software is COTS.

Notes: * Not available for all unit cost elements.
Source: US Department of Transportation: http://www.itscosts.its.dot.gov/.

Applications of ITS in Road Congestion Management

Road pricing has been introduced in a number of countries in different ways and for a number of reasons including congestion management, environmental improvements and infrastructure financing. Each case and motivation resulted in differing levels of the use of ITS or ITS components.

The first group of road pricing focused on CBDs and included Singapore, Hong Kong and Cambridge, UK. Singapore's area licensing scheme was initially a very low technology application and was begun in 1975. There was no electronic information checking or information gathering at his time, nor was there a need. The purpose was to reduce car use in a specific area and increase average vehicle speeds; it achieved both. ITS was neither needed nor available at the time the original licensing scheme was put in place. In subsequent years there was a need to vary the toll, allow certain types of vehicles to be exempt and broaden the coverage area. In 1994 additional complexity was added to the charging scheme but its motivation had not changed. The use of ITS in this case was still modest since all that was involved was a timing of passing a point and vehicle identification, which was an off-vehicle system.

As Singapore's area licensing scheme grew in complexity with a modest level of technology and an increasing array of licenses, it became clear that both the technology and approach needed to change. An electronic road pricing scheme was designed in the mid to late 1990s and introduced in 1997–1998. The pricing scheme was to optimize road use, that is, efficiency. The technology was an on-vehicle electronic unit and fixed road gantries that could read vehicle IDs in 0.4 seconds. Therefore, ITS components played an important role in meeting the objectives of efficient road use, vehicle identification and enforcement, all necessary for an effective road pricing scheme.

Hong Kong had aspirations of introducing a complex road pricing system with video enforcement. The complexity arose from the motivation to set tolls to reflect congestion levels although not necessarily close to social marginal cost; there were several charging zones reflecting differing levels of congestion, but it was not real time pricing. Small and Gomez-Ibanez (1998) state the technology used in Hong Kong [experiment] included radio frequency communications in in-road loop detectors and cameras for enforcement. The proposed system, which was tested but never implemented was complicated having 130 different charging points in some configurations that were examined. Note, unlike the case of Singapore, the motivation for pricing variation and enforcement led to greater use of electronics and was edging closer to ITS type electronics.

Cambridge, UK, was like Hong Kong a relatively complex road pricing system and one which was never implemented, again like Hong Kong. The desire to set road prices close to the social marginal cost required knowledge of congestion levels in real time and space and to set prices accordingly. Due to privacy concerns there was an on-vehicle system which charged by time and location but this information was not transmitted or transferred.

As stated earlier, the two key objectives of introducing road pricing have been efficiency and second, financing. The Scandinavian countries have introduced tolls for financing. Norway, see Waerstad (1992), introduced a cordon type toll which was relatively straightforward, with a simple charging structure and a cordon design. Road pricing were introduced in Bergen, Oslo, Trondheim. The objectives were modest, aimed at financing and providing revenues for cities. Both technically and in terms of fulfilling stated objectives, the toll cordons have been judged to be a success. Revenue from tolling has reached or exceeded expectations and projects financed by toll revenue have been completed. It is now proposed to extend the scheme and to consider toll rates differentiated by time of day. A recent amendment to the Road Act has paved the way for an alternative: road pricing. However, this shift to complex pricing from a simple cordon toll, requires a move away from off vehicle technology to on vehicle as well as additional ITS investments to gather and manage information.

Stockholm introduced a road toll in 2006 on an experimental basis and on 1 August 2007 it became permanent. The purpose of the road pricing plan is to reduce congestion, not to optimize the system and also reduce pollution, noise and increase transit speeds. Prices vary by time of day but not with traffic levels. It uses an off vehicle system which records license plate information and charges are paid using institutions or Internet access to accounts. The ITS components are relatively simple and serve to keep the cost of implementation down. It is not clear if the system as in place could be easily transformed to one which sets prices on a real time basis.

The London road pricing system, perhaps the best known among road pricing initiatives is a simple cordon charging scheme. The fee does not vary by time of day and is an area pricing scheme. It has proven to be highly successful in achieving its goals of reducing congestion and pollution and increasing average vehicle, including transit vehicles, speeds in a downtown area of London.

Canada has a number of roads with simple tolling structures aimed at financing the facility (for example, Coquihalla in British Columbia which opened in 1986) but only one facility which engages in road pricing for congestion management. Highway 407 north of Toronto, Canada is a private facility and prices are not regulated. However, service levels are set out in a contract with the provincial government. Highway 407 when it opened in 1997 was the first open access toll facility in the world; users could have a transponder (on-vehicle) or the license plate would be scanned by cameras on a gantry (off-vehicle). The tolls vary by vehicle type (truck versus car) and by time of day. The tolls are not set to optimize use of the facility but to achieve an engineering defined service level (average speed) and maximize a return to shareholders. Given the technology, which is relatively advanced, it could be transformed into real time pricing at a relatively modest cost.

The US experience with road pricing has been primarily with HOT lanes. There six HOT lane facilities to date which feature three distinct time patterns of toll variation; two facilities in Texas, State route 91 in Orange County, California, Express lanes on Interstate 25 in Denver, Interstate I-15 in Southern California and I-394 in Minneapolis. I-15 and I-394 facilities are designed to achieve a level of service (engineering service level 'C') and therefore have tolls varying dynamically with the level of traffic and delay. These use complex ITS components and could be shifted to optimize facility use relatively easily. In both cases the purpose was to ease congestion but there was a crude optimization objective as well. The remaining facilities have posted fee schedules. The Texas facilities have a flat fee whereas

Table 4.5 ITS components used in applications of road pricing

Charging Scheme	ITS Components
Singapore ALS 1975	• Information and guidance • Surveillance and monitoring
Singapore CBD Pricing 1992	• Information and guidance • Surveillance and monitoring • Automation and efficiency enhancement
Hong Kong	• Information and guidance • Controlling and directing • Surveillance and monitoring • Automation and efficiency enhancement
Cambridge	• Information and guidance • Surveillance and monitoring • Automation and efficiency enhancement
London	• Surveillance and monitoring • Automation and efficiency enhancement
Norway	• Surveillance and monitoring • Automation and efficiency enhancement
Stockholm	• Surveillance and monitoring • Automation and efficiency enhancement
Canada – Coquilhalla	• Automation and efficiency enhancement
Canada – 407 (Toronto)	• Surveillance and monitoring • Automation and efficiency enhancement
US – HOT lanes	• Surveillance and monitoring • Automation and efficiency enhancement

the others have variable fee by time of day. In all cases a relatively high level of technology is used despite having differing objectives and pricing structures. Table 4.5 provides a summary of the ITS components used in the cases just described.

Summary

This chapter had two purposes. First, to examine the intersection of the characteristics of road pricing schemes and the characteristics of ITS technologies to determine which ITS technologies could facilitate road pricing. Second, the chapter focused on implementation of road pricing therefore recognizing that it is important to consider issues beyond efficient road pricing and pricing for financing. Implementation requires that attention also be paid to alternatives to the tolled facility, enforcement and public acceptance. The last section of the chapter examined cases where road pricing had been introduced and assessed their level of ITS integration; until recently, relatively minor.

The implementation of road pricing schemes must consider where, when and the amount to toll. These will be determined by the objective of revenue for financing infrastructure or to reduce congestion. In the latter case there is the blunt instrument to reduce congestion to some exogenously determined level or to set prices to ensure optimal facility use. Successful implementation further requires how to toll and what infrastructure to manage, how to garner and maintain public support and how to ensure the system is efficient and effective.

Two factors determine the sophistication of the ITS technology; the choice of objective function, revenue versus economically efficient pricing and the spatial dimension over which road pricing is applied. If revenue is the objective, a simple tolling structure such as cordon is sufficient, increasing level of ITS sophistication may improve efficiency and enforcement but at a cost. Alternatively, if efficient road pricing is the objective, higher levels of ITS technology are required. The reasons include greater information flows, ability to vary prices dynamically, and efficiency in collection. As road pricing expands beyond a single facility greater levels of ITS technology are also required to realize successful implementation.

The four primary functions of the components of ITS are providing information, directing people and vehicles, providing an effective method of delivering the pricing objective and monitoring use. These functions intersect with the requirements of a successful road pricing implementation quite well. Surprisingly, the very important role of providing information particularly to users is being ignored. For example, there are a number of occurrences where variable message signs are used to report accidents, incidents and general facility conditions. However, this is done separately from a road pricing initiative. An important success factor in implementation is public acceptance. One dimension of public acceptance is the notion of fairness, providing people with information on an alternative to the tolled facility. If one compares the extent to which transit systems have used ITS technologies to improve transit service and reduce costs, there is nothing comparable for auto users. The primary reason is the lack of incentive on the part of any one auto user to provide such information, therefore the important role for the pricing authority to undertake this responsibility.

The use of ITS technologies has the opportunity to move road pricing out of a partial equilibrium system into a general equilibrium one. The evidence so far is that the potential for ITS to facilitate the successful implementation of road pricing has not been exploited to any significant degree. The focus seems to be on delivering the service rather than optimizing a system. An important feature of information flows for management and benchmarking performance would go a long way in demonstrating real benefits of such pricing schemes and ITS has the capacity to provide this management tool.

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Chapter 5

The Land Use and Local Economic Impacts of Congestion Charging

David Banister

Introduction

Congestion charging has been very successful in reducing the volume of traffic and in encouraging people to switch to other forms of transport. The transport benefits seem to be clear, but the wider impacts on the economy are less clear, as trip destinations and frequencies may also change as locations within the charging area become more or less attractive. In some cases (for example, retailing), these effects may be negative, but in other respects city centre businesses may be made more competitive.

This chapter explores the role that congestion charging[1] might have in contributing towards the objective of sustainable mobility, in terms of its impacts on land use and the local economy.[2] Most of the comments made in this chapter relate to the concept of a fixed cordon around the central area of the city, and some of the conclusions might not be so applicable in a purer form of road user charging, where the boundary of the charging area is flexible and where charges relate more precisely to current levels of congestion. Its focus is on the potential contribution that congestion charging can have in strengthening and concentrating land uses and developments so that journey lengths are reduced, and in exploring the wider impacts on the local economy. Land use and transport models find it difficult to incorporate the second round effects of transport interventions on land use and the attractiveness of city centres, and in isolating the local economic impacts (Marshall and Banister, 2007). Much of the evidence cited is preliminary, as there is almost no real empirical data on these wider impacts of congestion charging. It is only through actual implementation over a period of time that the real strengths and direction of these relationships can be established. After four years experience (2003–2007), evidence is now emerging from the most recent monitoring reports on the scheme in London (TfL, 2006a and 2007).

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1 In this chapter we concentrate on congestion charging, which is a form of road pricing. It is not a true form of road pricing, but it was introduced in London in 2003 as a cordon around the Central Area.

2 Some of the work reported here was influenced by a study carried out with Roger Vickerman and Peter Mackie for Transport Initiatives Edinburgh Ltd as part of their research into the introduction of congestion charging in Edinburgh.

Land Use Impacts – Theory

Considerable uncertainty exists over what the effects of congestion charging will be on land use, whether there is any impact, whether it is measurable and over what sort of time scale any change is likely to take place.

Short Term Impacts

These impacts of congestion charging are likely to be variable, both in terms of their location and their intensity. For businesses within the cordon area, the numbers and size of vehicles might be reviewed along with more efficient route planning. If the costs are high, relocation is a possibility, but this option is more likely to affect new businesses wishing to locate inside the cordon area. The net effect is likely to be a reduction in transport intensive activities within the cordon, and this could be measured through monitoring the mixes of business types by location within and around the cordon.

For workers, the travel to work costs increase for car drivers and for those who switch to public transport, as that mode is currently more expensive for them. But as car congestion falls, those willing to pay the charge may benefit. Current public transport users may see a loss of service quality as public transport becomes more crowded, but quality and reliability should improve as delays are reduced and as additional investment takes place in new bus capacity. For other travellers (for example, shoppers and theatre visitors), there will be little change as most of these people already use public transport or come after the cordon charging scheme ends or at the weekend. For suppliers, their transport costs will rise, but these increases can be passed on to the customer or even recouped through better reliability and time savings. They may also reschedule and reroute services to reduce the numbers of vehicles crossing the cordon. All of these changes can be captured in employer interview surveys, site based travel surveys and performance surveys with key actors to ascertain how industry has responded to traffic congestion.

Part of this adjustment would be to reduce travel distances through the use of more local facilities or even moving closer to the workplace and other facilities. In the city centre, this might result in an increase in the demand for central area housing and commercial property. Locations with good alternative public transport would have added attraction and city centre real estate prices would increase, at least in the short term or until the market responded with an increase in supply.

> Experience from theoretical studies, simulations and modelling is unambiguous: the centralising force dominates over the decentralising forces. The result is, hence, that households, commerce and workplaces are driven towards the city centre – the 'city' shrinks (Eliasson and Lundberg, 2003: 30).

Within the economy there are also sectors that might be more susceptible to congestion charging, as the patterns of movement are different to those normally associated with the traditional manufacturing economy. The service sector (in particular financial services, retail distribution and tourism) provides examples of competitive sectors that might be more sensitive to price changes, as they are footloose and operate within national and global markets. It is difficult to incorporate such potential changes in existing models, as these factors are not only local in their impacts but also city wide and even national or international in terms of their overall effects.

In addition to the potential differential effects on the various sectors in the economy, the locational issue is also important, as congestion charging is not city wide, but selective in its application. Property prices near to the boundary of a congestion charging scheme may have differential impacts to those locations further away from the boundary (Eliasson and Mattsson, 2001). There would seem to be an advantage in locating outside a fixed cordon rather than inside. For example, the simulation work carried out as part of the Dennis Agreement in Stockholm calculated a centralising effect from the proposed toll ring. But as the infrastructure investments outside the cordon were so large, the overall effect was a decentralising one (Anderstig and Mattsson, 1992). The simulation suggested that the package would cause a redistribution of about 1.3 percent of residents and about 2.3 percent of workplaces. These changes would take 15 years to happen, and most of the changes were instigated by the infrastructure investment rather than the toll ring.

The Longer Term Impacts

Here, it is necessary to look at land use and property changes. This requires two basic inputs – an understanding of the process of change and theory of change. The process involves establishing base information of what is happening prior to the policy change (that is, the introduction of congestion charging), what to look for after the change in terms of monitoring and causal analysis, control studies (to determine what is happening in the economy as a whole), and discussions with key actors to add a qualitative perspective and understanding of the changes taking place. The theory of change provides a framework within which change can be set. Three key elements occur in this complex figure of possible interactions and linkages, but they are not necessarily mutually exclusive. The interactions concern the linkages between commercial operations, income and welfare effects, and factor markets. Commercial operations relate to the way activities incorporate transport and wage costs in commercial decisions. This would include the configuration and mix of supplies, productivity, the customer base and the output mix, in each case relating not just the quantities involved, but also their spatial distribution, which in the longer term may also include relocation. Income and welfare effects identify the aggregate implications on production and consumption. Again, there may be longer term relocation and impacts on the housing market. The consideration of factor markets identifies the possibilities of factor substitution (for example, ICT for transport and capital for labour), as relative factor prices change. This can lead to changes in land uses through the changing viability of different development sites. There are a series of issues raised here, and three on them are now discussed in more detail.

The Low Cost of Transport Argument

The implications for land use change are potentially interesting, as the impacts of congestion charging are unclear. Transport costs as a proportion of total production costs or value added in many industries are relatively small, and other factors such as the availability of skilled labour, suitable sites, government grants, and the quality of the environment may all be more important than transport. Any changes in transport costs may not be reflected by changes in the final prices of goods and services. Savings may be absorbed by entrepreneurs or landowners through higher profits and rents, or they may be absorbed by employees in higher wages (Banister and Berechman, 2000). Conversely, any increases in transport costs (for example, congestion charging) may have the reverse effects, but employees may still demand higher wages to compensate for their higher travel costs. But at the margin, there must be an effect if all costs are stable except for transport costs where a substantial increase has taken place. But again, within a service based economy, there are many adaptations that can be introduced to adjust for increases in travel costs, through rescheduling or increasing the numbers of transactions carried out remotely, as there is a high level of complementarity.

The Geographic Concentration Argument

Geographic concentration relies on the interaction between increasing returns, transport costs and demand (Fujita et al., 1999). As returns to scale increase, transport costs become less significant as a determinant of location and the attractions of large market areas dominate. Labour market pooling, together with the supply of intermediate goods and knowledge spillovers, ensures economies of localisation. There is thus a circular or cumulative causation argument which reinforces the dominance of the centre. A change in transport costs may tempt firms to locate where it is cheaper, but it also facilitates the concentration of production in one location to realise economies of scale. Such an argument has interesting implications for congestion charging where transport costs are being raised, but at the same time it is expected that accessibility (seen as a combination of time and cost) is also improving. Even if firms have to pay higher wages and customers higher access costs, as long as the benefits from the time savings (including reliability) are greater than the additional costs imposed through congestion charging, activities in central locations will be better off.

Rent Seeking or Redistribution Arguments

This suggests a degree of competition, even if it is of a monopolistic kind, as prices may exceed marginal costs but excess profits are competed away by competition between imperfectly competitive firms. As competition becomes more imperfect the scope for rent seeking behaviour by firms (and individuals) increases. The benefits from a change in transport costs are a combination of the change in consumer surplus and the rent which accrues to the owners of factors in fixed supply, primarily land. It is often only the changes in rent levels that can actually be measured (Mohring, 1994). With congestion charging, changes in demand for different types of commercial property will lead to changes in rental (and capital) values of land. Owners of land may perceive that future values will increase as the desirability of locations with increased accessibility grows. Hence the impact of charging may be to reduce the immediate supply of land as these owners seek to maximise their rental values.

At the same time, the rental income from scarce labour may be reduced if the thickening of the labour market with improved accessibility increases the supply of labour with the required skills. This suggests that the key result of congestion charging, which imposes the full resource costs on users, is a redistribution of costs between sectors and labour markets. Complaints of hardship by one sector may be balanced by gains in another sector, even though the timescales of these changes may be different. It is only through careful monitoring of the property market (both commercial and residential) that the effects of increased (or decreased) capitalisation and value added can be identified and measured.

Consideration of how these effects will impact on the markets for different types of land use is important, but there is likely to be a considerable amount of indeterminacy in the expectations and outcomes. It is difficult to argue that congestion charging would necessarily increase the attractiveness of locations within the charging zone to developers through reduced travel times, or to decrease the attractiveness through increased travel costs. The net effect might well be no change, and it will be the other economic, technological and location factors that drive the changes in rent levels, land values and possible relocation. This minimal change in the implicit value of central locations may however mask an ongoing restructuring of central city locations away from the traditional retailing functions, which have a high physical transport element in terms of the delivery of goods and transport needs of workers and customers, and move towards high value added services which have a lower transport content that can be outweighed by the increasing returns of the activity.

The problems of adequate housing in large cities have already been mentioned, and this issue is particularly acute in the central area and for low income groups. Congestion charging has been criticised for being regressive in its impact (Santos and Rojey, 2004). The more general issue here is whether congestion charging will impact on urban development through encouraging infill, higher densities, mixed uses and compact development patterns. Urban economic theory implies that there would be an increase in density around the main attractors as prices increase, but this in turn might lead to more congestion and encourage development elsewhere so that the spatial structure becomes less concentrated. Arnott (1998) has argued that, within the standard model of urban traffic congestion and urban spatial structure in a monocentric city, congestion tolling leads to a more concentrated city as the rent and population density gradients become steeper. In his alternative bottleneck congestion model, which involves trip timing decisions, optimum congestion tolling without toll revenue redistribution has no effect on trip price, as there is a reallocation of traffic over the rush hour. So travel cost reduction equals toll revenue collected. Spatial structure will become more dispersed through the income effect that results from the possible redistribution of toll revenue. Reality probably lies somewhere in between showing some increase in concentration. But if the bottleneck model is correct, Arnott (1998: 503) suggests the ‘absence of congestion tolling has probably led to less excessive decentralisation of economic activity than was hitherto believed.’

The Impacts in Combination

Some of the main elements in the debate have been presented, but it is when they operate in combination that more interesting outcomes may occur, particularly in the longer term. But equally, these effects are harder to conceptualise over the longer term. This debate is well summarised by Kirwan (2001: 46):

> With a fixed spatial distribution of trip ‘attractors’ – employment opportunities, shopping malls etc. – there is general agreement, based on urban economic theory, that the impact of increasing the price of transport per person km will be to encourage (over time) a more dense pattern of settlement around those ‘attractors’. But the impact of congestion pricing in particular – where the price of travel varies between localities with larger and smaller concentrations of ‘attractors’ – in the longer run, when patterns of land use can change, is less clear.

To some extent decentralisation is already taking place with firms moving non essential activities out of the city centre where the costs of space and staff are much higher. Certain types of activities (for example, shopping, leisure, theme parks and industrial parks) are now located at accessible points on the periphery of cities. The benefits of agglomeration in the post industrial society may at best remain constant as the costs of travel increase (Kirwan, 2001). If the primary concern is sustainability, then this decentralisation process is important and the aim of policy (including congestion charging) should be to make the city centre a cheaper place to develop and live in, rather than a more expensive location. But if the concern is to internalise the costs of congestion and environment by making the user pay their full social costs of travel, then congestion charging should go ahead.

Traditional views on location decisions and the potential for agglomeration economies suggest that there are economic, behavioural and technological factors (Dosi et al., 1988). Economic factors include cost minimisation, externalities and economies of scale; behavioural factors cover qualitative measures of transactions and learning; and technological factors balance flexibility against being locked into the production process. More recent contributions (for example, Giersch, 1995; McCann, 1995) seek to draw a distinction between the costs incurred in overcoming distance and the costs incurred from being located at one point in space. McCann (1995) identifies four elements that are key to microeconomic theories of location.

Distance-transaction costs mean that firms will locate together assuming that they buy from the same supplier and sell to the same markets. The same argument is true of his second element, namely the location-specific factor efficiency costs. In both cases there are agglomeration economies of proximity and factor efficiency. But he qualifies this second argument for clustering by the statement that this occurs: ‘only where it is clear that the existing level of agglomeration is the cause of the existing factor-efficiency prices can we rightly talk about agglomeration factor efficiencies’ (McCann, 1995: 573).

The two other elements of possible agglomeration economies are hierarchy co-ordination costs, which relate to the nature and stability of the production and consumption hierarchy, and the hierarchy coincidence opportunity costs, which relates to levels of sales (the sales maximisation principle). These factors relate both to the existing numbers of firms and households, and involve agglomerations of scale in the traditional sense.

McCann (1995) argues that underlying spatial economic questions are issues of the nature of production hierarchies that help to explain why spatial clustering takes place. It is only when factor prices are pushed up through higher wages that this clustering process might breakdown. Even though firms may locate in close proximity to one another, this does not necessarily mean that they will have links with other firms in the same industrial sector (localisation economies) or with other firms or households in the same area (urbanisation economies). The linkages are increasingly important as telecommunications and networking, together with business related travel, form important components in service and technological based industries. However, these linkages need not be local, as they could also be regional, national or international, depending on the activity which the firm is engaged in. McCann (1995: 573) reaches the conclusion:

> Many clustering situations are wrongly characterised as localisation or urbanisation economies, when the cost reason for clustering has little or nothing to do with the location of other firms, but rather is due to the relationship between local factor efficiency prices and the cost considerations dependent on the location of suppliers and customers in totally different regions. The result is that authors (unspecified) then wrongly attempt to account for this observed spatial clustering in terms of hypothesised information economies, in situations in which this is simply not appropriate.

Yet the evidence seems to be accumulating to suggest that there are still agglomeration economies, even in high technology economy and that the new factors of production are instrumental in bringing this about. At the theoretical level Kutay (1988a and 1988b) has demonstrated that with two different transport costs (one for commuting and one for information), location depends on the relative balance between the two. When information costs are sufficiently low then all workers work at home, and the land rent gradient becomes convex at the centre.[3] This reflects diseconomies of agglomeration and employers would seek to disperse to the periphery.

However, such simple explanations may not be entirely appropriate as vertical disintegration means that the clustering of suppliers would lead to agglomeration economies (Storper and Christopherson, 1987). Out-sourcing and subcontractors work can be best maintained through close proximity and continuous contact. Indirectly, the clustering of employment may also facilitate the growth of short term, temporary and flexible work patterns, as job accessibility is important to those in employment or are seeking employment. The traditional view (Vickrey, 1977) that activities cluster geographically provided that the agglomeration benefits outweigh the congestion costs needs to be reviewed, as congestion is only one part of the location decision. The new structure of the labour market and the changing structure of businesses, together with the role of technology all need to be included in the new understanding of agglomeration. For example, the work of Romer (1996) suggests that the congestion cost curve flattens as technology improves, so agglomeration economies may be felt over a wider area, and this in turn would lead to footloose location. Others (for example, Simmie, 1998) argue that local factor production costs and qualities are critical innovation inputs. These are not the traditional factors of infrastructure, telecommunications, land and buildings, but the new ingredients of the knowledge-based economy, such as skilled labour, venture and risk capital, new technology, and new knowledge and information.

3 When the rent gradient is flat or even convex, it suggests that land values at the centre are the same as or less than those at the periphery.

In short, the longer term impacts of congestion charging in a major city such as London must be seen as a small (perhaps insignificant) part of the dynamic of city development. Certainly, it may have an impact, but that impact might well be variable over business, space and time, or it might act as a trigger for centralisation or decentralisation, or it might not be measurable. Elements of the transport, geographic and economic arguments all need to be placed in the context of the city dynamic, and the crucial role that proximity has in determining location. If the theoretical literature is ambivalent about the likely effects of congestion charging in London on land use, can a clearer picture be obtained from the empirical evidence?

Congestion Charging in London – Practice

London has provided the first real example of cordon pricing in a major European city (February 2003). Each vehicle is charged a fixed amount for crossing the cordon into the city centre. Prior to congestion charging, it was estimated that about 15 percent of commuters to Central London came by car (about 50,000 vehicles in the peak hour), and these vehicles spent about half their time in queues (stationary or slow moving) with an average speed of about 15 km per hour. The Road Charging Options for London Report (ROCOL, 2000) estimated that a £5 per car charge would reduce traffic by 12 percent, raise speeds by 3 km/hr, and give a net annual benefit of about £130m (Table 5.1).

Table 5.1 Estimated traffic impacts and economic benefits of a £5 area licence for Central London

Impact	Central London	Inner London
Change in traffic levels am peak (07.00–10.00) 14-hour (06.00–20.00)	Base vehicle kms - 0.8m (-10%) - 3.6m (-12%)	Base vehicle kms - 5.9m (-3%) - 25.5m (-3%)
Change in average traffic speeds am peak (07.00–10.00) 14-hour (06.00–20.00)	Including junction delays from 15–18 km/h from 16–18 km/h	Including junction delays from 21–22 km/h from 22–23 km/h
Economic benefits per year	£125m to £210m Mid point £170m	
Area licensing annual operating cost	£30m to £50m Mid point £40m	
Overall annual benefit	£95m to £160m Mid point £130m	

Source: ROCOL (2000) and www.open.gov.uk/glondon/transport/rocol.htm.

The cordon pricing scheme provides a major source of funding for the Mayor of London and there does seem to be widespread support for it provided that the revenues are used to finance public transport and other transport related improvements (Figure 5.1). The congestion charging scheme was really a package of measures that included the charge for cars, vans and lorries, heavy investment in new buses, the introduction of the smart card (Oyster) technology for ticketing, the reallocation of street space in Central London to the bus, cyclists and pedestrians, and a review of parking policy inside and outside the congestion charging zone (CCZ).[4] Details are given in Figure 5.1.

The congestion charging scheme is targeted at the four main transport priorities in Central London – reducing congestion, improving bus services, improving journey time reliability, and increasing the reliability and efficiency of freight distribution. Funding is raised for investment in transport in London.

The boundary is formed by the area within the Inner Ring Road of Central London, covering 22 square kilometres or 1.3% of the total area of London (Figure 5.2). There are 174 entry and exit points, with a daily charge of £5 for each registered vehicle – penalties for non compliance are £80, reduced to £40 if paid within two weeks and raised to £120 if not paid after 4 weeks.

The total budget was about £200 million, including £100 million for complementary traffic management measurements. The operating costs are about £80 million per annum and a £12 million budget for communication and marketing (London Assembly, 2002)

Impacts of Congestion Charging – 2003–2005

- Congestion in the charging area (CCZ) has reduced by 26% and traffic levels are 20% lower. It is lower than at any time since the mid 1980s;
- Taxi journeys have increased by 20%, and van and lorry movements have decreased by 10%. Cycling has increased by 30%;
- The number of motor vehicles entering the area during the charging hours (07.00 to 18.30 on Mondays to Fridays) has dropped by 16% – note that buses, taxis, residents (10% charge), and 13 other categories of vehicles are exempt or have discounts;
- Car journeys to and from the CCZ are quicker and more reliable, with travel times reducing by 14% and reliability increasing by 30%;
- Public transport is coping with the increase in passengers – 88% of people come into Central London by public transport;
- Bus services are more reliable as a result of less congestion and investment;
- No significant traffic displacement around the CCZ has been observed;
- Significant reductions of 17% in NO_x, 24% in PM_{10} and 3% in CO_2 emissions (on the annual average day) have been recorded (2003–2006):
- A more than 40% reduction in injury accidents in the CCZ and on the Inner Ring Road has been observed (2001–2005);
- The various payment schemes seem to be working;
- The public remain supportive of the scheme – 40% support it and 35% oppose it (2005);
- Average net revenues were £68m in 2003/04 and £90m in 2004/05.

Impacts of congestion Charging – 2005–2006

- Daily charge increased to £8 in July 2005;
- Revenue increased to £122m 2005/6 and £123m 2006/2007;
- Western Extension came into operation in February 2007, doubling the area of the Congestion Charging Zone and time of operation changed to 07.00 to 18.00 on weekdays (Figure 5.2);
- Support increased to 48%, with 35% still opposed to congestion charging;
- Oyster cards account for 43% of stages on buses and 53% on the underground (2005);
- Parking revenue to the Boroughs adjacent to the CCZ have declined by 18% inside the CCZ and increased by 8% outside the CCZ (ALG, 2004).

Figure 5.1 Congestion charging in London

Source: Based on information in TfL (2006a and 2007).

4 Note that the data all refer to the initial CCZ, not the extended CCZ that came into operation in February 2007. The original CCZ covers the right half of Figure 5.2. This Figure shows both the original and extended CCZ.

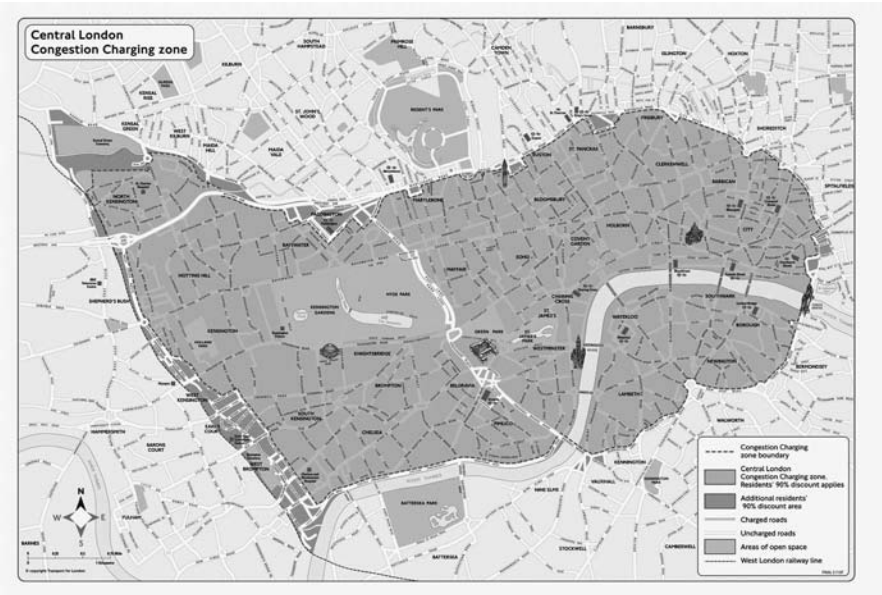

Figure 5.2 The congestion charging area in London

Source: © Transport for London. Reproduced with permission.

The wider effects on the local economy are harder to quantify, but from the retail 'footfall index'[5] it seems that 7 percent less shoppers are coming to Central London. For all purposes, this means that 70,000 less people have come into Central London out of a total of 1.6m, but as the vast majority of these already use public transport (85–90 percent), the contribution of congestion charging is likely to be less than one percent of the total reduction. The reduction in the footfall began before the charge was introduced and was more marked at weekends, when there is no charge. Other benefits from more reliable transport and more efficient deliveries should more than compensate for this loss (Carmel, 2004).

Lessons from the Implementation of Congestion Charging in London

The overriding lesson has been the strong political commitment behind the radical policy, together with a motivated and experienced team prepared to push through the scheme at all stages. It took less than three years to implement. There were strict requirements on carrying out the necessary background research in advance (much of which is contained in the ROCOL report, 2000), having a policy as part of a clear transport strategy, carrying out extensive consultation with all stakeholders,

5 Footfall indices uses cameras to monitor volumes of people entering shopping areas or particular stores, and it can also be used to estimate the amount of shopper activity through credit card transactions. There is continuous data for Central London from December 2001, see; www.caci.co.uk/retailfootprint.htm.

preparing draft scheme orders, modifying these after further consultation, testing the technology, preparing a range of payment schemes, and publicising the scheme in advance of C-day. It is no wonder that the Mayor and some of his closest advisers had 'sleepless nights' and wondered whether it was really worthwhile (Banister, 2003).

In addition to these implementation problems, success has been dependent upon the support of industry and the general public. Industry was convinced of the necessity for action on congestion as it was affecting their efficiency, whilst the general public was supportive provided that the revenues raised provided additional funding for transport in London, and that the quality of alternative public transport was improved in advance of implementation. There has been heavy investment in new buses in London, with some 200 additional buses in the central area. This has resulted in substantial increases in capacity, which together with the increase in reliability and time in use has resulted in more people using the buses. There has been a demonstrable switch from car to the bus (4 percent), and across the network bus patronage has increased by 18 percent (2002/2003–2005/2006, with a 31 percent increase in Central London during the morning peak – TfL, 2006b).

Where the congestion charging scheme has been less successful is in the higher number of exemptions and discounts. The Mayor's objective has been to make sure that the scheme is as fair as possible, and that it is perceived to be fair. In 2006, under half (46 percent) of vehicles pay the full charge, with some 12 percent having discounts of various kinds (mainly residents), and the remaining 42 percent of vehicles being exempt (this figure includes motorcycles, bicycles, licensed taxis, buses and coaches). Yet if the primary aim is to reduce congestion, it is unclear why residents should be given any exemption, let alone a 90 percent reduction. They benefit from emptier, quieter and cleaner roads, and from the improvements in public transport, yet they are not paying for this. Similarly, taxis have been one of the main beneficiaries of congestion charging, as they can travel more quickly within the charging areas and more people are now using taxis. Their revenues have increased by 20–30 percent since congestion charging was introduced, yet they do not pay the charge and they are still causing congestion and creating pollution (TfL, 2006a). In both these cases, the Mayor's fairness objective seems to have been forgotten, and once concessions have been made it is often very difficult to reclaim them.

This is the classic policy dilemma faced with respect to the implementation. To get any radical transport policy introduced requires extensive negotiation, consultation and public support. But at each stage of this process, the original aims are likely to be weakened as concessions are made to powerful interest groups. Eventually implementation is possible, yet the original objectives have been so weakened that the policy is ineffective, and as a result it may be seen as a failure. In the case of congestion charging, this position has not been reached and the Mayor has been able to implement a highly effective scheme, even though there were some major concessions made to business (for example, by reducing the proposed £15 charge for vans and lorries to £5), taxis (exemptions), and residents (90 percent discounts).

Impacts on the Local Economy

After more than three years of data it may be opportune to assess the impact of congestion charging on the local economy. Many of the benefits are transport related and fairly instantaneous in their impact. But of equal interest are the wider implications on the London economy and the effects that congestion charging might have on land use. Very little has been said about these longer term effects on land use that are more difficult to identify and measure, as outlined in the theoretical review. Most discussion has revolved around the short term business impacts, in particular the effects on retailing.

Impacts on Businesses

These impacts have been limited, as the expectations that measurable savings in distribution costs resulting in a reduction in vehicle requirements have not taken place, even though speeds and reliability have both increased. Workers seem to have shifted mode, mainly through making use of public transport for their entire journey, rather than parking and riding. Several studies have investigated the effects of congestion charging on retailing. The most detailed research was carried out on the six John Lewis[6] stores in London (Bell et al., 2004), one of which is located in Oxford Street, inside the congestion charging area. Data for four years was analysed (January 2000 to January 2004) from sales records and surveys, and these data were subject to a series of forecasting models to predict sales, which were then compared with actual sales. Further analyses with econometric models were made to try and isolate the effects of congestion charging as opposed to other factors. These included the closure of the Central Line (this key link in the London underground system was closed from 25 January 2003 to 2 June 2003), clearance sales, the state of the economy, the number of tourists, consumer prices, the Iraq war, trends and seasonality. The conclusion reached was that congestion charging was responsible for a 5.52 percent reduction in sales and that the closure of the Central Line accounted for a further 6.98 percent (from February 2003 to January 2004). The exit surveys carried out at the stores again suggested that people had changed their frequency of coming to Oxford Street (12 percent), whilst for the postal surveys the figure was higher (24 percent). However, it should also be noted that only 9 percent of the sample used the car to come to John Lewis before congestion charging, and this figure is supported by other evidence (Carmel, 2004) which suggests that between 6–9[7] percent of people drive to the central areas for shopping. Many of these shoppers may also come in during the evenings or at the weekend when congestion charging is not in operation. Since

6 John Lewis is a large department store selling a range of household goods and clothes. It has made available all transactions for these six stores by type of goods, location of store, time of day and day of week.

7 6 percent of shoppers came into Central London by car prior to congestion charging (2002) – this is from the street public space survey (10,000 respondents, including 2,500 shoppers), and half of these combine car with other modes. The average spend is £53 on shopping, higher for those coming by taxi (£94), car (£72) and mixed public transport modes (£62), and lower for those coming by car and other modes (£53), underground (£55), bus and train (£47), and walk (£36).

this comprehensive analysis and surveys were carried out, sales at John Lewis in Oxford Street have recovered and are now increasing in line with other stores there, such as Selfridges (which did not suffer from a loss in sales even in the short period immediately after the implementation of congestion charging).

The analysis was rerun with a newly available database (the London Retail Sales Monitor), a set of new control variables and three different models. It was now difficult to estimate the exact impact, even though it was still significant on the John Lewis Oxford Street store, and it was not possible to control for the effects of competition from other stores in Oxford Street. When looking at the sales in the Central London retail sector as a whole, no significant results were obtained. The team (Quddus et al., 2005: 26) concluded that 'since the area covered by Central London includes important shopping areas outside the charging zone, this leaves open the possibility of some spatial substitution, though this is unlikely to be substantial given that retail in the charging zone dominates total Central London retail as used in this study.'

Other surveys of businesses have suggested that smaller enterprises have been adversely affected. A survey by the LCCI[8] (2003) immediately after congestion charging was introduced claimed that 76 percent of traders reported reduced turnover year on year, but the scale of the reductions were not clear, and the congestion charging was not entirely blamed for that reduction by the traders. Other factors such as the Central Line closure, terrorist fear, the economic downturn and competition were also cited. The Greater London Authority Economics group analysed data (to June 2003) on Central London retailing before and after congestion charging and found that the onset of the decline is sales predated the introduction of congestion charging (GLA, 2004). The decline in Central London retail sales growth started in Quarter 4 of 2002 before the introduction of congestion charging (LRC, 2004). The decline was attributed to the general economic downturn,[9] the fall in overseas tourists, and the closure of the Central Line. The more recent LCCI surveys (2004) give a consistent picture for the 530 small retailers[10] that responded to the annual survey (1,234 questionnaires). Over 79 percent claimed that their turnover had declined, and 32 percent were considering relocation as an option, and there was 66 percent less spend per customer. Similar figures were given for restaurants, with 75 percent claiming turnover was down and 30 percent were considering relocation. Of the respondents, 42 percent suggested that congestion charging was partly to blame.

As part of the Westminster Business Survey (2004), one question asked whether the business was considering relocating outside the congestion charging zone (Table 5.2). These numbers were split to see whether those businesses considering relocation were in any particular sector. The two sectors most susceptible to relocation were the micro-sector and those selling food, perhaps reflecting low margins.

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8 The London Chamber of Commerce and Industry (LCCI) represents over 3,500 small businesses in London (www.londonchamber.co.uk).

9 Total economic growth in London fell below the UK average in early 2002 and remained there throughout 2003. Annual percentage change in Gross Value Added (GVA) is about 0.5 percent for much of 2003, well below the UK value of nearly 2 percent.

10 There are 3,681 retailers in the congestion charging zone, of which 28 percent are in fashion and 45 percent in miscellaneous (mainly luxury and gifts). The remaining 27 percent are in food, household and newsagents.

Table 5.2 Potential businesses relocating

Have you considered relocating your business outside the congestion charging zone?	Number	Percent
Yes	66	27.7
No	172	72.3
Total	238	100.0
Missing	131	
Total Sample	369	

Source: Westminster City Council (2004).

The RICS (2005) concluded that nine out of ten retailers have reported some loss of turnover, but that there appears to have been little or no impact on moves to relocate outside the CCZ, and the impacts on land values and rents have been negligible. Wilkins (quoted in Vickerman, 2005) has examined the business ratings value data that is used as the basis for property taxation on businesses. These values are based on the annual rent that the property would command if let at the valuation date. A comparative analysis was carried out on the rateable values of properties in ten locations inside the CCZ and another ten locations just outside the CCZ for the period immediately after the congestion charge was introduced. The implied property values in the CCZ rose at a faster rate than those outside, and this may be attributable in part to the congestion charge. Other decentralisation effects may have been more important, and a careful monitoring of the relationship been the supply and demand of different types of business premises would be needed to valid this preliminary finding.

Lessons on the Local Economic Impact

The effect of congestion charging has been relatively minor with difficulties in attributing changes to particular causes, and this in turn reflects the complexity of this type of time dependent analysis, even if that period of time is quite short. Generally, the business and financial sectors are still enthusiastic, particularly the larger employers, as they have benefited from reduced travel times and increased public transport reliability. It is in the retail and leisure sectors that some impacts have been felt, mainly in the first half of 2003, but this has been more than countered by a resurgence in 2004. This difference is illustrated in Table 5.3 where a Transport for London survey of 700 businesses gives an indication of perceptions of the causes of changes in performance. The more recent survey carried out in 2005 is not comparable as it has the effects of the July 2005 terrorist attacks on public transport embedded within them.

The footfall patterns (TfL, 2007: Figures 5.14 and 5.15) show that retail performance in the CCZ, as measured by the numbers of people using retail outlets, underperformed the UK average, but that this trend was reversed in late 2003 and in 2004. The figures for 2005 (after 7 July) have been influenced by the terrorist bombings in London and not the increase in the congestion charge that occurred at the same time. Since late 2005, the figures for the CCZ have again recovered and are now above the levels elsewhere in the UK.

Table 5.3 Perceived influence on business performance 2004 (%)

Sector (% employed in this sector in London)	Economic factors	Congestion charging	Tourism factors	Seasonal factors	Company factors	Other factors	Terrorism
Retail sector (17%)	41	18	12	11	9	9	0
Service sector (42%)	50	6	12	15	10	7	0
Overall	46	12	10	15	10	7	0
2005 %	16	16	3	10	21	15	19

Notes: Terrorism was not an issue in the previous survey (2004), and company factors include internal issues, and seasonal factors include a drop in consumer expenditure.

Source: TfL (2004) www.tfl.gov.uk/tfl.cclondon/cc_monitoring.shtml.

The general conclusion reached by TfL (2006a) and an independent assessment carried out by Ernst and Young (2006) is that the congestion charging scheme has had a broadly neutral impact on London's economy.

> The economic area directly impacted by the congestion charge is dominated by financial and business services and these sectors appear to have been less directly affected by the charge than other sectors thereby limiting the potential for any negative effects. There is also some evidence of benefits to businesses from the charge and these benefits may go some way to offsetting any potential negative effects of the charge on some smaller economic sectors within the charging zone (Ernst and Young, 2006: 3).

TfL (2006a: 5) make the conclusion more strongly by concluding that 'business performance in the charging zone was significantly better than in the rest of London, particularly in terms of profitability and productivity'. The generally positive message given by TfL (2006a) and Ernst and Young (2006) is modified by some concerns over the potential impacts on small enterprises (less than 6 employees), where workers operate outside the standard hours of business. This probably relates to shift workers and may have an effect on recruiting and retaining staff, and on their wage levels.

Elsewhere there seems to have been some adverse effects on the retail and hotels and restaurant sectors in the central area, where profitability growth has been negative or worse than comparator locations. This analysis has been based on Dun and Bradstreet data,[11] but again many of the trends can be identified before congestion charging was introduced and there is no difference between the times at which the congestion charge is in operation or not. Two other sectors are identified as having

11 Dun and Bradstreet – this is a business database that contains information on turnover by geographic location. The data are reported at the company level and it is not possible to identify individual site turnover. The analysis is carried out for smaller companies (under a turnover of £1 million), as these companies are likely to be single site locations and those within the CCZ can be located.

possible negative effects, namely education and construction (TfL, 2006a), but the patterns in these sectors are no worse than elsewhere in London (Table 5.4).

TfL have gradually become more confident in their conclusions about the impacts on the London economy and they come to an optimistic conclusion (2007: 3):

> There have been no significant overall impacts from the original scheme on the Central London economy. General economic trends are considered to have been the predominant influence on the performance of Central London businesses over recent years. The Central London economy has performed particularly strongly since the introduction of congestion charging, with recent retail growth (value of retail sales) in Central London at roughly twice the national growth rate.

Table 5.4 Employees by business sector (January 2007) and changes in sales from 2003–2004 (%)

Sector	Central Area Charging Zone		Greater London	Other Inner London	Other Outer London
Number of businesses in survey		1,223		1,536	1,807
Financial and business services	592,600	+5.5	1,326,700	+8.7	+2.4
Hotels and restaurants	89,900	+0.3	299,800	-5.8	-1.2
Manufacturing and construction	48,200	+3.0	327,800	+1.5	+5.7
Other services (including education and health)	180,500	+5.3	956,400	+6.4	+4.1
Public administration	84,700	+10.2	243,200	+1.8	+6.3
Retail	65,100	+6.0	375,700	+1.9	+0.1
Transport and communications	82,100	+8.1	312,000	+0.1	+4.0
Wholesale and other distribution	31,800	-3.5	215,900	+2.5	0.0
Total employees	1,174,900		4,057,500		
Total changes in sales		+4.7		+3.7	+2.9

Notes: Includes businesses with a turnover of less than £1 million per annum, excluding the top and bottom 5% from Dun and Bradstreet data. The figures for employee jobs cover all businesses and are based on the annual Business Inquiry from the Office of National Statistics, December 2005. Other services include education and health (about 50% in the CCZ and 70% in Greater London) and primary and utilities.

Source: TfL (2006a) based on a combination of Tables 5.1 and 5.3 and TfL (2007) Table 12.2.

This optimism is illustrated in Table 5.4, where positive trends can be observed in employment in financial and business services, public administration and retail sectors. Comparative analysis also reveals no evidence of differential effects, and those sectors (for example, hotel and restaurants and retailing) that were seen to be more vulnerable have shown stronger business performance by out performing other areas of London. Even the retail and office property markets, as reflected in the changes in levels of rental values, show the broader cyclical performance of the markets rather than the more localised impacts of congestion charging.

Conclusions

Congestion charging in London has exceeded expectations, both in terms of its outcomes (more effective than predicted in transport terms), and in its wider impacts (modal shift, better quality environment and the local economic impacts). In the short term (four years), the main effects have been on traffic and businesses, and there may have been some centralisation of activities, perhaps reinforced by the discounts that are available to residents and other users of the CCZ. Resident car drivers are one of the main beneficiaries of the congestion charging scheme as they have a 90 percent discount, and this is likely to maintain and enhance their residential property values. The limited evidence on the residential property market again suggests minimal impact, as property prices and rent levels have increased in line with national trends. Property agents report that 'occupiers find living inside the charging zone an advantage' (RICS, 2004: 2).

Retailers and the hotel and restaurant sectors have been most affected, even though a majority still support congestion charging (Table 5.4). The dominant financial and other commercial sectors are still positive, as their growth rates have been maintained. Small retailers are most concerned, particularly those located near the boundary of the congestion charging zone, and many are now looking for reductions in rent. But the evidence is limited, even though there does seem to have been a fall in retail rental values in the CCZ relative to the rest of Inner London (Ernst and Young, 2006), and other external factors may have contributed. The possibilities for relocation seem limited and the types of surveys carried out are always likely to overstate negativity and the possibility of change (opinion surveys and simple yes/no answers). The impacts immediately outside the congestion charging area have been limited, and this again may reflect the limited impact that congestion charging has on overall business costs.

In terms of the theory of change, the impacts have been limited and not much change has taken place in the location of new development and in the use of the existing stock. Over a longer period, there might be a marginal increase in the rate of decentralisation already taking place, and it might also encourage high value activities in the centre (greater exclusivity) in both the property and housing markets. All these impacts need careful monitoring, including the adjustments that might take place, and these changes must be set against the wider economic context within which these changes are taking place. The question still remains over the scale as well as the direction of any change. Eliasson and Lundberg (2003: 31) concluded that 'in general they (i.e. the changes in land use brought about by congestion charging) are expected to be very small, especially in comparison with the effects on traffic and the general changes in land use.' The evidence cited here in London would seem to concur with this conclusion.

The aggregate theoretical models suggest that congestion charging will not have a measurable impact on the city either in terms of the short term traffic and business related activity or in the longer term land use changes. It will not affect the centralisation or decentralisation processes that are taking place as a result of other long term processes or as a result of policy changes. This conclusion is consistent with the argument that transport costs are low and only form a small element in business and residential location decisions.

There may be some redistribution of activity and this is being seen within the context of the sectoral analysis summarised here. Certainly, the impact on the dominant financial services sector is minimal, whilst the effects on small businesses can be significant. This adjustment may be welfare enhancing as deadweight losses (from inefficiencies) are removed as a result of more efficient pricing. However, it may be incorrect to attribute this to small businesses or to retailing and hotels and restaurants, as there are limitations on the availability of suitable data, including levels of turnover change, productivity and profitability. But in the longer term, there may be some redistribution towards higher value added activities in the city centre, leading to higher levels of efficiency. It is in these spatial activities that the most interesting future research might be concentrated as it brings together the geographical concentration arguments with those of rent seeking and redistribution.

It would seem that clearly targeted local case studies might also help establish the detailed impacts of congestion charging, rather than the more general effects on land use and development. Included here could be the marginal users of Central London space (for example, small businesses), low income residents (for example, public service workers and students), local neighbourhoods (for example, residential areas), and particular essential sectors (for example, health and education). The local case studies would be supplemented by monitoring press and media coverage to gauge public support, an examination of the scope for modifications, and analysis to identify potentially unexpected outcomes in advance (for example, the number of business start-ups, planning applications, job vacancies, job turnover). This information would be in addition to the monitoring of travel, quality of life, environmental indicators, house prices and rental levels (residential and commercial).

Both the theory and practice are limiting in their analysis and understanding of a wide range of issues related to the land use impacts of congestion charging. London provides a unique opportunity to begin to answer some of the complex questions raised here, through a systematic empirical analysis that in turn informs theory. Such analysis is required both at the city wide levels and at the local level so that the complexity of the expected (and unexpected) impacts can be unravelled and our understanding of the effects enhanced. Equally important is the necessity to relate congestion charging to the wider objectives of creating a sustainable city, and one that substantially enhances the quality of life for residents and workers. Improved quality of transport in the city may be only one small part of that wider objective, and congestion charging may in turn only form one small part of the transport strategy. We need to be realistic about the role and limitations of congestion charging in impacting on land use and the local economy.

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Chapter 6

Tradable Driving Rights in Urban Areas: Their Potential for Tackling Congestion and Traffic-Related Pollution

Charles Raux

Introduction

Following the overall rationale of this book this chapter explores in detail a transport demand management (TDM) measure which could deal with congestion and pollution caused by automobile traffic, as they are major and recurring concerns in urban agglomerations all over the world. Taking the economist's perspective, these phenomena reflect over-consumption of scarce goods, that is, the road capacity in the case of traffic or the clean air in the case of atmospheric pollution: this over-consumption is the result of the under-pricing of these goods.

Since the seminal work of Marshall and then Pigou (1920), it has been established in standard economic theory that regulation by pricing is an efficient means of allocating a scarce resource. This issue is crucial for public goods which are subjected to congestion, for example in the transport sector where pricing is the proposed means of regulating congestion (Walters 1961; Vickrey 1963). The same rationale applies to the regulation of traffic-related pollution.

This is why, in response to congestion and pollution in urban areas, the TDM measure favoured by economists is road user charging or congestion charging which are both implemented by road tolls. In spite of the success of the London Congestion Charging scheme (since 2003) or the successful experiment in Stockholm (in 2006), social and political resistance to urban road pricing is still strong.

Although it is accepted that responding to congestion by introducing congestion pricing increases the welfare of community as a whole, redistribution occurs (Baumol and Oates 1988; Hau 1992). Surplus changes occur in the welfare of different categories of actors from before to after the introduction. The situation of motorists who forsake the road, deteriorates as they switch to alternatives which they found less beneficial before the introduction of road pricing. The situation of most of the motorists who remain on the road also deteriorates, in spite of higher speeds, as they are subjected to an increase in monetary cost which exceeds the value of their time saving. The situation of a minority of individuals improves as a result of their high values-of-time. Finally, the public authorities who collect toll revenues become wealthier.

So, in general, there is little chance of a congestion charge being accepted, unless motorists are convinced that the public authorities are benevolent and that they will distribute the resources collected efficiently and equitably; for example, by a reduction in taxation targeted at motorists or by financing new transport services which would compensate the first group of motorists referred to above.

These aspects are developed and discussed in companion chapters about road user charging in this book. However in the light of these difficulties, another instrument which combines economic incentives and regulation by quantity, namely marketable or Tradable Permits (TPs), might be of interest. This category of instruments is part of a wider one, namely transferable permits. According to a general definition given by Godard (OECD 2001), transferable permits cover a variety of instruments that range from the introduction of flexibility into traditional regulation to the organisation of competitive markets for permits. These instruments have in common: the setting of quantified physical constraints in the form of obligations, permits, credits or rights allocated to target groups of agents consuming scarce resources; and the permission granted to the agents to transfer these quotas between activities, products or places (offsetting), periods of time (banking) or to other agents (trading, hence 'tradable permits').

These tradable emissions permits (or quotas[1]) are frequently referred to as 'pollution rights', implying that those who can afford to are allowed to purchase the right to harm the environment. However, the allocation of emission quotas does not involve the creation of 'pollution rights', but the restriction of these rights when previously they were unlimited. Making these quotas 'tradable' therefore amounts to introducing flexibility and minimizing the total cost to the community of reducing emissions. For instance currently the European Trading Scheme applies tradable quotas of CO_2 emissions to about 12,000 energy-intensive fixed sources within the European Union.

The allocation of quotas for trips or vehicle-kilometres to motorists within a given urban area has been proposed, with the possibility of these quotas being tradable (Verhoef an al. 1997; Marlot 1998). An initial allocation would guarantee a free limited amount of travel – which would improve the acceptability of the mechanism in comparison with conventional road pricing – while any automobile travel beyond this allocation would be subjected to the equivalent of a road use charge because of the need to purchase additional permits. A credit-based congestion pricing mechanism has been proposed by Kockelman and Kalmanje (2005) by which motorists would receive a monthly allocation in the form of credits (in principle monetary), which can be used to travel on a road network or within a zone with congestion charging. The motorists would therefore have nothing to pay if they did not use up their allocation: beyond this allocation, they would be subjected to the congestion charging regime. Those who failed to use up their allocation completely would be able to use their credits later or exchange them for cash.

This chapter will deal with the interest of tradable permits in urban travel demand management. It has been shown theoretically that this type of instrument guarantees the achievement of the quantitative objective of limiting pollution at minimum cost.

1 The terms quota and permit will be used interchangeably in the rest of this paper.

Furthermore, this instrument is particularly appropriate in situations of uncertainty with regard to the response of demand, as is the case in transport. It also provides a way of separating issues to do with the allocative efficiency of pollution and congestion abatement efforts from equity issues by means of the initial allocation of quotas. The chapter will then show the types of adverse impact this instrument may be appropriate for in urban areas and what targets may be set.

To the best of our knowledge, none of the proposals quoted above is detailed enough for it to be possible to judge whether this type of measure could be applied in urban areas. In this context, however, 'the devil is in the detail': from the specification of the implementation of TPs for urban travel demand management, it will be shown which configurations are possible and relevant. The applicability of this type of instrument will then be demonstrated by referring to a detailed example, which will then be evaluated.

Why are Tradable Permits of Interest in Urban Areas?

Firstly the theory of tradable permits will be briefly recapped. Given TPs properties, nuisances within urban areas that are appropriate for TPs implementation will be identified. Then potential targets will be analysed and finally matched to nuisances previously identified.

Theory

The economic theory behind pollution permit markets can be traced back to the work of Coase (1960) on external costs, followed by that of Dales (1968) on regulating water use, and the formalization of pollution permit markets by Montgomery (1972).

A system of tradable permits equalizes the marginal costs of reduction between all emission sources. Under certain assumptions this is a sufficient condition for minimizing the total cost of achieving a given emissions reduction objective (Baumol and Oates 1988). This result is obtained independently of the initial allocation of rights: it should be stressed that this makes it possible to separate the issues of efficiency and equity.

However, Stavins (1995) has shown that when transaction costs are involved – the search for trading partners, negotiation, decision making, follow-up and compliance with the rules – the initial allocation of rights affects the final balance and the total cost of reducing emissions. The authorities may therefore attempt to reduce these transaction costs, for example by avoiding finicky regulations or by facilitating the activity of intermediaries between vendors and purchasers (Hahn and Hester 1989; Foster and Hahn 1995).

The use of transferable permits is not new. They have been used in the fisheries, and in the fields of construction rights and water pollution. The US 'Acid Rain' scheme has been developed as a large-scale system of tradable sulphur dioxide emission permits (Godard 2000). An appraisal of these experiments has made it possible to identify the principal criteria of success for such systems and the associated legal and institutional pitfalls (OECD 1998, see below).

With regard to the quantitative reduction objective, the essential difference between taxes and permits lies in the fact that in practice the public authorities do not possess full information on the reduction costs for the different agents. With a permit-based approach, achieving the quantitative emissions reduction objective is guaranteed, but there is no guarantee with regard to the level of the actual marginal costs of reduction. On the contrary, in the case of the tax, the marginal cost of reduction for each agent is fixed by the tax level, but there is no guarantee with regard to the quantitative level of emissions reduction.

This uncertainty makes it difficult to make a choice, as errors as regards anticipated damage or the reduction costs for agents, particularly with regard to the distribution of efforts over time and between agents, may be very costly to the community. Nevertheless, a number of criteria may be of use when making this choice (Baumol and Oates 1988).

A first criterion for the appropriateness of permits is whether the damage to the environment is in danger of increasing very rapidly or becoming irreversible when certain emission thresholds are reached or exceeded. In this case, tradable permits provide a guarantee of achieving the quantitative emissions limitation objective while minimizing the cost of evaluation errors in comparison with the tax. The problem of greenhouse gas emissions is a particularly good example of this situation. Another, in the field of transportation, is the case in which congestion may, in the short term, result in hyper-congestion which generates large-scale waste for the community.

A second criterion is whether agents are more sensitive to quantitative signals than price signals, particularly if the price-elasticity of demand is low in the short or medium term. In this case again a permit system is more appropriate.

For example, emissions from travel may be reduced by various means: changing driving style, reducing vehicle-kilometres of travel (by increasing the number of passengers in vehicles, reorganising trips or changing the locations of activities); by changing one's vehicle or changing mode in favour of one which consumes less energy. Some of these actions may be implemented in the short term, while others, such as changing one's vehicle, changing one's place of work or of residence, may take much longer. The result of this is elasticities which are generally low in the short term and considerably higher in the long term. For example, for fuel consumption, the price-elasticity values are between -0.3 in the short term[2] and -0.7 in the long term (Goodwin 1988).

Nevertheless, the choice between taxation and permits requires a case-by-case analysis. A general solution to this problem of uncertainty with regard to the costs of emissions reductions has been proposed by Baumol and Oates (1988, 74–6), on the basis of an idea developed by Roberts and Spence.

If the regulator does not put enough permits on the market (for a given year or a given sector), the free play of the permit market will result in an excessive price. The regulator can then introduce a payment in full discharge t, on the principle that any polluter has the right to emit more than the quantity of pollutant permitted by

2 That is, a 10 percent increase in price would lead to a 3 percent reduction in fuel demand.

his/her permit by paying the charge *t* for these additional emissions.[3] In this case, as soon as the price of permits exceeds the level *t*, it is in the interest of polluters to pay the payment in full discharge.[4] The upper bound of the permit price will therefore be equal to *t*. This is the hybrid solution which combines the allocation of permits and a payment in full discharge. It is to be applied when the regulator must make decisions either with regard to the temporal distribution of efforts (for example annual objectives) or with regard to the distribution of this effort between the different actors or sectors.

Furthermore, a third criterion that is an important factor for the effectiveness of TPs is the heterogeneity of the agents involved in the system. This means that the marginal costs of abatement must be sufficiently different between agents in order to allow benefits from trading permits thereby making the market function effectively.

In our context the marginal nuisance reduction cost curves are highly varied, and, in particular, rise as one moves from urban to suburban and then to rural settings. On two essential points, namely changes in the locations of activities and changes in transport mode, the possibilities for action differ very greatly in both nature and degree on the basis of the residential locations of the individuals in question (urban, suburban, rural). Changes in the locations of activities in order to reduce the distances between different activities are much easier to make in urban areas than in suburban or rural locations, as a result of the density of available activities: changes are possible in the short term for activities where the location imposes little constraints, such as shopping or leisure; reducing distances between home and work is easier in a conurbation which provides a high density of job and housing opportunities. Likewise, the large amount of trip flows which results from the high density of activity locations means that public transport which provides an alternative to the private car is more frequently available in urban areas.

Finally, last but not least, in political terms, systems where permits are allocated free of charge may be seen as a means of avoiding an additional tax, and this can enhance the acceptability of the new instrument. With this free allocation, economic agents have a supplementary incentive to save whether emissions, trips or distance travelled, beyond their initial allocation of permits because they can sell unused permits and then get tangible reward for their 'virtuous' behaviour.

The main arguments against the use of permits in the transport system are the cost of administration over a large number of mobile sources and the transactions costs of quotas transfer. However this issue is similar in the case of electronic road pricing and is now better addressed, as we will see, thanks to electronic technology which is affordable today.

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3 That is to say in lieu of having to buy permits at a price p which could rise to a too high level, the emitter could be discharged of his/her obligation to render permits by paying the charge *t* for each unit of emission exceeding the rights he/she holds.

4 This does not apply to the current European Trading Scheme as the penalty is not a payment in full discharge.

Appropriate Nuisances for Urban Areas

Two main criteria can be used to judge the appropriateness of transferable permit systems – the ability to impose a quantitative constraint or right within a specified space and time, and the ability of agents to transfer all or part of these quantitative obligations. These criteria can be applied initially to the main nuisances associated with transport activity, that is, greenhouse gas emissions, regional pollution, noise and congestion.

Space-time equivalents for greenhouse gas emissions occur at the level of the planet, that is, a ton of CO_2 has the same greenhouse effect irrespective of where and when it is emitted. Thus this issue is a global matter that goes far beyond the urban scale: the relevant market for such TPs is a world one and this will not be addressed here. While several proposals address the unitary vehicle emissions of automakers' fleets (Wang 1994; Albrecht 2000), a proposal for tradable fuel permits for drivers has been made by Raux and Marlot (2005).

In other instances such as local or regional air pollutants[5] it is possible to set precise and measurable targets for aggregate emissions. It is the sum of the individual outputs of agents that produces the overall output. It is also possible to establish space-time equivalents for air pollution for which permits can be traded within a geographical area. Since several local or national health regulations prescribe limits for air pollutant concentrations, this may require a quantity-based approach.

However, this does not apply to noise whose level does not increase linearly with the number of individual emitters.

Congestion is another area where limits may be made explicit. If the local policy is not to increase road capacity, a quantity constraint could be imposed on road traffic. Strictly speaking, space-time equivalents of congestion cannot be defined very broadly since an hour lost at a given time in a given location is not equivalent to an hour lost in another area or time. An efficient scheme would thus restrict trading of driving rights to the users of say a corridor during a limited time span. However, congestion primarily generates network interaction effects: congestion on one section of road makes drivers choose another route in order to save time. Congestion also generates rescheduling interaction effects: congestion at one period makes some drivers decide to drive earlier or later. Because of these two kinds of interaction the trading of driving rights could be extended between different locations within a same urban network and between different times and even days. The equivalence between driving rights could be fine-tuned by weighting them differently according to the level of congestion.

Another scarce resource indirectly related to transport activity is public parking space. Here again if the local policy is to not increase the amount of public parking space, a quantity constraint could be imposed on its use. However, it is clear that for parking there is no broad interaction as in the case of congestion. The market would be restricted to small scale areas (because generally two parking places are only equivalent when they are within walking range).

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5 Primary gases in the case of air pollutants such as CO, SO_2, NOx and VOC. Secondary chemical reactions, such as ozone formation, are not considered.

Potential Targets for TP Implementation in Urban Areas

On the demand side the congestion and environmental impacts of transportation stem from,

- technical characteristics of vehicles (energy source, unitary consumption, and pollutant emissions) and fuels,
- ownership and intensity of vehicle use (travel as a function of economic and social trends),
- land use (location of activities and its impact on distances travelled).

There is potential for controlling nuisances arising from transport in all these areas. However among these, some are obviously beyond the scope of local urban governments. This is the case for the regulation of unitary vehicle emissions and fuel standards (for a survey on TP applications in these areas see Raux 2004).

Car ownership In 1990 a scheme of car-ownership rationing involving auctions of a limited number of certificates of entitlement to purchase a new car was initiated in Singapore. The number of certificates is determined each year on the basis of traffic conditions and road capacity and the certificates are issued each month (Koh and Lee 1994). Chin and Smith (1997) showed control of ownership to be a useful instrument when automobile demand is inelastic and the social cost function is steep. Compared with price controls, quantity control reduces the welfare loss arising from any misperception of optimal equilibrium by the authority.

Car use This can be an intermediate solution for controlling congestion. Daganzo (1995) proposed a congestion reduction scheme based on a ‘hybrid between rationing and pricing’. This can be seen as a quota system, without the quotas being transferable. The system was modelled using the San Francisco Bay Bridge corridor by Nakamura and Kockelman (2002) who showed the difficulty of finding a combination of tolls and rationing rates which would benefit all groups of travellers. Other proposals involve setting quotas for vehicle kilometres travelled (VKT) or trips within a given urban area for motorists that could be transferred among them, as already referred to in the introduction.

Parking use When it comes to selecting targets in order to regulate the road externalities mentioned above, parking rights may also appear to be a promising instrument. However road externalities are created by vehicles that move while parking policy basically addresses vehicles that are stationary. For instance an excessively restrictive parking policy in residential areas would generate additional vehicle traffic as a result of vehicles moving elsewhere to escape the policy. In areas that are similar to a CBD in which jobs rather than residences are concentrated, the implementation of parking rights would interfere with or even duplicate driving rights with the same objective. These drawbacks mean that parking right markets do not merit further analysis (for a more detailed analysis see Verhoef et al. 1997).

Car pollutant emissions Some of the atmospheric pollutants result from the composition of fuels and therefore may be tackled by applying TPs to fuel standards (see above). The use of lead as an additive in petrol is being phased out in developing countries and has also been the subject of a successful application of TPs in the US (for an overview see Raux 2002a). Sulphur dioxide (SO_2) emissions are also covered by standards on the basis of the sulphur content of fuels.

However, other pollutants are produced by the inefficient burning of fuel in vehicle engines and ineffective filtering of exhaust gases. This category includes nitrogen oxides (NOx), hydrocarbons (HC) and particulate matters. For example, in Europe, unitary vehicle emissions are regulated by the Euro standards which apply to new vehicles put on the market. Table 6.1 gives the Euro values for private cars (class M1). It shows that between the Euro IV standard and Euro I standard the permitted levels for HCs and NOx, vary in a ratio of 1 to 10 for petrol vehicles and 1 to 3 for diesel vehicles. Particulate emissions standards have so far only been imposed on diesel vehicles (a ratio of 1 to 6 between Euro IV and Euro I) but the Euro V standard, which was still under discussion at the end of 2006, will introduce limits for petrol vehicles too.

Table 6.1 European road vehicle emissions standards

M1 petrol vehicles	Date of application for new vehicles	HC (in CH4 equivalent)	NOx (in NO2 equivalent)	Particulate matters
		g/km	g/km	g/km
Euro I	1993	0.97 (HC+NOx)	0.97 (HC+NOx)	
Euro II	1997	0.5 (HC+NOx)	0.5 (HC+NOx)	
Euro III	2001	0.20	0.15	
Euro IV	2006	0.10	0.08	
M1 diesel vehicles				
Euro I	1993	0.97 (HC+NOx)	0.97 (HC+NOx)	0.14
Euro II	1997	0.7–0.9 (HC+NOx)	0.7–0.9 (HC+NOx)	0.08–0.1
Euro III	2001	0.56 (HC+NOx)	0.56 (HC+NOx)	0.05
Euro IV	2006	0.30 (HC+NOx)	0.30 (HC+NOx)	0.025

Source: Hugrel and Joumard 2006.

Standards of this type can thus provide a basis for regulating the intensity of vehicle use with reference to their pollutants emissions class. In practical terms, the number of rights required to use a vehicle could, all other things being equal, be varied according to the vehicle's emissions category. It is this type of modulation which was used in the Ecopoints system which was applied to lorries crossing Austria until the end of 2006 (for a survey of this experiment, see Raux 2002a).

Land use In scattered settings, public transport is not viable so trips are usually made by car and distances travelled are longer. Land use is generally managed through regulation, however, there have been proposals for applying tradable permits to real estate developers on the basis of the travel volumes that their projects will generate (Ottensmann 1998).

However, to do this, it would be necessary to identify traffic generators (for example, shopping centres, industrial or small business zones) and it poses many market organisation problems, in particular with regard to minimizing transaction costs and making trading possible, not only within a conurbation but also between different conurbations.

Matching Nuisances Reductions to Targets

Targeting VKT with an adjustment according to emission category may be particularly appropriate for local and regional pollutant emissions, (see Table 6.2). Encouraging the use of less polluting combustion engine technologies is a way of reducing harmful tailpipe exhaust emissions per kilometre driven. Targeting only VKT or trips has the drawback of rationing travel, while being less optimally linked to pollutant emissions, since there is no incentive to shift to cleaner vehicles.

Table 6.2 Appropriateness of TP targets for different nuisances in urban areas

Targets / Nuisances	VKTs adjusted according to emission category	End user VKTs or trips	Land use	Car ownership
Local/regional pollution	xxx	x	xx	x
Congestion		xxx	xx	x

Notes: From x = low to xxx = high level of appropriateness.

Regarding congestion, the most efficient and decentralized incentive is on end-user VKT (or even trips on specific corridors or through an area). End-users as the final decision makers can modify their travel choices, activity locations, or choice of vehicle. However this has the same basic drawback of rationing travel (this will be addressed below).

For both nuisances, regional pollution and congestion, controlling land use is in principle an attractive way of reducing distances travelled, but it is controversial: it has still not been proven that it is possible to reverse the tendency to travel longer distances by compacting locations again. However the spatial concentration of activities yields more opportunities for cost-efficient transport alternatives that are less energy consuming such as mass transit.

Car ownership is another indirect way of controlling car travel but the linkage with actual use and hence congestion or pollutant emissions, is very crude.

From now on we will develop the specification of the implementation of TPs for urban transport demand management.

Specifications

This section will outline specifications for the implementation of tradable permit markets for urban transport demand management.

The purpose is twofold: to limit the increase on the one hand of vehicle-kilometres travelled (VKT), particularly during peak periods, and on the other hand of atmospheric pollutant emissions from vehicles. The ideal, from an efficiency point of view, would be to target VKT with the ability to make distinctions on the basis of time and space (congestion) and the type of vehicle (atmospheric pollutant emissions).

However, the limited possibilities of affordable technology mean that a compromise must be accepted with regard to this objective. We shall begin, therefore, by taking stock of technological possibilities at the present time and the near future. This will be followed by an examination of the conditions which a tradable permit system must satisfy in order to be implemented successfully.

Existing and Conceivable Technologies and their Costs

The most mature technology at the present time is roadside Electronic Toll Collection (ETC). This is based on an on-board electronic tag which uses Dedicated Short Range Communications (DSRC) to dialogue with roadside readers. The dialogue between the two, in the most simple version, is used to identify the vehicle and transmit information about the transaction to a central computer in order to invoice the owner of the vehicle. This procedure requires prior registering of both vehicles and drivers. The roadside reader must also be fitted with a video enforcement system (VES) in order to recognise the number plate of those vehicles for which the transaction does not succeed (because of fraud or for other reasons).

A more sophisticated version involves debiting on the fly a preloaded smartcard or credit card that is inserted in the on-board unit (OBU). Objections with regard to the protection of privacy can be overcome by allowing the anonymous purchase of cards which have already been loaded with units.

A system of this last type is used for the Singapore Electronic Road Pricing (ERP) system which was introduced in September 1998 to replace the manual toll payment scheme in operation since 1975. This covered the central business district known as the Restricted Zone (RZ). The new system covers the RZ and a set of major expressways. To begin with, in 1998, 32 gantries were installed and 674,000 In-vehicle Units (IU) were distributed free of charge with a total investment cost of US$114 million (Menon and Chin 2004). Drivers use preloaded CashCards that they can buy anonymously in retail shops and ATMs. The CashCard is inserted into the IU and debited at each crossing through a gantry. Annual operating costs stand at

US$9 million for roughly 6 million daily transactions in 2003. The average monthly level of fraud is less than 0.5 percent of all transactions. The owners of new vehicles must now purchase their IUs at a cost of US$69 (Menon 2000).

A second type of toll collection technology, based on a vehicle positioning system (VPS) that uses satellites (the international GPS system or the European Galileo system), is currently emerging. A well-known example is the TollCollect programme for lorries on the German motorway network. This technology is based on an on-board unit (OBU) which contains a GPS positioning device which dialogues with a constellation of satellites. This type of technology represents the most effective road toll collection system in that it can track the movements of vehicles so the exact distance travelled can be charged, at a rate which may be varied according to the location and the time of passage.

Although from the technical point of view this system requires no roadside equipment, currently it would nevertheless be extremely costly to implement. For example, the estimated cost of the OBU is between €200 and €400 (including installation cost). Furthermore, in order to optimize the cost of the system, all the vehicles which can potentially be charged must be included in the system at the outset: complex and costly manual procedures which duplicate the electronic system are required to process occasional users. Lastly, the possibility of permanently tracking vehicles raises obvious issues with regard to protecting the privacy of car drivers. However, it is probable that these initial problems will be overcome and ultimately acceptable and cost-efficient technologies will be developed.

On the basis of these technical possibilities and their present-day costs, two possible types of application can be envisaged:

- The first application would use well-proven technology based on roadside ETC (RS-ETC) and would aim to cover all motorized vehicle *trips* in the zone covered by the traffic restriction scheme.
- The second application would be based on the satellite vehicle positioning technology (VPS-ETC) and would aim to cover all the vehicle-*kilometres* travelled within the zone covered by the scheme.

The Conditions for Implementing an Emissions Permit Market

On the basis of experience of emissions permit markets and summaries that have been conducted elsewhere (cf. OECD 1997; 1998) the main criteria for the success of such systems can be listed (see Box 6.1). These criteria will serve as a reference for the design and appraisal of the proposal which will be made below.

In order to design an emissions permit market, a series of questions, briefly set out below, must be answered.

The first relates to the specification of the unit to be traded. In view of the stated objectives, this will consist of driving rights (DR). It must be possible to make distinctions with regard to these driving rights on the basis of space and time (congestion) and according to the vehicle's emissions levels (pollution). The mechanism for doing this and its parameters must then be specified.

Box 6.1 The criteria for the success of tradable emissions permits

1. Broad agreement is required on the need to act and the effectiveness of the system with regard to improving the environment and its lower costs in comparison to other systems or solutions.
2. The system must be simple and clear: it is necessary to draw up simple rules, create market boundaries and a specified measurable and verifiable unit of exchange and clearly identify participants.
3. The participants must be able to afford the foreseeable price of the permit in practice.
4. There must be a sufficient number of participants for the market to function.
5. Marginal depollution costs must differ sufficiently for gains to be made as a result of trading.
6. Transaction costs must be limited.
7. Tracking, checks and penalties must have credibility.
8. Certainty is necessary with regard to the mechanisms for allocating permits and their validity in the future.
9. The system must take account of equity and, more generally, social and political acceptability: the introduction of new pricing instruments is usually perceived as inequitable, so these aspects must be included from the outset with any corrective compensation measures that are necessary.

The second question relates to specifying the entities which will hold and trade quotas and be obliged to return them on the basis of their emissions. This can consist of motorists or inhabitants.

The third question is how these quotas will be allocated. Should they be allocated free of charge? If not, the entities affected by the scheme will have to buy all the permits they need on the market: in the event of the total available quantity on the market being small, it is equivalent to setting up a quota auction. Economically, this is the most efficient solution as it obliges actors to reveal their preferences. It is also consistent with the polluter-pays principle and creates a usable financial resource. However, as with congestion charging it immediately increases the financial burden on the actors involved: this would eliminate the essential acceptability advantage that driving rights could have over congestion charging. Consequently, at least some of the quotas would have to be allocated free of charge as a visible and immediate compensation in order to facilitate this instrument's acceptability.

If the quotas are allocated free of charge, to whom should they be allocated and with what distribution method? The problem is that although in theory these methods do not threaten the effectiveness of the instrument, they ultimately determine the financial burden on the participating entities. Will these entities be vehicle owners or inhabitants? Choosing the latter would amount to compensating inhabitants for the consequences of congestion and pollution. This would involve those who travel little, pedestrians and public transport users and not only motorists, which would improve the acceptability of the scheme.

Other issues relate to the period of validity of the quotas and the quota payment obligations. These parameters must be fixed in a way that maintains incentives to reduce consumption of driving rights, particularly during congested periods, and to reduce pollutant emissions.

The principal characteristics of the operation of the permit market must also be specified, that is to say how the transactions will take place, how much flexibility will be allowed to individual holders who trade rights, what role, if any, could be granted to financial intermediaries other than the regulating authority.

Last, two questions must receive particular attention. The first is the possibility of keeping the transactions anonymous, which is an obvious factor for the acceptability of a new control mechanism. The second is how to deal with ‘border effects’, in particular the management of occasional users and the anticipation of unforeseen behaviours which might undermine the effectiveness of the programme.

These points are covered in the following proposal.

A System of Tradable Driving Rights for Urban Areas

From the previous specifications, detailed aspects are now discussed. Firstly the unit to be traded is defined with the computation of driving rights according to congestion and pollution levels, followed by the issue of total quantity to allocate for free. Then successively aspects of market and quotas trading, period of validity of quotas, tracking and checks of driving rights consumption and finally the compatibility with other regulations, are analysed.

The Unit to be Traded

The unit to be traded would be the driving right (DR). In the RS-ETC system, the unit of account for DRs would be the trip, but in the VPS-ETC system the unit of account for DRs would be the VKT. The users would therefore pay a total number of DRs, that is, either trips or vehicle-kilometres of travel.

An agency in charge of transportation in the conurbation and receiving its powers from the local elected authorities would fix the parameters of the programme. To do this, the agency would make use of a survey system including, for example, Household Travel Surveys and traffic count data (for example from cordon traffic surveys).

The agency would specify the zones (on the basis of population density), the peak and off-peak periods, as well as the vehicle emission classes (using, for example, the Euro standards). These parameters would be used to compute the weighting of the DRs which would be charged to drivers. The DRs would be weighted on the basis of the level of congestion, which provides an indication of excess pollutant emissions, but also on the basis of the size of the vehicle in passenger car units (PCUs) and its atmospheric pollutant emission class.

All the vehicles entering and travelling within the zone covered by the scheme would be liable to return DR quotas to the agency on the basis of a computation method as described below.

Table 6.3 Weighting factors for driving rights

M1 petrol car	Euro I	10	Zone with low population density	1
	Euro II	5	Zone with high population density	2
	Euro III	2		
	Euro IV	1	Off-peak period	1
VP Diesel M1	Euro I	10	Peak period	2
	Euro II	9		
	Euro III	5		
	Euro IV	3		

Table 6.3 sets out some weightings which could be applied. With respect to pollutants, beginning with the vehicle that pollutes the least (the Euro IV M1 petrol passenger car) and on the basis of HC + NOx emissions, the multiplication factor can be deduced from the data in Table 6.1, that is, between 1 and 10.

It is also possible to establish a weighting factor for congestion, making a distinction between the zone of travel (low/high density) and the time of travel (off peak periods/peak periods) as a result of the increase in the level of congestion in these zones and the larger population that is exposed to nuisance in them.

For example, a Euro IV petrol vehicle would use DRs at a rate of 1 DR per trip (or VKT) during an off peak period and in a sparsely populated zone. In the case of a Euro IV diesel vehicle, three times more DRs than this would be used. The same Euro IV diesel vehicle would have to pay in all 12 times more DRs during a peak period and in a dense zone. Still taking as a reference the Euro IV petrol vehicle travelling in an off-peak period and a sparsely populated zone, the multiplying factor would increase to 40 for a Euro I vehicle travelling in a peak period in a densely populated zone. This may seem excessive, but these weighting coefficients have only been given as an example. Weightings must be adjusted precisely on the basis of the estimated costs of congestion and pollution.

These weightings obviously assume the capacity to differentiate between vehicles actual use on the basis of their Euro category (see ‘Tracking, Checks’ below).

Allocation

The proportion of the DRs allocated to the inhabitants of the urban zone would be estimated initially by the survey system described above. These DRs would be distributed free of charge equally between all the inhabitants. There would be no need to certify this estimate as being precise (indeed, from a statistical standpoint, this would be impossible), it would merely serve as a basis for the elected representatives to decide what they think it is fair to allocate free of charge to inhabitants. Each inhabitant would have a DR account with the agency, and this account would initially be credited with this free allocation.

The DRs which are not allocated would be sold by the agency. This means those motorists who live outside the conurbation and business users (for example, those making deliveries for firms, tradesmen, doctors, etc.), those making through trips, and those inhabitants of the urban zone who have used up their remaining DRs would be able to purchase DRs. The sale of these rights by the agency would resemble conventional congestion charging.

The agency would vary the total number of DRs allocated and sold over time: this total could be maintained constant if priority were given to limiting traffic, or it could be increased if the economic development of the conurbation so required. In this connection, the level of demand for the rights that are put on sale would provide a good indicator of user preferences and the need to increase transport supply.

As DRs are allocated to individuals but used by vehicles, there is an obvious incentive for carpooling.

The Market and Quota Trading

The trading of rights can take two possible forms:

- The more ambitious option would consist of a full market, those rights which are not allocated freely being auctioned. Financial intermediaries (banks) could be involved in trading and then offer rights to their clients. These auctions would produce an equilibrium price at which private individuals holding unused rights could sell them. For safety purposes, in order to avoid an excessive rise in the event of an error when evaluating the total number of rights to be put on sale, the agency would fix a maximum price for rights at which it would sell them.
- The less ambitious option would try not to leave the management of driving rights entirely to the market: rights which are not allocated free of charge would be sold at a price fixed by the agency and at which the agency would buy back unused rights.

However, nothing would prevent a holder of unused rights from transferring them (or even giving them free of charge) to an acquaintance. In practical terms, this would involve simply notifying the agency that rights have been transferred from one account to another (for example by making an electronic transfer on the Internet). Obviously, there would be no black market as sale and purchase would be unrestricted.

Likewise, small business users would be able to use the rights allocated to them as residents of a conurbation for either their private or their business trips. Last, it might be possible for families to combine the rights accounts of their members to form a joint account to which the DR smartcards of all the motorists in the family would be linked.

Period of Validity

At the start of the scheme, each resident in the urban zone would have a free allocation which is equivalent to several weeks of rights quotas, so that from the outset they would each be able to use the rights they are allocated variably from one week to another. Next, at the start of each week, the resident would be allocated rights quotas for a period of seven days, thus giving the rights holder the flexibility to distribute them over the week as he/she wishes from the outset. These rights would be valid for one year after they have been allocated. Unused rights could be sold back to the agency at any time, even after their validity has expired.

The balance of a resident's DR account should never be negative. Put another way, as soon as a resident's rights have been completely used up, he or she would have to buy the necessary additional rights at the market price.

The risk of over-consumption of rights at certain periods during the day, the week or the month would be quite limited for a number of reasons. First, the rate at which DRs are used up increases with the level of congestion and pollution: there would be an opportunity cost for each right, those used up during a congested period will not be used elsewhere or at another time. Next, using these rights would be associated with another (transport) expenditure to perform an activity whose net utility would have to be positive in order for it to take place. Last, as the agency would be able to buy back unused rights, residents would have no incentive to make additional trips to use up their rights.

Tracking, Checks

The DR collection system would be as described below, either taking the form of RS-ETC or VPS-ETC.

The electronic smart tags would be provided free of charge to motorists in order to encourage electronic transactions as much as possible, thus easing traffic flow through the checkpoints. This equipment would identify a type of vehicle and, in particular, its Euro class. It would permit the automatic debiting of the required number of DRs from a smartcard while vehicles are travelling.

The DR smartcards would be distributed free of charge to those who choose to have the on-board equipment. The cards would be credited with the DRs allocated to or purchased by the motorist.

In the RS-ETC system, the number of vehicle detection gantries should be minimised by using natural barriers (for example, rivers or railway lines) and the road network topology (that is, single ways).

In order to improve the acceptability of the scheme, a maximum daily number of DRs to be debited would be set, following the example of the maximum daily charge in the Stockholm congestion charging trial.

Coping with occasional users This is the Achille's heel of electronic toll collection systems. With the RS-ETC system potential malfunctions or violations must be detected with the help of video enforcement systems (VES) as previously quoted. The VES can be used to detect vehicles non equipped with on-board equipment either because they only drive occasionally in the zone (for example, visitors) or because they refuse to have on-board equipment of any type. This was the policy of the Stockholm congestion charging trial. While having being detected, the driver can pay the charge after his/her driving within a given period (for instance two weeks as in the Stockholm case). The payment and recovery mechanism for the invoice could be similar to that in the London or Stockholm scheme (unsolicited payment by Internet, telephone or in shops before a potential fine and recovery by a specialized firm).

In order to minimise the amount of such potential a financial incentive can be offered to register and get the on-board equipment. This incentive could be that the regular fee for driving through the scheme area for one day while not being registered would be the equivalent of the maximum daily number of DRs debited applicable to registered users (see above).

In the near future, a generalisation of interoperable on-board equipment is to be expected on vehicles, such as the Norway-originated Autopass system which is extending to other Scandinavian countries. That is to say a vehicle having contracted with an operator of an urban area would be recognised in another urban area. Information about the vehicle's Euro class could be retrieved on the basis of its registration number. It is possible that in the near future all vehicles will be fitted with tamperproof RFID tags containing all this information, as this has already been proposed as an anti-car theft measure.

However, in the VPS-ETC with a satellite-based vehicle positioning system, the management of occasional users would be more difficult, as it would require either the satellite tracking system to be duplicated by roadside gantries or manual checks. The resulting possibility of fraud or at least evasion could be seen as unfair by users with vehicles equipped with an OBU. A VPS-ETC system is only of interest if in the future all the vehicles are equipped with positioning systems which would be capable of interacting with the road pricing system. This would require technical harmonisation of the ETC systems in all urban areas and for the entire vehicle fleet.

Finally, it should be stressed that the privacy concern is adequately addressed with an RS-ETC system such as the one used in Singapore (see above). This is not yet the case with VPS-ETC.

Compatibility with Existing or Future Regulations

What is proposed would be an additional system and there would be no redundancy with a tradable fuel permit system (see above) which would not be restricted to urban zones. The objective of this system is in fact different as it aims to limit CO_2 emissions which are directly proportional to the consumption of fossil fuel.

TDRs would, of course, replace conventional congestion charging. Existing parking control systems could, however, be maintained.

An Example of Implementation

We give an overview of a proposed scheme that would be implemented in the Lyon urban area. This scheme is then assessed with computation of various economic surpluses.

Practical Implementation

The Lyon conurbation (1,200,000 inhabitants) has a typical European urban form in which the central zones contain approximately half the inhabitants and jobs with an average population density of 9,000 inhabitants per km². However, like similar agglomerations Lyon is subject to urban sprawl, with both population and jobs having a long term tendency to move into the suburbs and the outskirts.

The implementation of DRs would be based in a first step on an RS-ETC system as described above which would regulate the number of trips. For the sake of simplicity in the first years of the scheme no particular weighting would be applied to DRs according to Euro standard or to peak/off-peak period of driving. However the detection and debiting of DRs would be effective only in periods of higher traffic, for instance between 6h and 19h from Monday to Friday: this would be a proxy for weighting DRs according to congestion.

The main difficulty is then to detect car 'trips'[6] since traffic would be monitored only by detection of vehicles when passing a gantry. The solution would be to define the 'trip' as the period of one hour of car use[7] after the first detection by a gantry. That is to say, if the car is detected again within this period of one hour, it would be considered as the same trip and no supplementary DR would be debited. Trips of more than one hour duration would be longer distance trip and then it would be fair to debit one more DR.

Table 6.4 gives daily average number of trips for all individuals and workers (inhabitants of the Lyon area), and a distinction with the level of income,[8] according to data from the 1995 Household Travel Survey in Lyon (Nicolas et al. 2003).

Table 6.4 Daily average number of trips by car

	All individuals (5 and over)				Workers			
	%	as a driver	as a passenger	total	%	as a driver	as a passenger	total
Low income	35.2	1.13	0.44	1.57	24.2	2.35	0.27	2.62
Medium income	31.8	1.68	0.48	2.16	34.7	2.65	0.29	2.93
High income	33.1	2.13	0.53	2.66	41.1	3.03	0.30	3.33
Total	100	1.63	0.48	2.12	100	2.73	0.29	3.02

Source: Household Travel Survey, Lyon (1995).

6 The option of driving *days* rights is dismissed because it is not sufficiently linked to travel intensity and period.

7 This period of one hour looks sufficient given the current traffic conditions in Lyon.

8 This is an income per adult equivalent unit, in order to take into account differences in size and structure between households. Low income stand for income less than €886 per month, medium income between €886 and €1,344, high income beyond €1,344 (see Nicolas et al. 2003).

In order to avoid too much harmful immediate effect on car mobility when it is used to reach one's workplace, the free allocation of driving rights would for instance initially amount to 3 DRs (that is, 3 trips) per working day. According to this allocation, as shown in Table 6.4 on average low income workers would have rights to sell, medium income workers would be neutral, while high income workers would have to buy additional rights if they want to maintain their level of car mobility for work purposes. Such data show that the scheme would be progressive in relation with income level.

This kind of initial allocation would from the start of the scheme initiate a market between those who would have to buy additional rights and those who would sell unused rights, even if the total allocation would be large enough to cope with current total car trips. This initial allocation would improve the acceptability of the first years scheme implementation. However, after this first period, the agency in charge of allocation of DRs would announce a step-by-step decrease of the individual free allocation each year.

When the VPS-ETC is feasible and affordable then the trip DR scheme would be replaced by a distance DR scheme.

Assessment

Assessment method Our appraisal is based on the use of a strategic travel demand model developed for the Lyon conurbation in 1997. This model has a conventional architecture consisting of five submodels (Raux 2002b). These are: 1) zonal trip generation, estimated on the basis of socio-demographic and economic trends; 2) the spatial distribution of trip origins and destinations, based on a gravity model whose deterrence function varies according to the generalized cost of inter-zonal trips; 3) interzonal modal choice, which estimates the proportion of trips that use walking or bike and then distributes the motorized modes between public transport and the private car using an aggregate logit procedure; 4) transformation of the daily origin-destination matrices into peak period matrices by applying factors based on past observations; the four above submodels have been calibrated and operate in parallel for four types of trip purpose – work, shopping and services, education and other purposes. The last submodel (5) uses an iterative procedure to allocate the trips for all purposes to the different routes, and places them in competition with each other, and also with through and inbound/outbound traffic.

The model was calibrated on the basis of three household surveys (1976; 1986; 1995), which were conducted during a period when travel costs, particularly for private cars, were continually falling either because of an improvement in roads or a reduction in the price of fuel relative to purchasing power. This has resulted in greater travel distances which are integrated within the model by means of the origin and destination spatial distribution submodel.

However, introducing area road pricing or tradable driving rights into the agglomeration would break this trend with numerous impacts: changes in route in the case of different tolls for different routes, changes in trip times in response to peak period pricing, changes in travel mode, changes in destination when trip purposes allow it, and medium- and long-term effects on the location of activities (jobs, shops, services, housing). The last changes would result ultimately in other changes in trip destinations. The net direction and magnitude of these last effects are difficult to estimate, and this uncertainty reflects our limited current knowledge about the interactions between the conditions of transport and urbanization. For this reason, assessment has been limited to a short-term horizon.

In order to effectively isolate these short-term effects, we decided to freeze the socio-economic situation (population, jobs and their locations, income, and so on) and the spatial distribution of trips (origins and destinations) in 1995, the model's base year. Consequently, only two out of five submodels are 'active', the modal choice model[9] and the route assignment model:[10] a deterioration in the conditions of travel by private car can lead to a transfer to other modes or a change of route, and vice-versa. Lastly, the model computes the travel conditions on the road network during the morning peak hour (7–8am in 1995). In brief, the trip volumes for each origin-destination pair remain constant, all that changes is the modal choice and the route taken between zones.

The assessment of DRs scenarios will be performed with reference with a conventional road pricing alternative. Figure 6.1 shows a convenient approximation of the demand curve (or willingness to pay), that is to say change in demanded quantities (vehicle trips, on the x-axis of this graph) as a function of the price (on the y-axis). The current price (P_0) corresponds to the average generalised cost already borne by the driver (monetary cost of using the car plus time spent in travelling). To this is added the congestion fee or the price of the permit, represented by *t*, yielding the price P_1.

The transition from a price P_0 to a price P_1 will result in a modification of behaviours, which will in turn reduce car trips demand, from Q_0 to Q_1. The resulting surpluses will be as follows:

- S_1 represents the loss in consumer surplus resulting, for example, from the reduction of car trip-making or the purchase of a less polluting but more expensive car: this loss is net of the cost previously supported $(Q_0-Q_1).P_0$.
- S_2 represents, in the case of congestion pricing, the gain in local government's surplus that results from the newly congestion fee paid by the drivers, that is, $(Q_1.t)$. S_2 is a loss for drivers.[11] In the case of permits, local government is no longer involved and S_2 represents, for holders of permits, the gains that result from the sale of permits or the losses that result from the purchase of permits.

The surplus for drivers is (S_1+S_2). The surplus for local government is (S_2) when the congestion fee is applied. In addition, as we are only comparing congestion pricing with tradable driving rights, we take no account of the gains in congestion, accidents, local pollution and noise which would result from a reduction in traffic,

9 For the trips made by residents of the conurbation.

10 For the trips made by both residents of the conurbation, and through and inbound/outbound traffic.

11 (S_1+S_2) is of course offset by the suppression of the deadweight loss previously due to congestion.

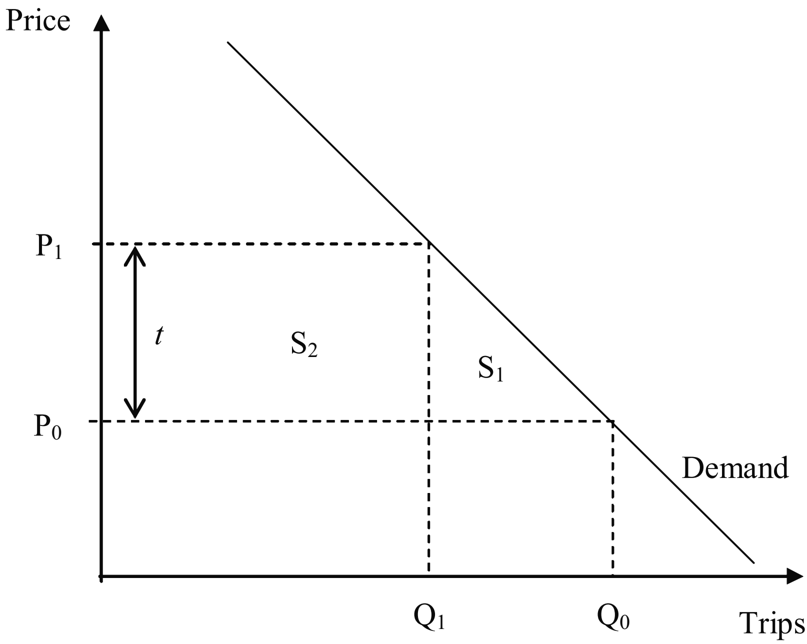

Figure 6.1 The effects of congestion pricing or tradable driving rights on travel demand

as these gains are similar in both cases. Moreover in our exercise the overall surplus change is the same when comparing congestion pricing and permits. The differences between the two instruments lie in the distributions of surplus between categories of motorists and between motorists and the local government.

Results An assessment of road pricing scenarios was conducted in a previous study on the Lyon conurbation using observation data from 1995 (Raux and Andan 2002). These scenarios assume that, by using appropriate electronic toll technology (for example the RS-ETC system described above), it would be possible to distinguish the vehicles belonging to residents of the conurbation from those of non-residents. The first group would pay an area pricing in the form of a fixed daily payment covering all trips and the second would be subjected to a first cordon toll when entering the conurbation and a second cordon toll when entering the central zone. The scenario which most reduces the total traffic in the conurbation (a 5 percent reduction in the 2.6 million daily vehicle trips of which 8 percent are made by vehicles from outside the conurbation), is that in which the area pricing for residents' vehicles is €3 per day and the toll for entering either of the two cordons is also €3 per day.

If motorists pay an average charge of €0.75 per trip (individuals make an average of 4 private car trips per day), we can deduce that the loss in surplus for drivers S1 is approximately €10 million per year. The surplus S2, that is, the revenue from the 95 percent of trips that continue to be made, would then be €370 million per year.

With the implementation of TDRs, if it is assumed that the quantitative objective is to reduce traffic by 5 percent in relation to the current situation, the loss in surplus for drivers S1 would be unchanged in relation to the situation with a toll.

However, in the case of TDRs most of the surplus S2 would be redistributed between motorists instead of becoming revenue for the transport authority. A small proportion of this surplus, corresponding to the 8 percent of external traffic without a free allocation of TDRs, would constitute revenue for the transport authority, amounting to €28 million. If all of the TDRs were allocated freely, €342 million would be spent on DRs or transferred between motorists wishing to travel by car within the conurbation.

Barriers to Implementation and How to Overcome Them

Barriers to the implementation of TDR are mostly the same as for conventional urban road pricing as the purpose of both instruments is to regulate transport externalities and hence travel intensity. These barriers have already been identified in the literature (see Jones 1998; Schlag and Teubel 1997). Firstly, the opinion must agree for the need for action and that depends on the level of concern for congestion or for environmental degradation originating from transport activity. The opinion must also be convinced that alternative solutions such as public transport improvements, park and ride schemes or policy encouraging alternative travel by bikes or walking, are not sufficient when congestion or pollution are reaching too high levels. Besides this indicates that TDR like urban road pricing is not a panacea that should be implemented in all urban areas. Building a broad agreement for action and ‘radical’ policy needs communication and debates.

The technical or practical feasibility of regulating vehicles with TDR has been addressed previously when analysing the already implemented electronic road pricing in Singapore. There is however a risk that economic feasibility could be undermined by an excessive cost of implementation and operation (see for instance the controversy about the net surplus of London congestion charging scheme due to the high cost of monitoring and collecting revenues: Prud’homme and Bocarejo 2005; Raux 2005). Here again figures quoted above regarding the Singapore implementation of ERP indicate that costs can be made moderate.

The issue of legal feasibility of regulating urban car travel with TDR is broadly analogous to the one for area or cordon road pricing. The national legal framework must be made compatible if needed, which is not yet achieved in many countries including France.

One of the main barrier to implementation of regulation appealing to the market is equity concerns, summarised as ‘the poor won’t be able to travel any more’. At this point there is a noticeable difference between TDR and road pricing, since part of the TDR can be allocated for free: this is a guarantee for a minimal travel capability which is not affected by the pricing of rights on the market, even for the drivers not willing or being able to abandon their car. Regarding acceptability this free allocation is an advantage for TDR upon road pricing.

Geographical equity is also a crucial issue when drivers living inside the charging zone get discount fees like in London congestion charging scheme, or travel for free if they stay inside the cordon like in Oslo or Stockholm. In these two latter cases this issue has been resolved by agreements between local governments of the charging and surrounding areas about the allocation of revenues from pricing. A similar agreement must be reached in the case of TDR since rights would be allocated for free to the inhabitants of the regulated zone and revenues would come from rights purchased by drivers living outside the regulated zone.

Conclusion

It has been shown that driving rights markets have three advantages over urban road pricing schemes which make them particularly appropriate for limiting congestion and the pollution caused by urban traffic. The first advantage is the guarantee that a predefined quantitative objective will be attained, whether this involves limiting congestion in the short term or not exceeding certain atmospheric pollution thresholds. The second advantage is that it separates issues of allocative efficiency from issues of equity: the possibility of maintaining a part of travel 'free' besides the part that is subject to a charge is an obvious factor that makes it more acceptable than conventional urban road pricing. The third advantage is that with this free allocation, individuals have a supplementary incentive to save whether trips or distance travelled by car, beyond their initial allocation of driving rights because they can sell unused rights and then get tangible reward for their 'virtuous' behaviour.

More generally, the allocation of TDRs creates a kind of rights on the urban rent which are shared among the inhabitants rather than being captured by the local government. These characteristics make TDRs essentially different from conventional urban road pricing even with special discounts for some users.

Analysis of potential applications for managing urban travel demand has revealed two priority targets: the first is trips or VKT, in order to control congestion; the second is the same target modulated on the basis of the pollutant emission categories of vehicles in order to control atmospheric pollution.

The assessment of ETC technologies has shown that one of them, that combines on-board and roadside equipment, is proven by effective implementation with acceptable cost in several cities. Another technology which may be considered, but more for the future, is based on the combination of a universally installed satellite-based vehicle positioning system and a toll collection system.

Based on these technologies and objectives with regard to limiting congestion and the environmental harm caused by urban traffic, the design of a system of tradable driving rights is possible. Quite a detailed design has been performed, which includes border effects such as the processing of occasional users, that makes it reasonable to envisage its application in an urban agglomeration.

Conventional congestion charging involves a transfer from motorists to the community, which is able to use the revenue as it judges best, while the free allocation of tradable driving rights confines a certain proportion of the transfers to within the group of motorists and population. This loss of revenue for the public authorities represents the price that must be paid for the acceptability of congestion charging, and this price may seem very high.

A possible strategy would be to introduce a traffic capping mechanism and keep this quantitative level constant from year to year. As demand increases with the growth of the agglomeration, purchases of the additional TDRs which are required would provide revenue for the transport authority. Thus transport users would reveal their preferences, providing a signal to the community to invest in a cost-efficient manner in developing the supply of transport, but not necessarily road transport.

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Chapter 7

The Politics and Economics of Parking on Campus

Donald Shoup

> Few institutions are so conservative as universities are about their own affairs while their members are so liberal about the affairs of others. Clark Kerr

Introduction

Big universities resemble small cities. They have athletic facilities, concert halls, housing, hospitals, libraries, museums, offices, restaurants, stores, theaters, and – of course – parking. Big universities also have big transportation problems, and to solve these problems a few universities have reformed their pricing policies for both parking and public transportation. The promising results of these reforms suggest that cities can adopt similar policies to reduce congestion, clean the air, and conserve energy.

Parking is a key element in transportation demand management (TDM), and universities have adopted two main approaches to campus parking policy: political and economic. The political approach relies on rules and regulations, while the economic approach relies on market prices. The results of these two approaches at the university level provide valuable lessons for TDM policies in the wider society.

What is the campus parking problem? Berkeley professors Horst Rittel and Melvin Webber once wrote, 'The information needed to *understand* the problem depends upon one's idea for *solving* it…The problem can't be defined until the solution has been found.'[1] In the spirit of this intriguing statement, I suggest that flexible prices are a solution that can help us understand the campus parking problem: *prices for campus parking can be adjusted to balance demand and supply at each location and time*. I will first examine how the administered approach to campus parking creates serious transportation problems, and will then explain how better pricing can solve these problems.

Administered Parking

University of California president Clark Kerr wrote, 'I have sometimes thought of the modern university as a series of individual faculty entrepreneurs held together by

1 Rittel and Webber (1973, 161).

a common grievance over parking.'[2] Earlier, as chancellor of the Berkeley campus, he remarked, 'The chancellor's job has come to be defined as providing parking for the faculty, sex for the students, and athletics for the alumni.' More recently, UCLA Chancellor Albert Carnesale said, 'At UCLA, parking is the most important issue for everyone.' UCLA has more parking spaces than all but two other universities in the United States – Texas A&M and Ohio State.[3] If parking is so abundant, how did parking become more important than sex and athletics? Campus parking problems, I will argue, stem from mispricing, not scarcity.

Feudal Hierarchy

In academia, you are not what you drive as much as where you park. At Berkeley, for example, only Nobel Laureates are eligible for the highest status symbol on campus – a reserved parking space. After Charles Townes won the Nobel Prize for physics in 1964 and Berkeley put his name on a space, Townes commented, 'It saves me a whole lot of time. The cost is not the big thing – it's the convenience.'[4] Shortly after Daniel McFadden won the Nobel Prize for economics in 2000, he received a standing ovation during halftime at a Cal football game. When asked which was better, the adulation of 50,000 people or the lifetime reserved parking space, he replied, 'Well, the parking space goes on and on. It's considered slightly more important than the prize itself.'[5] The California Institute of Technology also reserves spaces for Nobel Laureates. After Rudolph Marcus won the Nobel Prize for chemistry in 1992, and a colleague saw his name on the reserved space outside his office, Marcus remarked, 'Well, the Nobel Prize has to be worth something.'[6]

Universities often lead society in advocating social and economic equality, but their complex parking hierarchies make the *Titanic* look like a one-class ship. UCLA, for example, has 175 different types of parking permits, carefully graded according to the status of each administrator, faculty member, staff member, and student. Major donors also receive campus parking permits based on the size of their donations. Parking privileges are cumulative, which means that holders of

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2 Kerr (1966, 20). An earlier President of the University of California, Robert Gordon Sproul, defined the faculty even more succinctly: 'The faculty is a group of people who think otherwise.'

3 UCLA has 25,169 parking spaces. Texas A&M has 36,963 spaces, Ohio State University has 32,000 spaces. These other universities have big campuses in small cities, while UCLA has a much smaller campus in a much bigger city with far higher land values.

4 *The Chronicle of Higher Education* (11 August 1993). Professor Townes also told the *Contra Costa Times*, 'My parking space makes a very big difference to me' (31 May 2002). Professor Townes's work in the field of quantum electronics led to the widespread use of lasers.

5 'Severe Parking Crunch Plagues Universities,' *Los Angeles Times* (25 February 2001). Professor McFadden's work on the theory and methods for analyzing discrete choice has been especially influential in transportation economics.

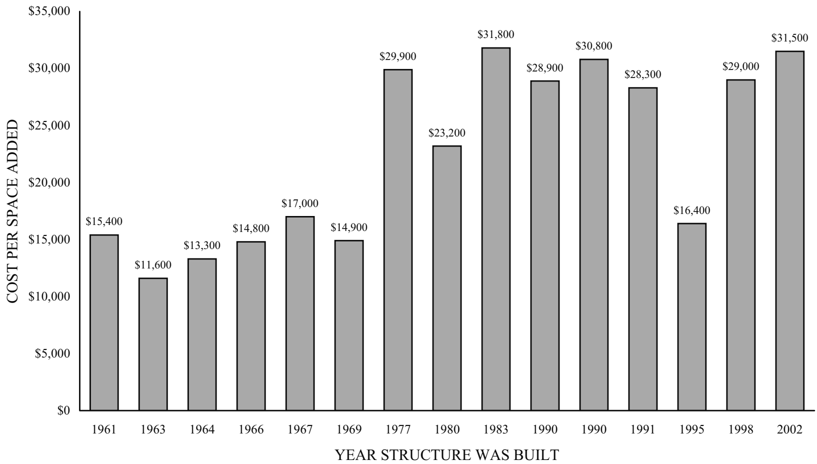
6 'Life among the Nobelity; For Southland's Laureates, the Thrill of Winning Comes in Small Ways,' *Los Angeles Times* (14 October 1994). Marcus continued to walk to work on most days, and kept his 1978 Oldsmobile for days he needed to drive.

higher-ranking permits can park in the spaces reserved for their own rank *and* in the spaces available to all permits of a lower rank. Blue-permit holders can always 'park down' in the spaces reserved for the lower-ranking Yellow permits, for example, but Yellow-permit holders can 'park up' in the spaces reserved for Blue permits only after 4:30pm when demand is lower. The best parking spaces on campus are reserved for the coveted 'X' permit, which allows holders to park in the premium spaces reserved exclusively for X permits *and* in the spaces reserved for all other permits. The X permit is the ultimate status symbol on campus, and is UCLA's equivalent to a knighthood.[7]

Average Cost Pricing

Because permit prices are not set to match demand with supply, parking shortages are to be expected. Students who cannot obtain a permit are put on a wait list, which the UCLA Transportation Service views as a measure of 'unmet need.' Building new parking structures to satisfy this unmet need is extremely expensive. After adjusting for inflation, the average cost of the spaces added since 1977 has been $27,800 apiece

7 The UCLA Parking Services issues a 24-page booklet ('UCLA Parking Permit Privileges') to every permit holder to explain the complicated hierarchal system. At the top, the privileges of the X-permit holder are akin to the feudal *droit de seigneur*.



Year built	Parking structure	Spaces in structure	Surface spaces lost	Spaces added by structure	Structure cost		Cost per space added	
					Current $	2002 $	Current $	2002 $
(1)	(2)	(3)	(4)	(5)=(3)-(4)	(6)	(7)	(8)=(6)/(5)	(9)=(7)/(5)
1961	5	765	219	546	$1,091,000	$8,421,000	$2,000	$15,400
1963	14	1,428	355	1,073	$1,745,000	$12,662,000	$1,600	$11,600
1964	3	1,168	213	955	$1,859,000	$12,985,000	$1,900	$13,300
1966	9	1,800	298	1,502	$3,490,000	$22,392,000	$2,300	$14,800
1967	8	2,839	666	2,173	$6,061,000	$36,896,000	$2,800	$17,000
1969	2	2,253	323	1,930	$5,610,000	$28,903,000	$2,900	$14,900
1977	CHS	921	319	602	$7,084,000	$17,980,000	$11,800	$29,900
1980	6	750	200	550	$6,326,000	$12,777,000	$11,500	$23,200
1983	4	448	0	448	$8,849,000	$14,229,000	$19,800	$31,800
1990	1	2,851	346	2,505	$52,243,000	$72,182,000	$20,900	$28,900
1990	RC	144	53	91	$2,040,000	$2,819,000	$22,300	$30,800
1991	SV	716	0	716	$14,945,000	$20,209,000	$20,900	$28,300
1995	3 Addition	840	118	722	$9,900,000	$11,831,000	$13,700	$16,400
1998	4 Addition	1,263	0	1,263	$33,217,000	$36,685,000	$26,300	$29,000
2002	7	1,500	0	1,500	$47,300,000	$47,300,000	$31,500	$31,500
Total		19,686	3,110	16,576	$201,760,000	$358,271,000	-	-
Average 1961-1969		1,709	346	1,363	$3,300,000	$20,400,000	$2,300	$14,500
Average 1977-2002		1,048	115	933	$20,200,000	$26,200,000	$19,900	$27,800
Average 1961-2002		1,312	207	1,105	$13,500,000	$23,900,000	$12,800	$22,500

Note: The ENR Construction Cost Index is used to convert current dollars to 2002 dollars.

Figure 7.1 Cost per parking space added by fifteen parking structures

(see Figure 7.1).[8] Seven of the nine structures built since 1977 have some or all spaces underground, which helps explain this high cost: underground parking requires expensive excavation, shoring, waterproofing, fireproofing, ventilation, and lighting.

Since the price of a parking permit is far below the cost of a new parking space, drivers who park in a new structure pay only a small fraction of the marginal cost of their parking. For example, UCLA opened a $47 million, 1,500-space parking structure in 2003. The capital and operating expenses were $223 per space per

8 See Shoup (2005) for the cost of UCLA parking structures.

month, but the price of a parking permit was only $55 a month.[9] Because the capital and operating costs are so high and the permit price is so low, new parking structures have a long payback period (the number of years before the accumulated cash inflow from operations will repay the initial capital cost). One campus parking structure opened in 2004 will have a payback period of 30 years.[10] How does this compare with the payback periods for other campus investments? UCLA's criterion for investing in energy conservation is that the payback period must not exceed three years (the money saved by reducing energy use must repay the capital cost in three years or less).[11] Because the estimated payback period for solar panels is about nine years, for example, UCLA does not invest in these panels. For a sustainable campus, it seems unwise to reject a solar investment that will take only nine years to repay its capital cost but build a parking structure that will take 30 years to repay its capital cost and will also – by attracting more cars to campus – increase energy consumption, traffic congestion, and air pollution. When it comes to promoting sustainability, UCLA seems to focus first on sustaining the Parking Service.

The difference between the high cost of a new structure and the low price charged for parking in it creates a substantial deficit for the structure. UCLA finances this deficit by raising the prices charged for all the other parking spaces on campus. Because the marginal cost (the cost of adding another space to the parking supply) is so far above the average cost (the total cost of the system divided by the total number of parking spaces), each addition to the parking supply drives up this average cost. Permit prices that cover the system's average cost increase every time a new parking structure is built (see Figure 7.2), yet the shortage of parking persists.[12] Even after spending $358 million (in 2002 dollars) to construct 19,700 parking spaces since 1961, UCLA cannot provide a parking space for every student who is willing to pay the system's average cost for a permit.[13]

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9 Brown, Hess, and Shoup (2003, 77).

10 Message from the Assistant Vice Chancellor for General Services on 16 November 2005. This payback calculation assumes steady increases in the price of parking permits during the next 30 years. The ratio between initial capital cost and the first year's cash flow is more than 50 years.

11 Message from the Assistant Vice Chancellor for General Services on 14 November 2005.

12 Toor and Havlick (2004) explain that when most parking on a campus is in surface lots, building the first structure does not greatly increase the average cost of parking because the high cost of a new structure is averaged with the low cost of the many surface spaces. But as surface lots disappear and more structures are built, the average cost rises rapidly. This phenomenon helps explain why the price of parking at UCLA increased slowly when the first structures were built in the 1960s, but increased rapidly after 1980 when few surface spaces remained. Until 1990, the three main types of permits (X, Blue, and Yellow) were priced the same; when four new parking structures were built in the early 1990s, the prices of X and Blue permits were increased above the price of Yellow permits to generate more revenue.

13 Parking spaces are even more expensive at Harvard, where the cost of building, financing, and maintaining the campus parking system will amount to more than $500 million during the next 25 years (Harvard University Operations Services 2001, 4). Most parking will be built underground at an estimated cost of $60,000 per space.

	PERMIT TYPE		
YEAR	X	BLUE	YELLOW
1961	$50	$50	$50
1962	$50	$50	$50
1963	$50	$50	$50
1964	$72	$72	$72
1965	$72	$72	$72
1966	$72	$72	$72
1967	$72	$72	$72
1968	$84	$84	$84
1969	$84	$84	$84
1970	$108	$108	$108
1971	$108	$108	$108
1972	$108	$108	$108
1973	$108	$108	$108
1974	$108	$108	$108
1975	$108	$108	$108
1976	$108	$108	$108
1977	$108	$108	$108
1978	$108	$108	$108
1979	$108	$108	$108
1980	$108	$108	$108
1981	$144	$144	$144
1982	$180	$180	$180
1983	$180	$180	$180
1984	$180	$180	$180
1985	$216	$216	$216
1986	$216	$216	$216
1987	$264	$264	$264
1988	$264	$264	$264
1989	$360	$360	$360
1990	$384	$384	$384
1991	$636	$588	$468
1992	$636	$588	$468
1993	$636	$588	$468
1994	$636	$588	$468
1995	$900	$588	$468
1996	$900	$648	$516
1997	$900	$648	$516
1998	$900	$648	$516
1999	$900	$648	$516
2000	$1,008	$720	$576
2001	$1,008	$720	$576
2002	$1,092	$768	$624
2003	$1,152	$816	$660
2004	$1,200	$840	$684
2005	$1,200	$840	$684
2006	$1,260	$876	$708
2007	$1,308	$900	$732

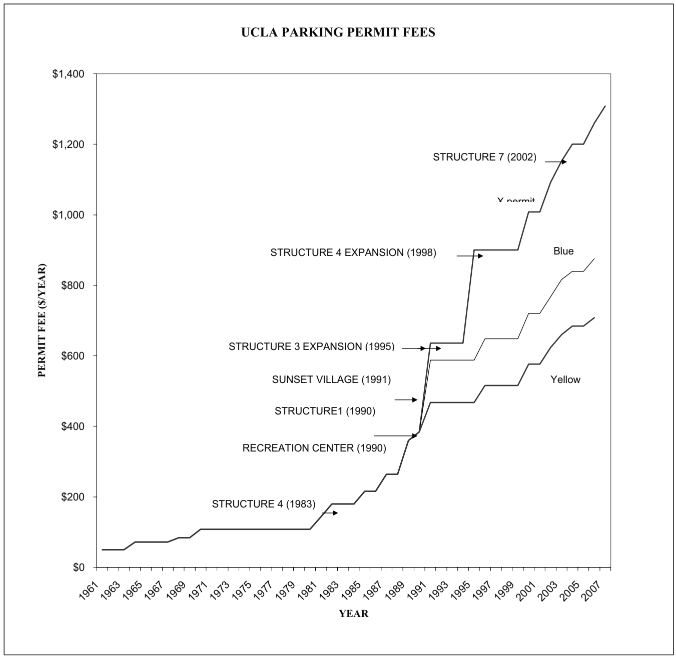

Figure 7.2 UCLA parking permit fee history

UCLA gives priority to administrators, faculty, and staff for permits in the locations they want, and allocates the remaining permits (about 10,000) to students. As a result, all new permits made available by a new parking structure are allocated to students.[14] UCLA then increases the fees for all permit holders – primarily faculty and staff – to cover the cost of the new structure. UCLA's Faculty Welfare Committee wrote to a Vice Chancellor to ask about the economics of a new parking structure built in 1998:

> Do you think that it is either fair or efficient for UCLA to build new parking spaces that cost $170 a month, offer all the new parking permits made available by these parking spaces to students at a price of $43 a month, and finance the subsidy by raising faculty and staff parking fees?

14 All the new permits made available by a new parking structure are allocated to students, but not all of the new students permits will be in the new structure because some administrators, faculty, and staff may shift into the new structure and release their previous spaces.

The Vice Chancellor responded:

> In our view, this planned approach is fair, efficient and appropriate.[15]

Most universities follow this average-cost pricing approach. A professor at the University of Illinois, for example, told me that after he recommended charging the users of new parking structures a price that would cover the cost of building them, an astonished administrator responded, ‘Why, if we did that, we wouldn’t build any parking structures!’[16] This objection is unfounded, of course, because parking structures can be built where drivers are willing to pay the cost-recovery price of parking in them.

Parking Anxiety

Because parking without a permit is difficult, students apply for a permit even if they don’t intend to park on campus every day. And because demand exceeds the supply for parking spaces that are priced far below their cost, administrators have devised a ‘point system’ that ranks students’ priority for campus permits.[17] A student’s chance of receiving a permit is based on a jumble of factors that supposedly measure the ‘need’ for parking, and the distance from home to campus is the chief measure of need. Each factor is assigned a point value, and the points are totaled to decide a student’s priority for parking. Yet students’ anxiety about the point system extends far beyond the simple issue of *whether* they get a parking permit; point totals also determine *where* they park. As Bob Hope joked, ‘It takes four years to get through UCLA, or five if you park in Lot 32.’ Because a permit to park in remote Lot 32 costs the same as a permit to park at the centre of campus, students whose point totals put them in Lot 32 will never be satisfied if other students pay the same price to park in more central locations.[18]

To see the effects of the point system, consider the results of a 1983 survey to learn the major problems experienced by UCLA students. The Student Affairs Information and Research Office sent questionnaires to a stratified sample of 8,852 students selected to represent the entire student body, and 4,400 students responded – almost one of every seven students at UCLA. Seventy percent of all respondents reported that parking was a problem, while only 12 percent were on the waiting list for a parking permit. In a subsequent survey of 2,681 students in 1989, 69 percent of students reported that parking was a major problem, while only 9 percent were on

15 Memorandum from the Associate Administrative Vice Chancellor to the Faculty Welfare Committee on 17 September 1998.

16 Message from Professor Bruce Hannon, 9 July 2004.

17 The point system is described on the website of the UCLA Parking Services at <www.transportation.ucla.edu>.

18 To get students from Lot 32 to the main campus, UCLA provides a shuttle bus system; originally intended only for Lot 32 parkers, it has grown over the years, and now stops at other parking structures on campus, so that drivers can park and ride the shuttle to and from their final destinations on campus. In 2006–2007, UCLA spent $2.2 million on the shuttle buses; UCLA’s average cost was $2.19 per ride on the shuttle, which is free to the users.

the waiting list. In both surveys, most students who identified parking as a problem either had a permit or never applied for one. Even the students who have permits think parking is a problem, but the problem is caused by faulty *pricing*, not by an insufficient *quantity* of parking. Yet the ‘need-based’ point system of allocating permits makes it seem as though the parking problem has only one long-term solution – build more parking structures, no matter how much they cost.[19]

Parking may seem trivial but it’s a serious problem in the minds of many students. In the 1983 survey, 70 percent of students reported parking as a problem, more than any other problem they experienced. Only 28 percent felt their writing skills were a problem, and only 24 percent felt their math skills were a problem. If most students see parking as a bigger problem than writing and math, the parking problem must be serious. The 1989 survey found almost identical results. Sixty-nine percent of students reported that parking was a major problem, while only 12 percent reported ‘too much school work’ as a major problem. Perhaps because of these depressing findings, UCLA has not conducted similar studies in recent years.

Cheating for Parking

Underpricing anything creates a shortage, and parking is no exception. UCLA’s point system is intended to deal with the self-inflicted parking shortage by distributing permits according to ‘need.’ The chief measure of a student’s need for parking – distance from home to campus – is based on the idea that students who live farther from campus have a greater need for parking. This sounds sensible, but since most UCLA undergraduates come from Southern California, they have a parent, grandparent, or other relative whose address they can use as a home address. Even students who live in apartments a few blocks from campus can get more points by claiming they live at a relative’s home that is far from campus. Many students who live near campus freely admit they have used a false address on their permit applications to get a better parking space; as the Chair of UCLA’s Parking Review Board said in the *Daily Bruin*, ‘From what you hear on campus, everyone is lying.’[20]

In 1997, UCLA’s Academic Senate appointed members to a review committee to examine whether the point system encourages students to misrepresent their circumstances when applying for parking permits. Students on the committee were frank about the problems with the point system. One student member of the committee said, ‘Students are driven to dishonesty by a need-based student point system.’[21] Another student said, ‘A lot of students use their [parents’] home addresses if they live in this area,’ making their commutes seem longer and therefore earning

19 Setting parking fees below marginal cost has long created a seemingly insatiable demand for new parking spaces on campus. Writing on the campus parking problem in *Traffic Quarterly* in 1956, the Dean of the University of Michigan’s College of Architecture and Design, Wells Bennett, concluded, ‘The only solution of the campus parking problem is *more parking*’ (Bennett 1956, 105, italics in the original).

20 *UCLA Daily Bruin* (23 September 1980).

21 Minutes of the 30 April 1997 meeting of the Ad Hoc Review Committee for the Point System.

more points for a parking permit. 'I'm from up north, so I can't do that.'[22] That is, the student's complaint was that she herself couldn't falsify her parking application. Confirming these views, the President of the Graduate Students Association wrote to the Chancellor:

> Almost all students, as well as many faculty and staff, know about the need to lie on parking permit applications. Resident Assistants in the dormitories, who must give an educational lecture once a quarter, even offer sessions about cheating to maximize points awarded when filling out their applications.[23]

Defending the point system, however, the Director of the UCLA Transportation Services argued, 'Cheating is rampant throughout society and the point system is not itself the cause of the cheating.'[24]

After complaints about the ethical problems caused by the point system, in 1998 UCLA engaged a consultant to survey the staff members who advise students. These student advisors expressed serious concerns about the almost compulsory dishonesty engendered by the system:

> *One of the biggest concerns interview participants have is that students frequently lie or falsify data in order to get a parking permit.* Most believe that cheating is rampant and that students routinely lie and coach others to lie to get enough points for a permit. Some say that the current system encourages dishonesty and unethical behavior, rewarding those who 'play the system' most effectively.[25]

The consultant also interviewed focus groups composed of student government representatives and randomly selected students who applied for parking permits. These students expressed similar concerns about the point system:

> *Each focus group talked about the ease with which students are able to falsify information on the parking application, indicating that commuting address and employment status are easiest to lie about.* A fair amount of discussion centred on how students cheat on commuting address – how they quickly learn not to list a local address, how they use the address of parents or relatives, how they share with friends and new students the best zip codes to use.[26]

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22 *UCLA Daily Bruin* (1 May 1997).

23 Letter from Andrew Westall to Chancellor Carnesale, 26 May 1998.

24 Minutes of the 12 February 1997 meeting of the Ad Hoc Review Committee for the Point System.

25 Sundstrom and Associates (1998, 9, italics in the original). This information did not surprise the administration. As the Dean of Students Robert Naples wrote, 'Mostly everything I'm hearing from students supports your statements' (e-mail message from Dean Naples on 12 October 1999).

26 Sundstrom and Associates (1998, 32, italics in the original). To gain additional information about these perverse incentives for dishonesty, the consultant then conducted a survey of 1,074 students. One question in the survey was: 'How significant is the problem of students falsifying information on their parking application?' In response, 76 percent of students reported that the problem of falsifying information of parking applications is either

A student who lives in an apartment in West Los Angeles (-4 points), for example, may report living at his or her parents' home in Long Beach (+16 points). The ease of claiming to live at home with one's family makes it almost impossible for the Parking Service to audit thousands of permit applications for false addresses.

In 2006, focus groups of students and of the administrators responsible for advising students were surveyed again about ethical problems created by the point system. Administrators reported that, 'Falsification of application information [is] seen as a given, part of the UCLA culture.' Students did not express a great deal of concern about providing false information on applications for permits, and a majority agreed that, 'Falsification will always exist because people will figure out how to game the system.'[27]

Similar views are expressed frequently in the campus newspaper, *The Daily Bruin*. In 1999, for example, one student wrote, 'Lie, cheat, and steal. These are the fundamental traits Transportation Services wants you to learn here at UCLA.'[28] Students sometimes criticize the point system at embarrassing times. During the Law School's graduation ceremony in 2000, the president of the graduating class said in her speech, 'I learned to get good grades, you had to work, work, work, but to get parking at UCLA you had to lie, lie, lie.'[29]

The point system encourages students to lie on their permit applications even if they expect they would receive a permit without lying. Why? All spaces on campus are the same price, but some are remote and inconvenient. If students need more points to get a space in a better location, and they suspect most of their peers are lying, many students are tempted to lie even if they don't need to in order to get a permit. Cheating to get a better parking space on campus resembles doping to improve athletic performance. If athletes believe their competitors use performance-enhancing drugs and that detection is difficult, they too will be tempted to use drugs. When two-time Tour de France champion Fausto Coppi was asked if he had ever used drugs, for example, he replied, 'Only when necessary.' When was that? 'Almost always.'[30]

Even the University's own official publications casually refer to campus parking scams. *UCLA Arts*, for example, commented on the 'notorious parking permit black market, allowing students to finance an entire college education with one Blue 5 permit.'[31] Parking on campus is an ethics-free zone, and students do whatever it takes to get a permit. Although the point system fails to allocate parking spaces fairly, efficiently, or ethically, it may have one educational value: it trains students to prepare an income tax return. Campus parking scandals even break into the national news, as when 22 UCLA football players were found using disabled placards to park

'very significant' or 'somewhat significant.' Only 8 percent of students reported that the problem is 'not significant' (Sundstrom and Associates 1999).

27 Sundstrom and Associates (2006, 11 and 19).

28 *UCLA Daily Bruin* (5 October 1999, 16).

29 *UCLA Daily Bruin* (22 May 2000, 14).

30 Wheatcroft (2003, 207). A big difference between doping and lying is that doping can damage your health; Fausto Coppi died at age 40.

31 'Parking Nightmares and other Horror Stories,' *UCLA Arts*, Spring 1999, 14. A Blue 5 permit is a permit to park in the better spaces in Parking Structure 5.

on campus. The athletes got their bogus placards by forging doctors' signatures for such conditions as asthma and palsy.[32]

As a result of many serious accusations about the point system, UCLA's Academic Senate requested the Chancellor to appoint a committee to study the problem, but he declined the request because, he said, 'The allocation of parking permits is delegated to an organisational level well below that of chancellor, and I consider that to be appropriate.'[33]

Parking does have a low status in the university hierarchy. The Director of UCLA Transportation Services reports to the Assistant Vice Chancellor for General Services, who reports to the Associate Administrative Vice Chancellor, who reports to the Administrative Vice Chancellor, who reports to the Executive Vice Chancellor, who reports to the Chancellor. Transportation is thus five organisational levels below the Chancellor.

These many levels of bureaucracy help explain how a faulty parking allocation system can persist. Top administrators, busy with other matters, see parking as a sideshow, and everything looks fine from their privileged 'X-permit' view of the world. Lower-level parking administrators control big budgets, undertake big construction projects, employ a big staff, and have their own agenda; they present themselves as experts who know how to handle the sideshow and its $40 million annual budget. Because the parking system is self-supporting – funded mainly from parking fees paid by faculty, staff, and students – it appears to take care of itself without taxing the university's general budget and thus escapes the careful, thoughtful, and exacting scrutiny given to all the academic departments on campus.

A need-based parking system engenders distrust on campus. A staff member of the UCLA Parking Service once used an intriguing analogy that helps to explain this distrust. The Parking Service awards permits like a professor who grades exams on a curve, she said. The point total necessary for a permit in a good location is determined only after all the applications have been received, just as the score needed for an A is determined only after all exams have been graded. The point system does resemble grading on a curve, and that creates ethical problems. Suppose you were a student in a class where your entire grade depended on the final exam. You have heard that cheating is easy, difficult to detect, and almost never punished. You have also heard that most students cheat on their exams, which are graded on a curve. What would you do, and what lessons for life would you draw from the experience? Students learn they can get by without their scruples, but not without their cars.

32 The Academic Senate's request for a committee to examine student parking allocation was rejected only two months after the football players' scandal. UCLA seems to be unusual only in the large number of football players who were caught misusing disabled parking placards. Similar scandals have erupted on many campuses. In 2003, the quarterback at Florida State University earned national attention for parking his SUV in spaces reserved for the disabled ('More Car Trouble for FSU's Rix,' *Tallahassee Democrat*, 24 September 2003). Also at FSU, when a student refused to pull out of a faculty parking space, a business professor rammed his Pontiac Grand Am into the student's Nissan twice, which is more violent than the shouting matches and occasional fistfights that are more typical ('A Strain on Civility?' *Chronicle of Higher Education*, 11 August 1993).

33 Memo from the Chancellor to the Chair of the Academic Senate, 22 November 1999.

Cheating for parking is not unique to UCLA, of course. For example, the University of New Hampshire requires first-year students to submit documentation of need with their applications for campus parking permits. Marc Laliberte of the university's Transportation Services wrote:

> It's very clear that many of these letters are pure baloney, but you can't call them liars without getting their parents (often equally eager to join in the ruse) in your face. I'm considering eliminating the documentation-of-need procedure since it was enacted when we had far fewer parking spaces on campus and since it takes forever to read them all, and since I'm sick of feeling like I'm getting lied to 100 times a day. We feel that commuter students who live within one mile of campus (who are not eligible for a permit) often just give us their home address instead of their apartment address. One can walk through a local off-campus apartment complex within a mile of campus and see many commuter permits. Of course at the time they are out of our jurisdiction, and there's really no hard evidence that they live at this complex, just a strong suspicion and circumstantial evidence. We don't really know what to do with these people.[34]

Students who lie to obtain a campus parking permit don't deserve all the blame for their actions. Consider the finding in the dismissal of a race-discrimination claim by a graduate student who was terminated at the University of Illinois for allegedly altering a campus parking permit. The US Court of Appeals for the Seventh Circuit concluded, 'This case concerns the corrupt, Machiavellian world of permit parking at the University of Illinois's Urbana-Champaign campus, and the ill fortune of a student who became involved in it.'[35] If a campus parking permit system is corrupt and Machiavellian, can we expect the students to remain incorruptible?

Inflated Parking Demand

UCLA's point system is meant to measure the 'need' for parking. Students whose need is judged to be lower than that of the approximately 10,000 students who do receive a permit are put on a waiting list. To reduce the waiting list, UCLA builds extremely expensive parking structures ($31,500 per space in the most recent structure) to provide parking for students who have been judged to need it least – primarily solo drivers and those who live near campus.[36]

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34 Personal communication from Marc Laliberte on 30 September 1999.

35 Stevens (2007) explains the decision in *Brewer v. Board of Trustees of University of IL, 479 F.3d 908* (7th Cir. 2007).

36 The goal of the Parking Service is to reduce the Fall Quarter waiting list to zero, although the Spring Quarter waiting list is already zero in most years: 'By Spring Quarter we do not have a wait list as student demand is lower at this time of year. One reason is fewer students are in school. We get a quarterly list from the registrar of those withdrawn and know several hundred withdraw by Spring' (Memo from Director of UCLA Transportation Services to the Faculty Welfare Committee on 10 May 1996). The goal is thus to build enough parking spaces to meet the peak demand at a price much lower than the cost of providing the new parking spaces, even if these spaces are used only in the Fall Quarter by students who live close to campus and drive to campus alone.

Among all the factors intended to measure the 'need' for parking, what is verifiable (such as being an athlete) seems arbitrary, and what is not arbitrary (how far from campus one lives) is not verifiable. The ease of claiming a false address, for example, means that the students who are most willing to lie tend to get the best parking spaces. Defending the point system, the Director of UCLA Transportation Services wrote, 'As flawed as the point system is, we feel it is better than a lottery, for example, where need is not taken into account at all.'[37] To say that something is better than a lottery is not a strong argument, but many universities are drawn to lotteries to replace a failed system for distributing permits. Duke University, for example, considered a lottery to replace its first-come-first-served system for allocating student parking permits: 'With the first-come-first-served method, we find a feeding frenzy results, with thousands of people waiting to hit the online registration site the minute we turn it on. This creates a heavy load on the system and "registration rage" if there are any technical glitches.'[38]

Lotteries and waiting lists are an attractive alternative because they appear to give everyone an equal chance of getting a permit, and the appearance of equality is a prominent feature of parking systems at many universities. Consider how *The Chronicle of Higher Education* described a new system to distribute parking permits at the University of Iowa:

> A strong current of 'Midwestern egalitarianism' at the university made it difficult to suggest favoring professors over staff members on the waiting lists. The new system, a Solomonic marvel, was devised by parking services and the university's staff council. It created two seniority-based waiting lists for every faculty and staff lot – one for professors and the other for staff members. As spaces become available, they are offered to the top person on each list by turns – faculty, staff, faculty, staff. Over time, popular lots will end up 50 percent faculty, 50 percent staff, even though staff members outnumber faculty members by more than five to one…For deans trying to hire star professors, the system has additional flexibility. A dean can ask that a faculty member be put at the top of the faculty list.[39]

When prices are the same in all lots on campus, everyone wants the most convenient spaces, and most people will put their names on the waiting list for a better space. As proved by the long waiting lists for the choice lots, the seemingly high 'demand' for convenient parking justifies new parking structures, but the users' parking fees pay only a small share of the cost. Inept distribution of underpriced permits thus leads to a bloated and highly subsidized parking supply.

UCLA allocates most new parking spaces to students who were on the waiting list for permits rather than to drivers who pay by the day. The marginal cost of parking is zero for all permit holders, and other drivers cannot park no matter how

37 Memo from the Director of Transportation Services to the Faculty Welfare Committee on 10 May 1996.

38 E-mail message from George Oberlander at Duke University, 16 November 2004.

39 'Notes from Academe,' *The Chronicle of Higher Education*, 5 October 2001. Even the old system, which was based on the date a staff or faculty member put their name on the waiting list for a particular lot, gave faculty requests a boost by automatically backdating them a year.

great their need. Relatively few spaces are available to drivers without permits, and UCLA typically puts out the 'full sign' for daily parking by 10am. To see the problem, consider this e-mail message from a professor of engineering at UC Irvine, who drove up to UCLA for a meeting:

> Sorry that I was not at your meeting with Gary Hart at UCLA. I did try; I arrived at the parking kiosk before 2 p.m. and was told by the attendant that all the campus lots are full and I may be able to park in a public lot several blocks away. After finding the lot, it was also full. So, I gave up and drove back to my office, partly because it was 100 degrees outside and my presence was not essential. I will try to communicate my thoughts to you some other time. I trust you had a good meeting.[40]

The round-trip from Irvine to UCLA is 110 miles! The professor's trip was fruitless because most campus parking spaces were occupied by students, staff, and faculty who can park free once they get their permit. If UCLA is an ivory tower, the Parking Service is its moat.

Increased Vehicle Travel

As the saying goes, if you build it, they will come. After the $47 million Structure 7 opened in 2003, the *Daily Bruin* interviewed several delighted new users: 'Alicia de Anda used to park her car on the corner of Beverly Glen and Sunset Boulevard every morning for a 25 minute walk to campus. Now one of the 545 proud owners of a Lot 7 parking permit, de Anda is thankful the new structure opened early. "There are quite a few students who park on Sunset," de Anda, a fourth-year art history student, said. "It's a pain walking when it's hot or when it's raining."'[41]

The new parking structure also attracted former vanpoolers. One new student driver happily reported, 'I didn't have a permit before so I had to vanpool. For me, having a permit is awesome.'[42] Paying only $55 a month to park in a space that costs UCLA $223 a month *is* awesome. That's quite a subsidy, and there's probably no better deal on campus.

Underpricing creates the demand for more parking spaces on campus, and the added spaces increase other costs in the transportation system. After all, universities provide new parking spaces so drivers can use them. We should therefore ask: do the additional parking spaces increase vehicle travel? If so, how will this added vehicle travel increase the external costs of traffic congestion and air pollution?

Parking spaces do not create vehicle travel, but they clearly enable it. The phenomenon of vehicle travel induced by new parking spaces (added vehicle-*storing* capacity) is similar to vehicle travel induced by new roads (added vehicle-*carrying*) capacity. The environmental impact report (EIR) for UCLA's newest parking structure provides an example of how new parking spaces increase vehicle travel,

40 E-mail message on 14 October 1997. Some professors might not have been so even-tempered about the incident, but the mismanagement of campus parking is so common the incident did not seem extraordinary to the frustrated visitor.

41 *Daily Bruin*, 9 April 2003.

42 *Daily Bruin*, 9 April 2003.

traffic congestion, and air pollution. The EIR was conducted for the 1,500-space Parking Structure 7, completed in 2003.[43] The EIR provides full documentation for nearly every aspect of the structure, including the estimated increase in the number of vehicle trips to campus and vehicle-miles travelled (VMT).

The EIR reports that the 1,500 new parking spaces generates 5,630 one-way vehicle trips per weekday, or 3.8 trips a day per space, implying a parking turnover rate in the structure of 1.9 vehicles a day per space.[44] If we assume that the structure is used only 22 weekdays a month, each space generates 82.6 vehicle trips a month (which underestimates total trips because no trips are calculated for the weekends).[45] The EIR reports that the average distance for vehicle trips to campus is 8.8 miles, so each space generates 727 VMT a month per space (82.6 x 8.8), and the structure generates 1.1 million VMT a month (727 x 1,500).[46]

This added vehicle travel is not a problem for UCLA, but it is for Los Angeles, which has the worst traffic congestion in the nation; in 2002, the cost of wasted time and added fuel consumption caused by traffic congestion in Los Angeles was estimated at $11.2 billion.[47] To put this congestion cost in perspective, in 2002 the total general revenue of all cities in California was $13.7 billion.[48] That is, the cost of traffic congestion in Los Angeles alone may be almost as high as the total general revenue of all cities in California combined. In this congested environment, added vehicle travel to campus makes a bad situation for the region even worse.[49]

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43 Intramural Field Parking Structure Final Environmental Impact Report, State Clearinghouse Number 1999091001, University of California, Los Angeles, May 2001. Because UCLA commissioned the EIR, the structure's environmental impacts are unlikely to be overestimated.

44 5,630 trips/1,500 spaces = 3.753 one-way trips or 1.9 round-trips a day per space.

45 3.753 x 22 = 82.6 one-way trips a month. The neglect of weekend traffic produces a conservative estimate of vehicle trips and VMT per month.

46 This estimate may sound high, but it is based on uniformly conservative assumptions because the VMT are estimated only for weekday trips, and the average one-way trip distance is only 8.8 miles, while the average one-way automobile commute to work in Southern California is 15 miles. Annual surveys conducted between 1989 and 1996 found that average one-way vehicle commute distances ranged from 14.8 to 16.9 miles (Southern California Association of Governments 1996).

47 Texas Transportation Institute (2004, Tables 1 and 2). The Texas Transportation Institute (TTI) annually surveys traffic data in American cities, and calculates the Roadway Congestion Index to rank them by the severity of their traffic congestion. Los Angeles has ranked highest on the TTI Roadway Congestion Index in every year since 1983.

48 California State Controller (2004, Figure 7.1). General revenues are defined as revenues that cannot be associated with any particular expenditure; examples include property taxes, sales taxes, and business license fees. General revenues do not include fees and charges for direct services, such as the revenue from municipally owned electric utilities.

49 Beyond the impacts of *using* the new 1,500-space parking structure, *constructing* it required excavating the 10-acre site to a depth of 31 feet. Removing 222,000 cubic yards of earth required 26,000 truck trips (sometimes more than one every minute) through the campus and Westwood Village on their route for disposal.

A Failing Grade on Campus Parking

Campus parking is closer to communism than to capitalism but it manages to combine the worst features of both systems. Universities distribute parking according to status and purported need but rarely give any preference to low-income staff or students. Providing cheap parking on expensive land inflates the demand for travel by car and does nothing to help those who cannot afford a car. So let's consider a novel alternative: *let market prices allocate parking spaces*.

Performance-Priced Parking

With all the intellect on campus, one would expect universities to teem with creative ideas about how to solve the parking problem. Nevertheless, most universities price parking at average cost and distribute permits according to status or assumed need. Research in economics, political science, and urban planning seems to have little impact on administrators. Naturally, professors should not expect to decide how to allocate campus parking because universities hire faculty to think and they hire administrators to make decisions. Problems can arise when the faculty try to make decisions and administrators try to think. Nevertheless, administrators should not totally ignore academic research in making university policy.

A few universities do charge higher prices for the more convenient parking spaces in high demand. Washington State University, for example, uses a zone system of parking prices. The price in each zone is set according to three criteria: proximity (location with respect to major destinations on campus), quality of the facility (garage, paved surface, or gravel surface), and demand (competition for the zone). WSU sets fees that allow drivers to choose the parking spaces they are willing to pay for.[50] Taking the zone system to its logical economic conclusion, prices for parking can be adjusted to balance demand and supply at each location and time.

Flexible prices can balance demand – which varies over time – with the fixed supply of spaces. We can call this balance the Goldilocks Principle of parking prices: the price is too high if too many spaces are vacant, and too low if no spaces are vacant. When a few spaces are vacant everywhere, the price is just right. If a parking shortage or surplus regularly occurs at any time in any location, the price can be raised or reduced. If prices keep a few spaces vacant at every location, drivers can always find an available space near their destination.[51]

50 Shaheen and Khisty (1990). John Shaheen is the Director of WSU's Parking, Transportation and Visitor Center.

51 The purpose of charging the right price for parking is to ration a scarce resource, *not* to finance the cost of constructing it. Public agencies often price facilities at their cost of provision, regardless of the market, but parking spaces should be priced at their market value, regardless of their construction cost.

Performance-Based Prices

If the goal of pricing is to create a few vacancies everywhere, what is the appropriate vacancy rate? Traffic engineers usually recommend that about 15 percent of spaces should remain vacant to ensure easy access. This cushion of vacant spaces eliminates searching for a place to park, which can be a major source of frustration for students and faculty with time-sensitive schedules. If we accept this recommendation, the performance-based price for parking should vary by time and location to balance a variable demand with the fixed supply and produce a stable vacancy rate of about 15 percent. When the price is *not* right, either too many spaces will be empty (the price is too high), or shortages will appear (the price is too low).

Figure 7.3 illustrates this performance-based price for parking (the price at which demand equals the supply of spaces available with a 15 percent vacancy rate). The number of spaces at any site is fixed, so a vertical line positioned at the 85 percent occupancy rate represents the supply curve. The demand curve for parking slopes downward, and the point where this demand curve intersects the vertical supply curve shows the price that will clear the market for spaces. For example, when demand is high (demand curve D_1), a price of \$1 an hour produces a 15 percent vacancy rate (point P_1). When demand is moderate (demand curve D_2), a price of 50¢ an hour produces a 15 percent vacancy rate (point P_2). When demand is low (demand curve D_3), the vacancy rate is 70 percent even with free parking, so the right price of parking is zero (point P_3).

Prices that produce about 85 percent occupancy can be called performance-based for two reasons. First, these prices allow the parking system to perform efficiently. Most spaces are occupied, but drivers can always find a vacant space. Second, these prices allow the whole transportation system to perform efficiently. The parking supply is fixed, but demand rises and falls during the day, so demand-responsive

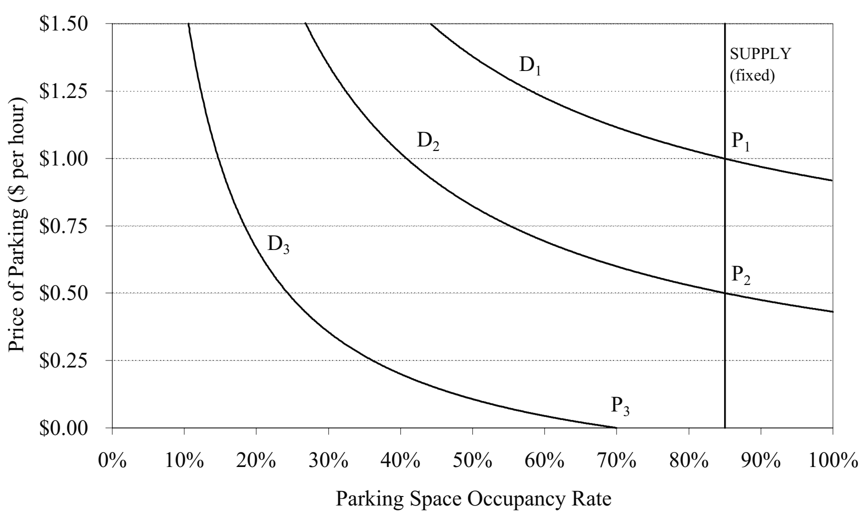

Figure 7.3 Performance-based parking prices

parking prices will necessarily rise and fall to maintain the desired vacancy rate. Obviously, prices cannot constantly fluctuate to maintain a vacancy rate of *exactly* 15 percent, but they can vary sufficiently to avoid chronic overcrowding or underuse. Drivers who are searching for parking will not congest traffic, waste fuel, and pollute the air.

How will drivers know what to pay if the parking prices vary throughout the day? Electronic parking meters can charge variable prices, and the basic idea is simple. Suppose experience shows the right price to achieve a few vacancies in a lot at the centre of campus is zero from midnight to 6am; 25¢ an hour from 6am to 8am; $1 an hour from 8am to 6pm; and 50¢ an hour from 6pm until midnight. If you arrive at 7am and want to stay three hours, how much money should you put in the meter? The first quarter you insert will give you one hour (until 8am). Each additional quarter will give you another 15 minutes. So you will have to pay $2.25 for three hours (25¢ for the first hour, and $1 an hour for the next two). The meter shows the price of parking during each hour, and you simply get less time for your money at the peak hours. Prices would be lower in lots farther from the centre of campus, but they would still vary throughout the day.

Parking occupancy can be reviewed periodically to see whether prices are producing the target occupancy rate. If a parking surplus or shortage regularly occurs at any time in any location, the price can be adjusted. With newer electronic meters, the parking authority can monitor occupancy rates, remotely reconfigure the price schedules, and send the new rates wirelessly to all the meters on campus. These pricing adjustments will preserve a few vacancies during peak hours, and fill spaces that would otherwise be vacant during off-peak hours. This arrangement differs only slightly from existing meters that have a uniform rate during the daytime and are free at night.

The familiar image of pushing quarters into a parking meter is used only to suggest how much time you get for your money. Electronic pay stations accept payment by credit cards, debit cards, and cell phones. The transactions are cashless so drivers don't have to carry a pocketful of change to pay for parking. Multispace meters can also display information on an interactive screen, including the variable price schedule. The information can be multilingual, include graphics, and guide the user through transactions. New York City, for example, uses multispace meters in Manhattan to charge variable prices of $2 for the first hour, $3 for the second hour, and $4 for the third hour during the daytime, and $2 an hour during the evenings and on weekends.

A variable price for parking may seem impractical at first, but the price of most commercial parking already varies by time of day and day of the week. Parking lot operators instinctively raise prices when their occupancy rates approach 100 percent, and some operators claim they don't own a 'full' sign because they never need one. To set the prices for campus parking, universities can use the traditional four-step process that commercial operators use to set prices for off-street parking:

1. Look to see if your lot is full or empty.
2. Then check your competition.
3. If you are full and they are empty, raise your price.
4. If you are empty and they are full, lower your price.

Campus parking should *not* be priced like a private parking lot, however, because commercial operators aim to maximize private profits, not social benefits. Nevertheless, this example does show that the price of parking can be adjusted to create a few vacancies everywhere. The purpose of 'right-priced' parking is *not* to gouge drivers or to maximize revenue. Instead, *the right price of parking is the lowest price that will avoid shortages*.

Some cities have adopted this pricing policy for their curb parking. The municipal code of Redwood City, California, for example, succinctly states the goal of parking management:

> A. To accomplish the goal of managing the supply of parking and to make it reasonably available when and where needed, a target occupancy rate of eighty-five percent (85%) is hereby established.
>
> B. At least annually and not more frequently than quarterly, the Parking Manager shall survey the average occupancy for each parking area in the Downtown Meter Zone that has parking meters. Based on the survey results, the Parking Manager shall adjust the rates up or down in twenty-five cent ($0.25) intervals to seek to achieve the target occupancy rate.[52]

Similarly, universities can vary the price of parking to match the quantity of parking demanded with the available supply at each location and time. Prices will be lower in less convenient locations and at off-peak hours, and it can be free whenever and wherever there is excess capacity, such as on weekends and during vacations. Free parking at off-peak hours will encourage students to come to campus during uncrowded times to use the library and athletic facilities, attend plays and concerts, or to take advantage of the many other resources of the university. Why charge students anything to park when the spaces would otherwise remain empty? Free parking at off-peak hours will help to make the campus a livelier and thus safer place at night and on weekends.

Performance-based parking prices will also reveal where expanding the parking supply is justified. If high prices in some locations produce parking revenues that would recover the cost of building a new structure, investment in more parking may be warranted. Similarly, low prices in other locations will reveal where new construction is unwarranted.

Converting Fixed Costs into Marginal Costs

UCLA now allocates parking permits to students either for the quarter or the year. Drivers thus pay an up-front cost for the permit and nothing extra for parking on each trip. The zero marginal cost of parking invites permit holders to drive to campus alone, encourages overuse of scarce spaces during peak hours, and leads to

52 Section 20.120 of the Redwood City Municipal Code.

shortages that generate demands for even more campus parking. The permit system works well for conventional commuters who come to campus five days a week and stay on campus all day. The system does *not* work well for students who come to campus only on certain days, who do not remain all day, or who drive to campus only occasionally.

Some universities charge everyone for parking, even those who don't drive to campus. Florida State University and Florida Atlantic University, for example, bundle the cost of a parking permit into tuition payments.[53] Parking is free on every day, and because the cost is hidden, students don't know they pay for parking. Even students who are too poor to own a car pay for parking.

Universities that do charge for parking usually give a big discount for monthly permits. At UCLA, for example, the price of parking is $9 a day or $63 a month for a permit in 2008–2009. Someone who wants to drive to campus more than seven days a month thus finds it cheaper to buy a permit, and the marginal cost of parking on campus then becomes zero. For a month with 21 working days, the cost of buying a permit is only 36 percent of the cost of paying per day. Permits are also much more convenient because the users can drive straight into their parking lots, while those without permits must line up at a kiosk to pay every day, and spaces are often not available. Convenient, discounted monthly permits are an invitation to drive to campus alone.

In contrast to selling discounted monthly permits, or bundling the cost of parking with tuition, some universities offer convenient ways to pay for parking on a daily basis. In their survey of university parking policies, Elizabeth Isler, Lester Hoel and Michael Fontaine (2005) found some campuses accommodate the occasional parker without a permit:

> The University of Michigan has scratch-off cards that cost $35 for a 10-pack. Each scratch unit is valid for 1 day of parking, and the user scratches the card to reveal the appropriate date and displays the card in the vehicle's windshield. Other schools such as Utah State University have similar daily permits in the form of punch cards. Day-to-day permits such as this help prevent the 'all you can eat' syndrome that is often enabled by long term permits. If a driver has already paid for a full parking permit, he or she has no incentive not to drive and park every day rather than occasionally using alternative modes…Short-term options such as hourly or daily permits, and a guaranteed ride home program have also been used to fill a niche for the campus user who needs to drive to school occasionally but ends up driving every day because he or she paid for a semester or annual permit or may need a vehicle in the event of an emergency.[54]

The University of Texas has also devised a convenient and cheap Share Pass system to serve alternative transportation users who occasionally want to drive to campus. Customers purchase debit cards and swipe them through a card reader when entering a garage. The Share Passes give users up to a 75 percent discount from the normal

53 Isler, Hoel, and Fontaine (2005, 6).
54 Isler, Hoel, and Fontaine (2005, 8–10).

daily rate, but this still exceeds the price for conventional permit holders.[55] A few universities charge a marginal cost for parking, with no fixed cost. The University of Massachusetts and the University of Wisconsin use in-vehicle parking meters (which resemble debit cards) to pay for parking (Shoup 2005, 387–9). The basic idea is simple: the longer you park, the more you pay. Drivers use these in-vehicle meters to pay for parking on every trip, and they pay only for the exact time they use – no more, no less. This system encourages commuters to consider alternatives to solo driving for each trip because they can save money by carpooling, riding transit, bicycling, or walking.

The structure of parking prices at airports provides an example of what performance-based prices on campus could look like. Everyone expects not only to pay for parking at airports, but also to pay higher prices for parking closer to the terminals. The expensive central spaces encourage short-term parking and carpooling, while the cheaper remote spaces attract long-term parkers and solo drivers. Many passengers use public transportation or shared-ride vehicles to get to and from the airports specifically to avoid paying for parking (which, incidentally, has become a major source of income for airports). Similarly, once people have become accustomed to performance-priced parking on campus, the idea of going back to administered parking will seem as absurd as expecting free parking at airports (desired, perhaps, but understood to be neither realistic nor ultimately beneficial).

Low Cost of Administration

Letting prices manage parking will take a heavy burden off university administrators who now devote endless hours debating how to micromanage parking for faculty, staff, and students. Even higher political bodies, all the way up to the President's Cabinet in Washington, waste time talking about parking, as suggested by this description of a cabinet meeting in which Daniel Patrick Moynihan participated: 'a cabinet meeting which was mainly bitching about parking in federal buildings – all right, it was supposed to be about office space, but it was also about parking, it always is.'[56] What Joseph Schumpeter said about politics in general applies perfectly to the politics of parking in particular: 'The typical citizen drops down to a lower level of mental performance as soon as he enters the political field. He argues and analyzes in a way which he would readily recognize as infantile within the sphere of his real interests.'[57] If universities let prices allocate parking, everyone will be able to spend more time dealing with academic issues.

Parking Cash Out

Parking cash out is another way to reduce the demand for campus parking. Faculty members at many universities pay nothing for parking, and it may be politically

55 Stone (2005, 26). Information about the Share Pass is available online at <http://www.utexas.edu/parking/parking/utsharepass/>.

56 Takesuye (2001, 36.).

57 Schumpeter (1942, 262).

impossible to begin charging them. In this case, a program of parking cash out – offering employees the option to choose the cash value of any parking subsidy offered, in lieu of the parking itself – can achieve almost the same efficiency gain as charging for parking, but without the political pain. Consider the cash-out program run by the Pfizer Corporation at its laboratories in Kent, England. Pfizer estimates that the capital and operating cost of providing parking for its employees is more than £1 million a year, and that the average cost per space is £2 a day.[58] Under the program, employees can park free at work on any day, but any commuter who works on site without bringing a car receives a credit worth £2. Commuters can either park free or take the cash value of the parking, and they can make different choices on different days. Although everyone can park free, commuters who drive to work alone forfeit £2 a day. The daily cash option therefore encourages every commuter to consider the alternatives to solo driving whenever possible.

The program is simple. Employees automatically earn a credit of £2 each day when they use their company identification cards to enter their office building. If they have driven to work, they use the same identification cards to access the company parking lot, and £2 is deducted from their account.[59] A solo driver thus receives both a credit and a debit of £2 for the day (so the net value is zero), but a commuter who has walked, biked, or taken the bus to work receives a net credit of £2 for the day (because there is no debit for parking). These accumulated credits are forwarded to the payroll office at the end of the month, and the cash value is included in each employee's salary one month in arrears. This arrangement automatically enrolls all employees in the program even if they usually drive to work alone.

Daily parking cash out is fair and flexible for both the firm and its employees. Giving a credit for arriving and then deducting it for parking informs every commuter, every day, that parking has a cost. Commuters can earn a cash bonus on any day simply by showing up at work without a car. Rather than charge commuters to park, the firm pays them not to park. This policy levels the playing field among all modes of travel because all commuters receive the same subsidy, regardless of their mode choice. Parking cash out does not favour the alternatives to solo driving, but instead offers the same subsidy to drivers and nondrivers alike – a parking subsidy

58 Pfizer is the world's largest pharmaceutical company. Sandwich is a coastal town on the English Channel, 70 miles east of London. The consulting firm of John Whitelegg and Associates designed the cash-out program for Pfizer. The cash value of a parking space is based on the capital cost and on operating costs for security, maintenance, planting, and lighting. The cash-out program began in June 2001, and is described in the brochure, 'Check-In, Cash-Out,' available from Pfizer Global Research and Development in Sandwich, Kent, England. The program is also described in UK Department of Transport (2002).

59 Pfizer keeps a record of each commuter's credits and debits; the charge for parking is deducted when a card activates the exit barrier as a driver leaves the company parking lot. Charges are deducted only when a car passes through the exit barrier for the first time during the workday; subsequent exits from the car park using the same identification card do not register any further deductions, so drivers can leave and return during the day without charge. An alternative policy is to offer each employee a monthly transportation allowance, and to deduct a payment for parking on each day a commuter uses an access card to enter the firm's parking facility; the money that is not used for parking can be taken in cash at the end of the month.

for drivers and a cash subsidy for nondrivers. This seems generous to nondrivers only because most employers offer nondrivers nothing.

The daily parking cash-out arrangement is particularly well suited to universities. Some professors argue that charging for parking discourages coming to campus, while free parking encourages the faculty to make themselves available to meet with students, attend committee meetings, and participate fully in the life of the university. In this situation, daily parking cash out serves everyone's interest. Professors who drive to campus can park free, while those who come to campus without a car receive the cash value of the parking they do not use. Even economics professors can have a free lunch if they forgo a free parking space, and professors who stay at home receive nothing. What could be fairer or more efficient?

Parking Fee Level versus Parking Fee Structure

The daily cash-out option illustrates a key distinction between the *level* and the *structure* of parking fees. The level of the fee refers to the amount, while the structure refers to the way drivers pay it (per hour, day, or month). A fee of $5 a day and $100 a month both amount to the same charge for 20 working days a month, but drivers react differently to a daily fee than to a monthly one. Drivers will often respond more to a change in a parking fee's structure than to a change in its level. Imagine, for example, that the price of a parking permit is $100 a month. If a commuter wants to drive to work twice a week (for example, to run errands at lunch or after work), then the rational decision may be to buy a parking permit. With a permit, the marginal cost to park at work on any given day is zero. Once you have bought your car, paid for your insurance, and have a parking permit, why not drive? As a result, commuters are more likely to drive to work *every* day. If the permit price increases to $110 a month, most commuters will continue driving to work, so the higher price will do little to reduce vehicle trips.

Now suppose the fee level remains $100 a month, but the structure is changed to include the option of paying $5 per day (the collection can be automated with electronic payments to avoid any inconvenience for the drivers). In this case, commuters need not buy a permit for an entire month. Instead, they can pay only for the days when they drive to work. On other days, they can ride transit, carpool, walk, or bicycle to work and save the $5 daily fee. Offering the option of a daily fee will increase the number of commuters who drive only a few days each month, and reduce the number who drive every day. In this way, restructuring the fee without increasing its level can reduce the number of vehicle trips by giving commuters new options.

Another benefit of offering the daily fee option is that employees won't oppose it. Raising a parking fee from $100 to $110 a month, for example, can arouse strong opposition but only slightly reduce solo driving. In contrast, adding the option to pay $5 a day can reduce solo driving but arouse no opposition because it does not increase the monthly cost for someone who drives every day. Pfizer's daily cash-out program does not increase the price of parking, is popular with employees, treats full-time and part-time drivers equally, and provides a financial incentive for everyone to rideshare, every day.

Efficient Location Choices

With performance-based prices, drivers who choose parking locations to reduce their individual costs will park in a pattern that also reduces the total cost of time spent walking to and from the parked cars. Why? Because the performance-based prices will allocate the central spaces to carpools, short-term parkers, and those who place a high value on saving time, for three reasons.[60] First, because carpoolers split the cost of parking among two or more people, they are less sensitive to parking prices and will therefore use the more central spaces. Second, because short-term parkers pay for only a few minutes, they are also less sensitive to parking prices and will also use the more central spaces. Third, those who place a high value on saving time will use the more central spaces because the time they save outweighs the higher cost.

Drivers may have different destinations on campus on different days, and they can park in different locations on different days. Those who want to spend only a short time on campus – such as for a quick trip to the library – will not have to spend a long time walking from their assigned parking spaces to their final destinations. The faster turnover of the central parking spaces will make them available to more people.

If parking prices increase toward the centre of campus, will rich drivers monopolize the central parking spaces? All else equal, drivers who place a high value on saving time will pay more and walk less, but time value is only one of several factors that determine the optimal parking location. Because parking duration and the number of people in a car also affect location choice, drivers who place a high value on time will not automatically park in the best parking spaces. Many other factors affect how much drivers are willing to pay to save walking time on any particular trip: whether they are late or tired, the weather, the scenery, safety, heavy packages they are carrying, whether they want the exercise, their health, and other circumstances that are unique to each trip. The value of saving time can vary greatly from one place to another, from one person to another, and from one trip to another. An old Ford may park in an expensive space at the centre of campus if its driver is in a hurry and plans to stay for only a few minutes, while a new Bentley may park in a cheap space at the periphery if its driver has plenty of time, enjoys walking, and plans to stay all day. To allay equity concerns, any extra revenue that results from higher prices for the central spaces can be used to pay for alternative forms of transportation, such as fare-free public transportation for students, staff, and faculty.

Fare-Free Public Transportation at Universities

Many American universities contract with the public transit agencies in their cities to offer fare-free public transportation for everyone at the university. Universities have given their transit programs a variety of names – such as UPass, ClassPass, and BruinGO – but they are often referred to by the generic name of Unlimited Access.

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60 In linear-programming terms, the user-optimizing solution is the same as the system-optimizing solution. Shoup (1999) analyzes how market-clearing prices will allocate parking spaces efficiently.

Unlimited Access programs turn university identification cards into public transit passes. The university pays the transit agency an annual lump sum based on expected student ridership, and the transit agency accepts the university's identification cards as transit passes. For every eligible member of the university on any day, a bus ride to campus (or anywhere else) is free. Unlimited Access is not free transit, but is instead a new way to pay for public transit.

UCLA's partnership with the Santa Monica Big Blue Bus, called BruinGO, has proved to be a great success for both the university and the community. During BruinGO's first year, transit ridership for commuting to campus by faculty and staff who live within the Blue Bus service area increased by 134 percent, while ridership was almost unchanged outside the Blue Bus Service area (Brown, Hess, and Shoup 2003). Even larger increases in transit ridership have been reported at other universities with Unlimited Access programs (Brown, Hess, and Shoup 2001). BruinGO increases transit ridership, reduces parking demand, reduces traffic, and also provides two other important benefits for the university: financial aid for students, and a tax-exempt fringe benefit for staff and faculty. Seventy-six percent of student BruinGO riders receive financial aid from the university, so free public transit isn't just another perk for people who don't need it. For these students, the fare subsidies effectively increase their financial aid packages. Using the revenue from campus parking to fund a fare-free public transportation program should thus allay most fears that performance-based parking prices will, on balance, harm low-income students.

Table 7.1 Faculty/staff bus share for commuting

	Blue Bus Service Area	
	Inside	Outside
Before BruinGO	8.6%	7.2%
With BruinGO	20.1%	7.6%
Difference	11.5%	0.4%
Percent change	134%	6%

Source: Crain and Associates (2002, Tables 3 and 4).

Transportation Prices Turned Upside Down

Pay-as-you-park pricing for drivers combined with fare-free public transportation for transit riders will change the price of travel in two important ways. First, the price of parking will switch from a fixed cost per month with no marginal cost to a marginal cost per hour with no fixed cost. Second, the price of public transportation will fall from a marginal cost per trip to nothing. The increased marginal cost of parking will reduce vehicle trips, and the reduced marginal cost of using public transportation will increase transit ridership. Taken together, these two price reforms will reduce vehicle travel much more than either one acting alone because in combination they will turn transportation prices upside down.

Conclusion: Let Prices do the Planning

In *The Public Use of Private Interest*, Brookings Institution economist Charles Schultze wrote 'Harnessing the "base" motive of material self-interest to promote the common good is perhaps *the* most important social invention mankind has yet achieved…[But] the virtually universal characteristic of public policy…is to *start* from the conclusion that regulation is the obvious answer; the pricing alternative is never considered.'[61] Campus parking policies based on regulations rather than prices are a perfect example of Schultze's argument. Is there a better way to manage campus parking – a lower cost alternative that is fair, efficient, and does not encourage rampant cheating? A system that relies on incentives rather than on penalties to encourage honest behaviour? There is, and some universities already use it: they charge higher prices for the more desirable parking spaces, and they charge users by the hour rather than by the month or year. In short, they rely more on the market and less on bureaucracy.

Pilot Program

Universities can use a pilot program to test performance-based parking prices that vary by time and location. Offering a pilot program for a sample of a few hundred students, staff, and faculty will show how drivers respond to the new option, and how much revenue it produces. If performance-based prices provide better service and produce more revenue than conventional permits for the spaces used by the pilot project, the pay-as-you-park option can be expanded incrementally. The results of the pilot project can be carefully evaluated before proceeding to more widespread adoption. So long as the new revenue from performance-priced parking replaces the lost revenue from conventional permits, the university will lose nothing from the shift. A pilot program could be used to test whether performance-priced parking produces these 12 benefits:

1. The system will be transparent and will treat everyone equally.
2. All students will be eligible to park on campus, not just students who manage to obtain a conventional parking permit.
3. The administration will not need to judge whether a student 'needs' parking.
4. By encouraging faster turnover and higher vehicle occupancy for the better-located parking spaces, the existing parking supply will serve more people.
5. If performance-priced parking increases total revenue, the extra money can pay for alternative transportation, such as fare-free public transit, that benefits the poorest students.
6. Drivers will pay only for the parking time they use – no more and no less.
7. Charging drivers for the time they park will encourage everyone to consider alternatives to solo driving for every trip to campus. Anyone can always save money by carpooling, riding public transit, bicycling, or walking.

61 Schultze (1977, 18 and 47).

8. Drivers will have more flexibility. They can pay a higher price to park in the more central spaces when they are in a hurry, when they want to park for a short time, or when they carpool. They can save money by parking in the cheaper, peripheral spaces when they are willing to walk farther, want to park all day, or drive solo. Students, staff, and faculty can park free on campus at off-peak times when demand is low.
9. Areas where high parking demand leads to high parking prices will signal where new parking structures should be built. Similarly, areas where low demand leads to low prices will signal where parking structures should *not* be built. Performance-based prices will create a dynamic, self-correcting parking system and will help to guide the allocation of scarce land and capital.
10. Lower off-peak prices will draw students to campus during the summer, in the evenings, and on weekends when the university has empty parking spaces waiting to be used. Populating the campus at off-peak times will make it livelier and safer for everyone.
11. Drivers with disabilities can be offered transportation allowances to park in the best-located spaces, enhancing their access to the campus and their overall mobility.
12. Highly-recruited students can be offered transportation allowances to be used for parking on campus or for any other purpose. By rewarding academic or athletic excellence, for example, the transportation allowances can further the academic and other missions of the university.

This experiment could have one result that might cause parking administrators to oppose a pilot program. The campus parking service may lose revenue from faculty, staff, and students who now buy monthly permits but drive to campus only occasionally. These people would be likely to jump at the chance to pay only for the parking they use, rather than to pay for a whole month. In effect, the permit holders who drive occasionally would no longer subsidize the permit holders who drive every day. Parking administrators may hesitate to offer convenient daily parking if they fear that occasional drivers would give up their monthly permits and pay only for the parking they use. Any pilot program should examine both increases and decreases in parking use and revenue.

The Lessons for Cities

Big universities resemble small cities, and the innovations in transportation demand management at universities provide important lessons for transportation demand management in cities. To reduce automobile dominance on campus, a growing number of universities have reformed their pricing policies for both campus parking and public transportation.

To manage the parking supply, some universities adjust parking prices by zone and time of day to balance supply and demand for parking at each location. In lieu of conventional parking permits, some universities also use in-vehicle meters so that drivers pay for parking by the hour rather than by the month. These performance-based parking prices favour high-occupancy vehicles and short-term parkers, accommodate occasional users, create more opportunities for individual choice, and reduce vehicle travel.

Universities have also pioneered another strategy, Unlimited Access, to reduce automobile travel. They contract with their local public transit operators so their university identification cards serve as transit passes for everyone at the university. Paying the fare for a bus ride to campus is far cheaper than building a parking space on campus, and avoiding the expense of new parking spaces is thus a major benefit of fare-free public transit. Unlimited Access programs allow universities to satisfy their transportation demand with a smaller parking supply, and at much lower cost.

Performance-based parking prices can manage travel demand, but are they fair? At universities, it seems fair that carpoolers, short-term users, and well-paid senior administrators pay a higher price to park in the most convenient spots in the centre of campus while solo-drivers, long-term users, and financially-challenged students pay a much lower price to park at the periphery – especially if the university spends the revenue earned by the higher-priced central spaces to finance fare-free public transportation for everyone at the university. Similarly, in cities it seems fair to charge higher prices for curb parking in the centre of business districts than in the more distant spaces – especially if the city spends the revenue to reduce the price of public transportation.

With both performance-based parking prices and Unlimited Access programs, universities are leading the way for the rest of society. Some cities already set a goal of about 85 percent occupancy for curb parking in their central business districts, and instruct their parking authorities to adjust meter rates to achieve this goal. Similarly, some transit agencies already offer private employers the option to enter into fare-free public transportation contracts that cover all their employees. Performance-priced parking and Unlimited Access programs, which are appropriate for so many different settings, can contribute to many important goals of transportation demand management: traffic reduction, clean air, energy conservation, and sustainable cities. Few other transportation reforms contribute to so many goals, produce such easily quantifiable benefits, and have such low costs. All these benefits accrue simply by following the age-old axiom in public economics: get the prices right.

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Chapter 8

A View of Parking Policy in an Australian City

William Young

Introduction

The attractiveness of cities depends on the economic, social and environmental quality provided. This quality is influenced by many factors, one dimension being the policies of government and the reaction to these policies by residents, businesses and visitors to the city. Cities land use, transport and parking policies influence and are influenced by the economic, social and environmental character of a city. A clear enunciation of the objectives of these policies is required.

Transport and land use policies are often seen as the main drivers towards achieving urban sustainability. Parking is often seen as having an active impact on transport and land use quality, however, unless all the policies work towards the same objectives, parking policy will not support the other policies in achieving broader economic, social and environmental aims.

This chapter looks at urban parking policy in Melbourne. It highlights the general trends and points to their influence on the aims of transport and land use policies.

A View of Urban Aims and Parking Policies

McShane and Meyer (1982) identify six broad categories of goals which may underpin most urban parking policies. These are: healthy economic climate; efficient use of transport and land resources; ease of mobility and accessibility; equity of resource distribution; improvement of environmental quality and enhanced amenity and cultural attractiveness. There are a range of parking supply, access, location and price controls that have varying degrees of influence on these urban goals. McShane and Meyer (1982) argue that some of these goals are certain to conflict while others may be served concurrently. These urban goals could provide a useful framework for identifying how parking policies can influence urban outcomes.

Valleley (1997) categorises parking policy in London, England, into:

- Pre 1965: The development of measures to ensure the safe and efficient transport movement.
- 1965–1980: Introduction of transport management to balance the costs of car use.

- 1980–1990: Convergence of the role of parking policy and parking management.
- 1990–present: The setting of parking policy in the wider context of environmental and economic policy.

He outlines parking policy as part of a process where urban policies influence parking policy and hence supply. In turn, parking supply and the urban system combine to develop parking activity patterns.

Brown, McKellar and Lansdell (2004) argue that although parking is often perceived as a 'passive' element of the transportation system, its management and control can generate impacts and influence outcomes within the broader environment. This is because car parking provision can impact on: trip generation, trip distribution, network assignment, urban amenity, the perceived convenience, safety and security of destinations, time of travel, as well as the viability of modes that compete with the private car. On this basis, car parking can be considered an 'active' force, the management of which can assist the achievement of a number of urban goals.

Litman (2006) broadens the discussion of parking policy, putting forward the view that more focus on parking management could increase the utilisation of land and transport in urban areas. He focuses on parking supply and price as mechanisms for ensuring parking provision is appropriate and that its utilisation is maximised. Litman (2006) emphasises the role of parking in a cycle of car dependency. The cycle including: Increased Vehicle Ownership, Automobile Oriented Transport Planning, Reduced Travel Options, Alternate Modes Stigmatised, Suburbanisation and Degraded Cities, Automobile Oriented Land Use Planning, Generous Parking Supply, Dispersed Development Patterns and so on. The provision of high levels of parking supply contributes to the increasing dispersal of urban areas. Litman (2006) states that:

> Current parking planning practices are inefficient and often ineffective at solving parking problems. Minimum parking requirements tend to be excessive because they are generally based on demand surveys performed in automobile-dependent locations, and so require more parking than needed in areas with good travel options, accessible land use, or transportation parking and management programs.

Shoup (2006) and Smith (2006) support the paradigm shift presented by Litman (2006) and Brown et al. (2004) pointing specifically and pricing and supply strategies as mechanisms for changing the demand for transport and land use.

The level of influence parking policy decisions have on urban and transport strategies varies and is related to community preferences and opportunities. Taken by themselves parking policies can only set a direction of influence. This chapter outlines this direction.

Parking Policy in Melbourne, Australia

The Parking Policy Framework

Melbourne is the second largest city in Australia. It is located in the south east in the state of Victoria. The Melbourne Statistical Division has a population of approximately 3.5 million (ABS 2001) spaning an area of 7,700 km^2. Car ownership in 2003 was 573 vehicles per 1,000 population (ABS 2004) with an average distance travelled of 14,200 km per vehicle. Melbourne has developed considerably over the last 50 years. This development has coincided with a period of growing access to the automobile and considerable flexibility in choice of home location, work location and mode of travel. Melbourne has progressively grown into a decentralised multi-centred city spread over a large tract of land. Generally urban densities are low on a world standard. This decentralisation of activities has been associated with a decentralisation of travel patterns (Patterson 1970; O'Connor 1994) and a dominant use of the automobile for travel (TRC 1996).

The decentralisation of Melbourne has resulted from the development of transport technology, in particular the growing use and availability of the automobile. One aspect of the motor vehicle is its need to be parked at some point in the trip so that the occupant can partake in the main reason for the trip: an activity.

Victoria is divided into two levels of Government: a State and Local level. There are 33 Local Government areas in Melbourne. These vary is size, population and level of transport provision. Melbourne, because of its historic development has a central location generally termed the central activity district (CAD). The CAD is located at the centre of the public and private transport networks. Urban parking policy is generally focused on this area as it provides high concentrations of activity and high quality provision of transport infrastructure focuses on it. The Melbourne Central City Council has some control over the supply, duration and price of parking. As one moves outwards from the central city the limitations on the supply and control of parking price is decreased. This results in making parking in outer suburban Local Government areas more attractive.

In Melbourne, the Victorian Local Government Act (1989) states that councils control amongst other things parking on all roads. The state road authority VicRoads has control of parking on major roads in the sense that it can designate 'no parking' for traffic flow considerations. VicRoads also works with councils on traffic management issues. The Victorian State Government sets the State Transport Policy Framework (SPPF) (DSE 2005) on which local councils base the development of their Local Planning Frameworks. The policy framework can operate over various spatial levels, these are termed the Activity Centre or Precinct Level. At the Activity Centre level the Activity Centre Guidelines (DSE 2004) have objectives of:

- To maximise on-street parking.
- To use on-street parking efficiently.
- To minimise off-street parks visually dominating public space.
- To improve pedestrian and cycle safety and amenity in and around off-street parking.

At the Precinct Level local councils or developers can consider the total provision of parking in an area and develop appropriate parking schemes:

> The Parking Precinct Plan's primarily function is to manage parking in a precinct, rather than on a site-by-site basis. Plans measure the parking characteristics of their precinct and provide procedures for evaluating the number of car spaces required, based on those characteristics and the desired change (DOI 2002).

With regard to parking Clause 52.06 of the Victorian Planning Provisions (VPP) (DSE 2005) aims to ensure that the design and location of car parking areas:

- Does not adversely affect the amenity of the locality, in particular the amenity of pedestrian and other road users.
- Achieve a high standard of urban design.
- Create a safe environment for users, particularly at night.
- Enable easy and efficient use.
- Protects the role and function of nearby roads.
- Facilitates the use of public transport and the movement and delivery of goods.

A Local Council works within these guidelines to develop parking policies. Further, Local Council's directly influences building activities in local areas since developers must submit an application to Council and it assesses these against the planning scheme. This gives it considerable control over the construction of off-street parking facilities. However, the power to change parking supply once constructed is a greater challenge for Local Government. The planning schemes for each council are briefly outlines on DSE (2005).

The Victorian State Government has recently released Melbourne 2030, a strategy for the development of Melbourne over the next 30 years. This plan provides a number of major initiatives in developing an urban strategy. Melbourne 2030 pointed toward the co-ordination of parking policy at a metropolitan level but at this point in time Melbourne does not have one clear policy on parking, rather parking policy is still dependent on Local Councils (DSE 2005). These councils generally develop procedures which relate to the control of the supply, duration, location and price of parking. These are usually set such that the supply of parking is lower in the central city encourages short term business and retail parkers. Longer term commuter parking is discourages since it is thought this group can use public transport. Residential development in these areas is encouraged in the central area but parking provision is lower than in outer suburbs.

Central City Parking Policy

Central Melbourne is managed by the Melbourne City Council (MCC), one of the 33 local councils in Metropolitan Melbourne. Melbourne City Council's *City Plan 2010* and transport program 2003–2006 (MCC 2003) aim at developing a sustainable central city and improving public transport provision to vitalise the city. Consistent with the general vision of a sustainable and liveable central city, parking policy is considered as an integral component of travel choice and urban design, with objectives to:

- plan and manage parking as a part of wide-ranging travel demand management; and
- manage parking to minimise its effects on on-street public space, particularly around key activity centres.

The key issues, as seen by the Melbourne City Council (MCC 2005), associated with parking policy are:

- Parking supply is fundamental to modal choice.
- Parking provision in the CAD is limited by the Planning Scheme – but control is difficult (for example, ensuring car park operators comply with short term v. commuter car parking provisions).
- Relationship between land use and congestion should be recognised.
- Acknowledging the existing supply of parking and better utilisation of the existing stock.
- Tools to influence parking, land use and transport choice need development.

Parking supply in the central city is managed (MCC 2005) by:

- Limiting car parking through the development approval process.
- Investigating changes parking provision to reduce the amount of on-site car parking allowed for developments.
- Managing on-street parking to allow pedestrian and vehicle movement.
- Developing parking management plans for major centres.

Parking rates are usually set at around 1 space per 200 m^2. Although parking supply is controlled in the central area Kenworthy et al. (1999) estimated it was approximately 33.7 spaces per 100 employees. This is high on a world standard (Kenworthy et al. 1999).

The City of Melbourne's parking limitation policy were initially developed in the 1974 Strategy Plan and included into the MCC Planning Scheme in the mid 1980s. The original objectives of the Parking Limitation Policy were concerns for the environment, especially in terms of air pollution and the congestion of the city road network especially during peak hour.

The MCC's (2005) present planning scheme limits the number of car spaces that can be provided in any new development, based on:

- the (limited) capacity of inner City streets and roads to cater for large volumes of commuter traffic;
- the strategic emphasis on the use of public transport; and
- the need to reduce air and noise pollution from vehicular movements and to improve the quality of living in the inner cities.

A main objective of the MCC's parking policies is to support economic activity in the CAD by ensuring that there is a good supply of convenient short-stay parking. Presently the MCC looks to augment the availability of short term car parking in the city. Specifically it aims to provide flexible and responsive on-street and off-street parking that balances the need of commuters and short stay parkers. Council's off-street, short-stay parking policy is directed towards providing parking for up to four hours for shopping, social, personal business and multipurpose trips.

During weekdays, on street parking provides premium spaces to service short visits of up to two hours, with time limits starting from 15 minutes. On-street parking in the CAD retail core is also regulated with the objective of increasing the turnover of parking spaces to improve the attractiveness of the CAD for visitors. Approximately two-thirds of on-street car spaces are for loading zones.

The majority (95 percent) of CAD car spaces are provided off-street in undercover parking, with the remainder provided as on-street spaces (MCC 2005). The MCC (public parking) and private operators (private parking) both supply off-street parking spaces, open to the public for fee-paying parking. The number of public parking spaces in off-street car parks within the CAD has increased by 48 percent since 1995, following a 12 percent increase in the previous five years to 1995. Over the period since 1995, private parking increased by 42 percent, after little change between 1990 and 1995.

There are significant imbalances in the cost to users of parking spaces in the City. Some private non-residential car parking spaces are offered to employees as part of salary packages and are used by commuters at no direct cost to them. Some Melbourne employers recognise the value of space used for parking and charge their employees for it. The cost of parking can also vary greatly depending on the duration and time of use (See Table 8.1). The cost of parking for two hours in some private CAD car parks can be much higher than parking all day in the same facility. This practice, while tolerated by business users may detract from the attractiveness of short-stay parking for many city visitors.

Table 8.1 Parking prices in Australian cities

City	CBD daily rate (Range)	CBD daily rate (Average)	CBD cheapest or early bird daily parking rate (Range)	CBD cheapest or early bird daily parking (Average)
Sydney (NSW)	\$10.00–\$52.00	\$27.60	\$10.00–\$45.00	\$18.56
Melbourne (Victoria)	\$6.00–\$52.00	\$20.54	\$6.00–\$41.00	\$16.44
Brisbane (Queensland)	\$17.00–\$33.00	\$22.62	\$9.00–\$19.00	\$13.38
Perth (Western Australia)	\$4.00–\$25.00	\$10.15	\$4.50–\$18.00	\$8.50
Adelaide (South Australia)	\$4.00–\$24.00	\$12.47	\$4.00–\$24.00	\$9.44

Source: Information obtained from web-sites or phone calls in January–June 2005.

Off-street, short-term parking is also typically more expensive than on-street parking, hence some motorists drive around to seek out an on-street meter – contributing to traffic congestion and air pollution. To achieve parity between on-street and off-street prices, some on-street prices would need to be slightly increased while off-street (non-commuter) prices would need to be significantly reduced.

To assist in managing parking supply funding public transport and discouraging increased car use in the CAD, Melbourne City Council and the State Government proposed a parking levy be applied to the CAD parking spaces. Within the levied area the funding collected would be used to improve public transport. This introduction of the parking levy, by the Victorian State Government in January 2006, followed the lead of Sydney, Australia. The 2005 Victorian State Government budget introduced a long-stay car park levy in inner Melbourne to reduce traffic congestion, encourage greater use of public transport. All revenue raised by the levy should go directly to transport initiatives across Melbourne. A separate levy will be imposed on the owners of non-residential, long-stay off-street car parking spaces in the Melbourne central business district and adjacent highly congested areas with the revenue raised to be used for important metropolitan transport initiatives. It will apply from 1 January 2006 and be $400 for the first year and $800 (subject to indexation) a year thereafter.

Parking prices in Australian Cities are shown in Table 8.1. It can be seen that the daily parking rate for Melbourne is high but not the highest in Australia. It is possible, using early bird parking, to park for only $6.00 per day. Taken as an average cost per space the parking levy can amount to between 8 percent of the daily parking rate.

An important dimension of parking management is enforcement. Strong enforcement of parking duration and payment is exercised in the CAD.

Inner Suburban Local Councils' Parking Policies

In the Local Councils (DSE 2005) immediately surrounding the central city, parking is controlled with the balancing of retail, residential and business parking forming the basis for parking policy. Residential parking permits are common. The control of parking in these areas has also influenced the price of off-street parking spaces, creating a market for the purchase of these spaces.

At this point the role of market forces should be recognised. In Melbourne a major influence on parking is the private sector. This influence is exercised at the residential, commercial and retail levels. The market is influenced by three things – taxes imposed on the market; local planning schemes that specify what is required of new developments and what has to be provided (that is, parking ratios indicating minimum requirements); and what is provided by the public sector. Existing planning policies are primarily directed at the second of these influences (that is, what is required of new developments), and they are quite limited in their effects – by and large, planning policies do little about existing parking spaces and only tackle new entrants. Similarly there is little financial interference in parking pricing in inner suburban areas.

Further to the role of market forces parking management, enforcement in the inner and middle regions is carried out. However, the introduction of parking duration limits in some privately owned industrial and retail centres may not be as strenuously enforced as inner city parking precincts monitored by Local Council parking enforcement units.

Outer Suburban Local Councils' Parking Policies

As one moves to the middle and outer council areas a large number of councils indicate a desire 'to reduce the dependence on the private car for travel' (DSE 2005). However, parking is usually provided 'to meet parking demand' (DSE 2005) or should satisfy the needs of users without detriment to local amenity (Monash 2004), on the basis of parking rates. These rates are generally set to supply parking at the usage levels.

As one moves away from the central city into the outer suburbs the level of control on the supply and price of parking decreases. Many local governments pay some consideration to discouraging car use. Parking duration controls are set in some high activity retail and business areas. However, parking supply is generally provided to meet the demand set by a land use. Parking rates of 6 spaced per 100 m^2 in suburban shopping centres are not uncommon. This compares with parking rates in the central city of 1 space per 200 m^2.

This general trend towards increasing parking rate provision was also present in London in the mid 1990s. Bayliss (1998) points to the London Advisory Planning Committee (LPAC) providing guidance on the maximum provision of parking as:

- Central London – 1 space per 300–600 sq metres (Gross Floor Area).
- Inner London – 1 space per 600–1,000 sq metres (Gross Floor Area).
- Outer London – 1 space per 1,000–1,500 sq metres (Gross Floor Area).

Particular developments such as shopping centres, sporting facilities and airports may result in particularly high parking demands in outer-suburban areas. Rarely do outer suburban shopping centres have parking pricing policies. Those that do often do not charge for the first few hours. Under supply of parking at some times in the year (during sporting grand finals, high demand shopping periods) may require parking duration limitation or residential parking permits to control parking in adjacent residential or business area.

Overview of Potential Impacts of Parking Policy

Parking provision is the key interchange from the motor car to a destination. This is the point that people move from one mode the car to another. Parking provides a bridge between land use and transport activities. It represents an essential component of the urban transportation systems in cities by enabling access to land uses by private and commercial vehicles. Parking is often used to encourage other transport outcomes. The control of the supply and price of parking is used to discourage the use of modes like automobiles and encourage the use of public transport. Parking can be provided and managed to help achieve a range of desirable environmental, economic and social outcomes in cities. However, this requires overall co-ordination.

This chapter briefly outlined the parking policies and directions taken in Melbourne. The main policies directions have been:

- Restrict the amount of parking provided in the central and inner areas.
- Encourage the introduction of short term parking in central and inner city areas.
- Charge parkers to use parking facilities in central and inner city areas.
- alance conflicting needs of retail, residential and business in inner suburban areas.
- Supply parking in middle and outer suburban areas at a rate consistent with general usage.
- Do not charge for parking in middle and outer suburban areas.
- Do not set parking duration limitations in middle and outer suburban areas.
- Provide parking at major public transport interchanges and stations.

Each of these policies will impact particular trips and urban location choices in different ways. Tables 8.2 to 8.4 provide an indication of the directionality of these impacts on particular transport users for central city and outer suburban travel:

- all-day parking (commuters) (Table 8.2);
- visitors on business or personal trips who generally wish to park for a shorter period of time (Table 8.3); and
- shoppers, diners and entertainment patrons who typically want to stay for two to six hours (Table 8.4).

Table 8.2 Impact of parking policies on work trips

Location	Policy	Aim			
		Making this a more attractive destination to work	Encourage public transport use	Increasing the trip rate to the area	Make this attractive location to develop a work place
Central/ inner area	Restricting the provision of parking in central areas	-	+	-	-
	Charge for parking	-	+	-	-
	Increase supply of short tem parking spaces	-	+	-	-
	Develop parking along major public transport corridors leading to the central area	+	+	+	+
Middle/ outer suburban	Supplying parking to meet usage (Parking rates)	+	-	+	+
	Do not charge for parking	+	-	+	+
	Do not set parking duration limitation	+	-	+	+
	Supply parking along major transport corridors	0	+/-	+	0

Notes: + is a positive direction; - is a negative direction; 0 no discernable direction of impact.

Table 8.2 summarises the general impact of parking policies on work trips and locations. It can be seen that parking policies of restraint and pricing in the central city and those of providing parking at the usage rate and not charging in suburban area encourages decentralisation of work trips and work places. This is counter to the encouragement of economic development in central areas but does encourage economic development in outer-suburban areas.

Table 8.3 indicates the impacts of these policies on business trips. Weekday trips for business and for some personal services (for example, visiting a medical specialist) are however highly dependent on a supply of short term parking. Hence the provision of short term parking near to the destination can encourage business trips to use the car.

Table 8.4 summaries the general impact of parking policies on shopping trips and locations. It can be seen that parking policies of restraint and pricing in the central city and those of providing parking at the usage rate and not charging in suburban area encourages decentralisation of shopping activities. This is counter to the encouragement of economic development in central areas.

Consideration of the relationship between travel, location choice and parking policy in Melbourne shows a number of clear trends.

Parking policies in Melbourne's outer suburbs focuses on the provision of parking, at or near the parking demand, for particular land uses. In the inner city areas the

Table 8.3 Impact of policies on business trips

Location	Policy	Aim			
		Making this a more attractive business trip destination	Encourage public transport use	Increasing the trip rate to the area	Make this attractive location to develop a work place
Central/ inner area	Restricting the provision of parking in central areas	-	+	-	-
	Charge for parking	-	+	-	-
	Increase supply of short term parking spaces	+	+	+	-
	Develop parking along major public transport corridors	+	+	+	+
Middle/ outer suburban	Supplying parking to meet usage (Parking rates)	+	-	+	+
	Do not charge for parking	+	-	+	+
	Do not set parking duration limitation	-	-	-	-
	Supply parking along major transport corridors	0	0	+	0

Notes: + is a positive direction; - is a negative direction; 0 no discernable direction of impact.

Table 8.4 Impact of policies on shopping trips

Location	Policy	Aim			
		Making this a more attractive destination to Shop	Encourage public transport use	Increasing the trip rate to the area	Make this attractive location to develop a retail outlet
Central/ inner area	Restricting the provision of parking in central areas	-	+	-	-
	Charge for parking	-	+	-	-
	Increase supply of short tem parking spaces near retail activity	+	+	+	+
	Develop parking along major public transport corridors	+	+	+	+
Middle/ outer suburban	Supplying parking to meet usage (Parking rates)	+	-	+	+
	Do not charge for parking	+	-	+	+
	Do not set parking duration limitation	+	-	+	+
	Supply parking along major transport corridors	0	0	+	0

Notes: + is a positive direction; - is a negative direction; 0 no discernable direction of impact.

provision of parking is set at levels where not all land use activity can be facilitated by people driving their car and parking in the area. This would encourage drivers to look at locations in the outer suburbs if parking is a major determinant of the trip.

Further, the parking policies in Melbourne are set in the context of the availability of public transport. That is, if public transport is not available then higher parking provision is made. The proactive use of parking restrictions to encourage the provision and use of public transport in outer suburban areas is not generally stated or used as a policy direction (DSE 2005). It should be noted at this point that parking is just one policy dimension and the interaction and need for supporting policies in other areas is not discussed.

The direct use of parking policy to encourage land use development is not explicit in Melbourne land use and transport planning. The indirect impact of parking policy on land use development is one of encouraging decentralisation of activities.

Conclusion

The urban area is a system. It consists of many sub systems which interact to form an overall system. A system has a number of interactions, these must be monitored to determine if the overall impact of an urban policy is positive. This chapter investigated the role parking policy has in influencing transport and urban activity. It concludes that parking policy is not used to support other policies. Parking policy can have a considerable influence on where and why people travel and a co-ordinated approach to parking policy will have a considerable impact on the performance of an urban area.

Melbourne's land use and transport policies state a desire to consolidate urban development and increase the use or public transport. The above discussion points to an inconsistency between parking, land use and transport policy. The impact of this inconsistency on the sustainability of urban areas will depend on the relative strength of the relative weightings given by the public, businesses and governments to the provision of land, transport and parking. Transport, land use and parking policy combine together to encourage decentralisation. The decentralisation has results in an urban form where most trips concentrate in particular Local Government area (O'Connor 1994). As the areas grow the traffic congestion increases and pressure is placed on further decentralisation. In most Australian cities this decentralisation is continuing, it is not stopping. New tracts of land are developed on the outskirts of cities attracting new residents (Stimson 1999) and placing increased demand on infrastructure and removing high quality farm land from this market. Parking policy's role in this process is generally one of supporting decentralisation.

This chapter has briefly outlined the parking policies and directions taken in Melbourne. It points to the focus of parking policy on local issues with little co-ordination at an urban level. This lack of co-ordination does not encourage overall parking strategies which encourage and facilitate appropriate urban development and transport use. The chapter does not recommend a particular direction for parking policy rather points to its failure in supporting other transport and urban policies in Melbourne.

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Chapter 9

Park and Ride

Stuart Meek

Introduction

This chapter looks at the concept of Park and Ride (P&R) which is a supply-side measure that is used internationally as a means of dealing with car use, congestion and traffic-related pollution. In the UK, it is bus-based P&R that has become particularly popular over the past 40 years and it is on this experience that this chapter predominantly draws.

P&R is generally implemented by local authorities in the UK, including unitary authorities, county councils or, in major metropolitan areas, Passenger Transport Executives. Although it was initially pioneered in response to local capacity constraints on transport infrastructure, during the 1990s the UK Central Government recognised P&R within transport policy and local authorities have since considered it as a means to reduce congestion and traffic-related pollution. P&R is used to do this by persuading motorists to transfer to public transport for part of their journey, by offering price or time savings against the alternative of driving for the whole journey and parking in the host centre's urban core.

The aim of this chapter is two-fold. First, to look at the UK's experience of P&R outlining the salient issues surrounding its implementation and highlighting how best it can be introduced. Second, the chapter will consider the role of P&R within the framework of transport demand management. As such, it begins by delineating the concept of P&R by discussing its constituent elements and its various formats. The implementation of P&R is then considered in terms of the preconditions for its success and the process by which it is best introduced. It moves on to examine the evidence on the effectiveness of P&R in reducing car use and traffic-related pollution. In light of this, the role of P&R is then evaluated with particular consideration of its position within transport demand management.

The Park and Ride Concept

P&R is generally associated with the notion of multimodal transport, which is the use of two or more modes to form a complete trip between its origin and destination (Krygsman and Dijst, 2001). The P&R concept however, is somewhat narrower in definition than this as it is a tool that provides an interchange facility for transfer specifically between private and public modes (Spillar, 1997).

Furthermore, the P&R concept can be disaggregated into its three main constituent elements, as shown in Figure 9.1: public transport access, a planned service, and a private transport mode terminal.

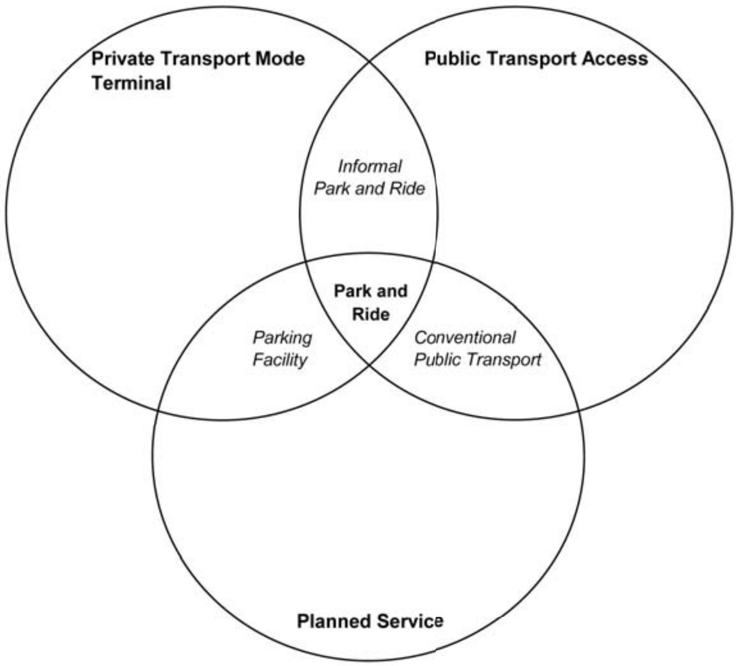

Figure 9.1 The components of park and ride

Public Transport Access

P&R sites are typically found at the edge of urban areas. This enables the relative benefits of both private and pubic transport to be utilised. The flexibility benefits of private transport mean that P&R can be accessed by passengers from dispersed origins such as low density suburban areas. The use of public transport to access high demand destinations such as urban economic centres provides efficiency benefits and can offer time savings to users (in terms of both journey time and search time for car parking) whilst removing traffic from the urban area.

In terms of the public transport mode for which access is provided by P&R, there are a number of variations. In Europe, P&R on both light and heavy rail systems have been used, for example in Germany, France and the Czech Republic (Topp, 1991). Bus-based schemes have been used but to varying degrees of success in Belgium and the Netherlands (van Wee, 2003; Bos and van Heijden, 2005). Bus-based P&R has also been particularly popular in the UK where services are generally operated by dedicated buses serving only the P&R site and a limited number of stops at high-demand destinations, thus maximising time savings to users. The popularity of ridesharing in the US has led to P&R systems with access to high occupancy vehicle lanes.

Planned Service

P&R provides the intentional or planned integration of private and public modes. This occurs in varying scales, ranging from the use of small shared-use sites to those purpose-built with several thousands of spaces. Distinction should be drawn however, with 'informal' P&R which is practised by individuals in an ad hoc manner, where parking is found near to a public transport service that is not provided specifically for the purpose of P&R.

Private Transport Mode Terminal

Not all of the instances where travellers transfer to public transport should be necessarily classified as P&R. A bus passenger for instance will walk to a bus stop and this is conventional public transport use (Bos, 2004). A P&R scheme then is accessed by a private transport mode and provides a terminal for vehicles. As well as car parking, cycle storage may be provided either alongside or exclusively at rail stations or bus stops with the provision of Bike and Ride schemes. Kiss and Ride may be provided where there are facilities for car passengers to be dropped-off for access to the public transport service, allowing car drivers to continue their journey. Terminal facilities are not necessarily dedicated to P&R and shared-use sites are also used, particularly in the US, where P&R exists on land which is used as parking for other purposes at other times, such as at shopping centres and churches (Wambalaba et al., 2004).

The Implementation of Park and Ride

Over the past 40 years or so, the UK has witnessed the increasing popularity of P&R, particularly bus-based, and there are currently over 100 such sites in operation (TAS Partnership, 2007). This is unsurprising given that a recent survey (CfIT, 2001) found that over 80 percent of the English population supported the expansion of P&R. Nevertheless, not all attempts to implement P&R have been successful and failures have been made both in the relative infancy of P&R as a concept and more recently. Whilst the implementation of P&R will vary to some degree depending on the context in which it is used, the UK's benefit of experience provides some common considerations which are key in the implementation process. First, whether or not P&R is a suitable instrument for local circumstances. Second, the political context in both a local and wider sense. Third, setting the appropriate objectives for P&R. Fourth, the funding that is available for schemes. And fifth, the practical issues involved with the actual design of schemes.

Suitability

After P&R was first introduced in the UK in the late-1960s it became clear that it was not a policy suitable in all contexts. The first schemes to be opened were in a variety of settings such as Leeds, Nottingham, Leicester and Oxford. The only scheme to survive beyond the 1970s however, was in Oxford. This was due, at least in part, to the physical constraints within the City imposed by the concentration of historic buildings (Williams, 1999). Historic towns pose particular problems for transport planners because of the physical constraints limiting road and car park expansion. Coupling this with their tourist attraction role, the resultant congestion means that not only do policymakers often have the weight of public support to implement a scheme, but demand already exists for P&R (Simpson, 1994). Indeed, following the success of Oxford the next wave of schemes in the first half of the 1980s were initiated in the historic centres of Aberdeen, Cambridge and Chester (TAS Partnership, 2007).

More recently however, demand for P&R has been stimulated in towns and cities across the UK in a range of settings beyond historic centres as a result of worsening traffic congestion. From the perspective of local policymakers, there has also been competitive pressure on local economic vitality from both neighbouring centres and out-of-town development. P&R contributes to local economies by both improving the accessibility of its host centres by increasing their total parking stock and potentially releasing land otherwise used for car parking or access roads within the urban core for more valuable uses (Parkhurst, 1996). The increased viability of P&R is highlighted particularly well by the re-launch of schemes in Nottingham, Leicester and Leeds in 1988, 1997 and 1998 respectively after the aforementioned failure of their first schemes in the 1970s.

Nevertheless, although P&R has been considered as a viable policy option in a wide range of settings (DETR, 2000), it is clearly more suited to some contexts than others and it is not appropriate everywhere (EHTF, 2000). At the most basic level, the geographical structure of the host centre will influence the suitability of P&R. For it to be successful it clearly has to attract sufficient users. Motorists will not divert to P&R sites if the perceived time costs are excessive in doing so. Available land is therefore required for P&R within close proximity to one of the host centre's access routes. Furthermore, it is beneficial for this route to be a main corridor and one of a limited number of available access routes. This enables the catchment area from the rural hinterlands of the host centre to be maximised and for a 'critical mass' of motorists travelling into the centre to be intercepted. As P&R develops within the host centre, the trend has been for local authorities to introduce further sites thus encircling the centre with sites on all main access routes.

In terms of host centre size, bus-based P&R has remained popular in medium-sized centres yet large cities have also introduced successful services (such as Bristol). Clearly large cities tend to be served by light- and heavy-rail infrastructure so rail-based schemes have also become popular, either alone (as in Sheffield and Birmingham) or alongside bus-based schemes (as in Nottingham and Edinburgh). Nevertheless, host centres are generally characterised by concentrated CBDs of which trips are gravitated towards. This enables the viability of P&R since a key element of the benefits that it offers are the time savings that are made by serving only a limited number of destination points (bus stops or rail termini).

To maximise the success of P&R, demand can be induced through the use of other mechanisms. Traffic congestion on access roads and a high demand for central parking may provide some shift to P&R but the use of complementary measures are advantageous in reducing the attractiveness of driving into the CBD and using central parking (Parkhurst, 1994; DfT, 2005). In terms of supply-side instruments, reallocating road space to provide bus lanes on the access routes to the CBD has been particularly popular. Not only does this dissuade driving into the central area, but it also decreases the travel time of P&R users.

A transfer of parking stock to P&R can be achieved through the removal of public parking within the central area. This can nevertheless be particularly difficult for local authorities to achieve, at least in the short term, because many central parking facilities are operated by private operators. In the longer term however, this can be controlled through the planning process. The problems associated with this, or the hesitance of local authorities to reduce parking which encourages visitors to their centres, may explain why there has been a lack of reductions made in proportion with the number of P&R spaces created (Huntley, 1993). The number of private non-residential spaces can also be influenced by P&R in a similar way. This is facilitated by the use of commuted payments for P&R from developers, where a limited number of spaces are permitted onsite while payments are made towards the capital costs of P&R provision. In Winchester for example, the City Council have adopted the parking standard guidelines set out by the UK Central Government except in the central area. Here, developers have been required to provide only minimal parking provision and commuted payments have been made towards the extension of one of the City's two P&R sites. In the future, payments will be used for the development of two further sites (Winchester City Council, 2003).

Complementary measures that are in use in the host centre may not only be used to encourage P&R use, but P&R also has an important role to play in improving the acceptability of other measures when implemented as part of a package of transport policy instruments. After all, P&R offers a 'carrot' to motorists by offering an alternative to car use, which may balance 'sticks' that are introduced that seek to restrain car use. In Oxford for instance, P&R was a component of the 'Balanced Transport Strategy' which was introduced in 1973 after plans were rejected to develop infrastructure within the urban core. As well as reallocating road space to bus lanes and introducing bus priority at traffic signals, the Strategy included the pedestrianisation of parts of the City centre. Central parking measures were also introduced including the designation of areas for only residents' parking, the enforcement of stringent maximum parking standards and an increase in parking charges. With this package in place, there has been no growth in the City's traffic and the provision of P&R has increased. The implementation of packages of transport measures that include restraint instruments relies to some degree on their acceptability to the public. The use of P&R certainly seems to have aided the implementation process in Oxford and over 70 percent of car users in the City voted in favour of further closures of through-roads and pedestrianisation in 1993 (Williams, 1999).

Political Context

The first P&R schemes in the UK in the 1970s were introduced by local authorities primarily because of the constraints imposed by the limited physical capacity of historic centres which provided only limited opportunities for the expansion of central roads and car parks. This presented potential constraints on the future economic vitality of the centres by limiting accessibility for shoppers, workers and visitors.

In the early 1990s however, P&R was officially recognised by the UK Central Government which was in turn influenced by philosophy changes within transport policy. The Government's 'predict and provide' attitude – matching road capacity with demand – had reached its zenith with the publication of the White Paper *Roads to Prosperity* (DoT, 1989a) promoted by ministers as '*the biggest road-building programme since the Romans*'. This was the initial response to the DoT's revised road traffic forecasts (DoT, 1989b) that suggested between 82–134 percent growth in car traffic between 1988–2025. After the realisation that it was ultimately impossible to build out of the problem however, and coupled with severe financial constraints at the time, 'predict and provide' started to become an increasingly discredited solution. This was exacerbated further by a rising political awareness of environmental issues, with the 1987 Bruntland Report (WCED, 1987) and its subsequent recognition by the EU and the 1992 'Earth Summit' (UNCED, 1992) (see Goodwin (1999) for a full description of the philosophy transition).

At the same time there was mounting opposition to road building, particularly town centre bypasses such as those at Twyford Down and Newbury (Bryant, 1996; Kingsnorth, 2004), as a result of increasing public awareness of its environmental impacts. Hence, new solutions to capacity constraints had to be sought. The environmental White Paper *This Common Inheritance* (DoE, 1990) advocated P&R as a traffic management instrument to relieve congestion in urban centres whilst maintaining accessibility to sustain economic activity, sentiments which were echoed in the subsequent Planning Policy Guidance (PPG) Note 6 for *Town Centres and Retail Development* (DoE, 1993).

While 1996 saw the publication of a revised PPG6 *Town Centres and Retail Development* (DoE, 1996) further encouraging local authorities to implement schemes, it was the election of the Labour Government in 1997 that signalled new impetus for P&R. The initial indication of a new direction for policy from the new Government was a press release stating that '*predict and provide is dead*' (DETR, 1997), but the first White Paper of the Government suggested a retreat from such a hard-line approach;

> Our new approach is about widening choice, not forcing people out of their cars when using a car is their preferred option … We want to see more opportunities for cars to be used as part of an integrated transport system. We are therefore encouraging park and ride facilities to town centres to help beat congestion … (DETR, 1998a, p. 42).

Hence, there had been a philosophical regression to '*Pragmatic Multimodalism*' (Shaw and Walton, 2001) in attempting to satisfy sustainability objectives *to some extent*, whilst not displeasing the generally pro-car electorate. P&R thus offered an ideal solution within the 'new' policy setting, not only as a discernible example of the widely quoted mantra of the time – 'integration', but as a more politically acceptable transport option than 'sticks' such as road user charging and increased parking restraint. Accordingly, P&R was backed explicitly as a tool to reduce both congestion and traffic-related pollution in the guide for local authorities, *Planning for Sustainable Development* (DETR, 1998b, p. 100), and in the longer-term by *The Ten Year Plan* (DETR, 2000):

> [P&R schemes] can offer an effective way of reducing congestion and pollution in busy urban centres, especially when combined with bus priority measures on the routes to the centre and parking controls … Park and ride therefore provides a flexible tool for local authorities, and we see considerable scope for new schemes in a wide range of towns and cities … (p. 60).

Objectives

The goals of reducing congestion and traffic-related pollution that were given to P&R by the UK Central Government clearly represent divergence from those of the first experimental schemes developed by local authorities. The goals of Central Government, as well as its changing philosophy towards transport policy, have nevertheless disseminated to local authorities, whose responsibility remains with implementing P&R. Combined with the Local Transport Plan process in which authorities have to bid for funding for P&R, these goals have become almost universal justifications for the implementation of P&R by local authorities. Notably, this remains the case despite the effectiveness of P&R in reducing car use and its related environmental impacts being questioned (see below). Furthermore, it should be remembered that the P&R concept has remained relatively unchanged. P&R continues to be a tool for increasing the accessibility of host centres on economic grounds and these goals remain central to its implementation (for example WMPTA, 2003; Leicester City Council/ Leicestershire County Council, 2005).

The goals for P&R set at the local level are nevertheless key factors in the implementation process. These goals need to be borne in mind throughout the process and communicated both within the implementing agency and externally to enhance public support (Bixby and Bullen, 1983; Parkhurst, 1994). Commitment has to be given to both these objectives and the package of policies within which P&R is included from all those involved in the implementation process of P&R. To maintain this commitment at each stage of the development of P&R from inception to delivery and operation, it ought to be supported by political determination for the policy to succeed (Macpherson, 1992). The loss of political support can have a detrimental effect, as in the case of Aberdeenshire where the political backing that had initiated the small P&R scheme diminished resulting in most of the plans for its expansion to be abandoned (Aberdeenshire Council, 2006).

Political momentum is of course more difficult to maintain in instances where the implementation of P&R is incremental rather than where a 'big bang' approach is taken. Yet most successful P&R schemes have been developed on an incremental basis, with the exception perhaps of Durham where three site were opened simultaneously (TAS Partnership, 2007). This incremental approach is highlighted particularly well by the development of P&R provision in York. The first P&R service was launched experimentally in the 1970s during the Christmas shopping period using two existing under-utilised car parks on the edge of the City. To cater for the market for tourists to the City a further scheme was launched from York College car park, to the south-west of the City, during the Easter and Summer school holidays. By 1989, the demand for the service had grown from both seasonal visitors and local shoppers so the service was expanded to all school holidays and every Saturday. Also at this time, plans were being put together by the City of York Council for four permanent purpose-built sites. The first of these opened in 1991 at Askham Bar, opposite the existing site at the York College car park, forming the first daily operation. A scheme was also launched to the north of the City at Clifton Moor using a cinema and retail centre car park, initially on Saturdays and during school holidays, and then daily in 1996. After incremental additions, York currently hosts five full-time daily sites (EHTF, 2000; TAS Partnership, 2007).

Funding

At the outset of the implementation process of P&R, one of the primary considerations for policymakers is its funding. Both capital and operating costs need to be considered to establish the total cost of initially implementing P&R and its operation in the longer-term. The capital costs for P&R include initially the acquisition of land for the P&R site. The location of the site, as is discussed below, is a key element in the success of P&R so careful consideration is required in balancing the land acquisition cost and its operational value. After land acquisition there is of course the development of the site. This involves fundamentally the construction of the car park, its access links and the associated alterations to existing highway infrastructure but other elements include marketing, road signage, on-site facilities such as waiting areas and toilets, site landscaping and security measures such as CCTV and security staff facilities (a gatehouse for instance). In the longer-term however, the operating costs of P&R include the provision of public transport services (which is not of course considered where P&R is implemented on existing transport services) and the operation of the P&R site with staff, maintenance and energy (Surrey County Council, 2006).

There are a number of sources from which funding can be obtained in the UK to meet both capital and operating costs:

- Support from the *Central Government* is obtained primarily through the Local Transport Plan (LTP) process in which local authorities submit a strategy and bidding plan every five years. Within this, funding can be obtained from the Integrated Transport Block which includes improvements to transport networks, or for specific minor or major scheme funding. Additionally, financial support for schemes can be given through the Transport Innovation Fund or Supplementary Credit Approval (DfT, *passim*).

- Non-LTP *local authority* funds can be used to cover initial capital costs of operating deficits. Typically these would come from the sale of local authority assets or Council Tax/Business Rate payment.
- Under Section 55 of the Road Traffic Regulations Act 1984 *hypothecated funds* may be collected from other areas of transport to contribute towards P&R provision. To date, central area parking charges have generally been the source of this revenue using a car parking fund such as those used in Chester and Oxford where a levy is placed on off-street parking (Pickett and Gray, 1996; Butler, 1987). In the future however, funds could be used from workplace parking levies or road user charging (CPRE, 1998).
- From the private sector, funds can be obtained from *developer contributions* made within a general planning agreement from anticipated extra business or lower costs. Similarly, *commuted parking payments* can be made by commercial sector developers using Section 106 planning agreements in lieu of communal parking or transport infrastructure improvements.

While subsidy is generally required to initially implement P&R, its operation in the longer-term is assisted to some degree by the revenue it creates. P&R schemes are rarely implemented on a profit maximising basis however. Furthermore, to encourage P&R use and thus achieve modal shift, charges for P&R use need to take into account central area parking charges. It has also been argued (Parkhurst, 1995) that the fares of existing public transport services need to be taken into account to avoid increasing car use from the transfer (abstraction) of passengers to P&R, thus creating a hierarchy of costs with P&R being priced lower than central parking but higher than conventional public transport services.

Resultantly, there are generally operating deficits with P&R schemes and for P&R sites, these are typically covered by the local authority. For P&R bus services, contracts are usually awarded to private bus operators by the local authority under a service and fare agreement. After patronage has built sufficiently however, there are examples where bus services are operated commercially. In York for instance, the City of York Council contract P&R bus services to the operator First York but this is done at their commercial risk and rather than subsidy being paid by the Council, the operator pays a fee for the use of P&R sites (TAS Partnership, 2007). The general trend for P&R schemes however is for patronage to be low in their infancy with it increasing with maturity, so this kind of arrangement is only possible after the proven success of P&R.

Scheme Design

The successfulness of both implementing and sustaining P&R services rests heavily on how the various scheme components interact to provide a viable alternative to car travel. The use of dedicated bus services, as is the norm with UK schemes, not only allows time savings to be made by users because of the limited number of stops, but it can also encourage a distinct image to be conveyed. The use of modern, user-friendly vehicles for instance, can result in perceptions of a high quality service which is particularly important in attracting motorists who would not otherwise use traditional bus services. As well as attracting commuters, P&R is generally geared towards visitors to host centres and shoppers. It is thus beneficial for buses to have storage space for users and to have facilities for families (such as pushchair access) which can be combined with wheelchair facilities.

A carefully developed marketing and publicity strategy is required to ‘sell’ the potential benefits to interest groups and potential users both at the planning stage of schemes (further discussed below) to ease the implementation process and when the scheme is launched to attract patronage. Clear timetables, route information and payment instructions can be used for example to give users confidence as P&R may be an unfamiliar form of transport (EHTF, 2000). The use of branding is clearly important and this may be for P&R alone or for the wider transport policies package within which P&R is included. In Nottingham for example, P&R services form part of the Big Wheel brand which is a partnership of the City Council and other organisations from across the City and encompasses the City’s transport services. The brand is heavily publicised in Nottingham with other components including the tram and business travel planning service. The publicity extends to vehicle liveries and the brand is also used for integrated timetabling (Nottingham City Council, 2007).

Although it is generally accepted that to attract patronage, P&R charges ought to be lower than those for parking in the urban core, less straightforward is the choice of mechanisms used to collect payment from users; either charging for bus travel or for parking. While charging users on the bus is the responsibility of the bus operator and may therefore be cost effective, it may slow down the boarding time of buses and discourage high occupancy vehicle use. Charging users for parking on the other hand, allows a direct comparison to be made with town centre parking but does require on-site payment facilities (TAS Partnership, 2003).

In Norwich for instance, a pay and display system is operated whereby users are issued with both a ‘park’ and ‘ride’ ticket, the former to display in the car and the latter to travel on the bus service. While an all day parking fee is the equivalent to two hours’ parking in the centre and a discount is available for cars arriving after 12:30 on weekdays, further discounts are available for weekly, monthly or yearly tickets. An additional tool is used to aim specifically at the scheme’s target market with the ‘Business Club’ scheme which offers discounted P&R charges for the employees of City businesses, a scheme which has attracted over 80 member companies (Norfolk County Council, 2007; TAS Partnership, 2007).

The design of the P&R site is central to the experience of users and to schemes’ overall popularity. At the most basic level this includes the facilities offered such as waiting areas and timetable information and the overall landscaping of the site. It is important however, to consider perceptions of safety and security as remote P&R sites do not often benefit from the ‘natural surveillance’ of busy town centre parking facilities. Although security is enhanced by CCTV systems, lighting and on-site security staff for example, it can also be incorporated into site design if considered in the planning stages, through fencing or the overall design of the site (EHTF, 2000).

An integral part of the site design is also that of minimising the time spent by users on the interchange process. Sites are designed to minimise the walk time for all users by designing car parking so as to encircle a central bus stop, while segregation of cars and buses allows quick access and egress (Macpherson, 1992). Further, to benefit from both regular and occasional users (such as visitors to the host centre), there should be good access links from the main road to minimise rerouting and the site ought to be well signed.

The location of the P&R site in relation to the host centre is also a key consideration to maximise the interception of motorists. EHTF (2000) for example suggest that sites should be located close to a major approach route on the edge of the built-up area to minimise the time spent interchanging and provide the maximum time benefits from bus priority measures. They also suggest that P&R should be operated away from traditional public transport services to avoid abstracting passengers and that adjacent land ought to be available for the future expansion of sites. Within the UK, sites are usually located at a distance of 1–6 miles from the centre (TAS Partnership, 2007).

Selecting the appropriate location for the development of a P&R site however, represents the most significant barrier to implementation, at least in terms of public opposition. Such opposition is based on the increase in traffic accessing the P&R site and the associated local air pollution, noise and road safety implications, particularly if surrounding areas are residential. The presence of the site in itself can bring noise pollution from its construction and operation as well as visual intrusion where lighting is used onsite (Dawe, 2003; Clark, 2005).

The opposition to P&R construction is compounded where the proposed site is on greenbelt land. This land is usually protected from development but in some instances P&R provides an exception. The Planning Policy Guidance Note (PPG) 2 *Greenbelts* (DoE, 1995) which governs greenbelt development was amended in 2001 by PPG13 *Transport* (DETR, 2001) which set out that P&R development was indeed permitted but only where '*non-Green Belt alternatives* [are] *investigated first*' (Annex E, 3.17). Such development however, may result in countryside amenity being diminished and pressure for neighbouring development. Nevertheless, for policymakers implementing schemes the greenbelt typically covers the area at the optimal distance from the urban core to intercept motorists, which is the preferred location of P&R sites.

For local policymakers however, a trade-off is made with the development of P&R and its localised disbenefits, in favour of its perceived contribution to decreasing congestion, air pollution whilst providing economic gains (WMPTA, 2003; Cheshire County Council, 2007). Nevertheless, to overcome the opposition to P&R its benefits have to be 'sold' to the public. The key solution here has generally been of sustained public consultation throughout the development of P&R.

In Leicester for example, worsening traffic problems on one of the City's main access routes from the M1 motorway induced the inception of a new P&R scheme after the sustained success of P&R in other parts of the City. The scheme however, a joint venture between the City Council and County Council, was planned to be located on the Soar Valley Green Wedge. At the end of 2005, a public consultation was launched with the early plans for the scheme, outlining its location, how the service would be operated and its objectives; to tackle congestion and air pollutions whilst assisting in the regeneration of the City centre. The consultation took place around both the City and the County and included a shopping centre exhibition and leaflets and publicity within post offices, libraries and other public buildings. Importantly, part of the exercise was to gain feedback from the public and over 500 participated indicating that over half of these supported the scheme. Subsequently, in March 2006 the County Council's Cabinet considered the results of the consultation and resultantly included the scheme in the LTP and prepared a planning application for the development of the site. Later in 2006, a further consultation was launched which provided further details of the scheme and its impacts on the City through the full planning application, with the particular aim of obtaining feedback from residents near to the proposed site. The planning application was then submitted to Leicestershire County Council's Development Control and Regulatory Board in January 2007 and was subsequently approved, before it was submitted to the Secretary of State for Communities and Local Government. The following month planning permission for the site was granted with the decision that a public enquiry was not necessary. Operations are planned to being at the site by 2010 (Leicester City Council/Leicestershire County Council, 2005; Leicestershire County Council, 2007).

Park and Ride Effectiveness

Given the increasing number of schemes and their sustained success, P&R has clearly become a popular instrument for both policymakers and motorists. Yet during the 1990s and as discussed above, the objectives for P&R shifted towards reducing congestion and traffic-related pollution to align with the changing Government philosophy towards transport policy. The bus-based P&R concept has nevertheless remained relatively unchanged since it was first pioneered in the 1960s to maximise the accessibility to its host centres. A number of problems have been identified (by Parkhurst, 1995; Pickett and Gray, 1996 and CPRE, 1998 for example) which have led to doubts over its suitability to fit into the 'new' framework of transport demand management. First, the abstraction of users of traditional public transport services. Second, the generation of new trips and diversion of trips from elsewhere. Third, the making of longer access trip to P&R sites than would have otherwise been made to the urban core. And, fourth, low load factors on the high-frequency dedicated P&R buses.

Abstraction from Public Transport

To attract passengers, P&R must offer incentives to motorists, such as low fares, high frequency bus links and the use of comfortable modern buses. Yet these incentives offered to motorists also lend themselves to users of existing public transport services. Taking the price incentive for example, P&R services must compete with parking charges in the urban core to attract their target motorists. Of course, this can be done by increasing these parking charges (strengthening the 'stick' within the package of measures), but is also done by lowering the price of the P&R service which is indeed possible because they are often subsidised (Pickett and Gray, 1996). However in doing so conventional public transport fares can also be undercut (Huntley, 1993) which, in the privatised public transport industries, do not generally have subsidy support.

Table 9.1 Park and ride user survey evidence

Source	Centre (Site)	Day	n	Proportion of all Park and Ride users (%)											
				Mode						Didn't Travel to Centre Before P&R (%)	Visited More Since P&R (%)	Wouldn't Travel to Centre Without P&R (%)	of which (%)[4]	Travel Elsewhere (%)	Not Travel (%)
				Public Transport (%)		Car (driver) (%)		(Other) P&R (%)							
				Previous	Alternative	Previous	Alternative	Previous	Alternative						
WSA (1998)	Brighton	Mon-Fri	220	18	41	50	26	–	–	–	–	28		31	68
Hewett and Davis (1996) (Avon County Council)	Bristol (Bath Road)	Thurs	674	–	40	–	54	–	–	–	–	3		23	77
		Sat	902	–	18	–	70	–	–	–	–	12		30	70
EHTF (2000)	Bristol (Long Ashton)	Mon-Fri	651	–	22	–	71	–	–	–	–	4		50	50
		Sat	1211	–	14	–	80	–	–	–	–	5		40	60
WSA (1998)	Cambridge	Mon-Fri	204	10	24	58	39	–	–	–	–	12		38	63
Jones (1994)*	Chester[1]	Mon/Sat	124	13	14	74	60	7	15	6	15	12		–	–
WSA (1998)	Coventry	Mon-Fri	208	17	21	52	50	–	–	–	–	21		44	53
Pickett and Gray (1996)	Maidstone	Mon-Sat	1000	–	15	–	66	–	–	–	27	10		16	84
Pickett and Gray (1996)	Norwich	Mon-Sat	1000	–	12	–	78	–	–	–	15	5		38	62
WSA (1998)	Norwich	Mon-Fri	204	24	29	56	53	–	–	–	–	12		40	56
Pickett and Gray (1996)	Nottingham	Mon-Sat	1000	–	25	–	59	–	–	–	25	10		38	63

Table 9.1 continued Park and ride user survey evidence

Source	Centre (Site)	Day	n	Proportion of all Park and Ride users (%)											
				Mode						Didn't Travel to Centre Before P&R (%)	Visited More Since P&R (%)	Wouldn't Travel to Centre Without P&R (%)	of which (%)[4]	Travel Elsewhere (%)	Not Travel (%)
				Public Transport (%)		Car (driver) (%)		(Other) P&R (%)							
				Previous	Alternative	Previous	Alternative	Previous	Alternative						
Collins et al. (1987)*	Oxford	Fri/Sat	553	39	–	42	–	7	–	–	–	–		–	–
Devonald et al. (1978)	Oxford	Wed	262	24	–	66	–	–	–	4	–	–		–	–
		Sat	391	13	–	81	–	–	–	4	–	–		–	–
Papoulias and Heggie (1976)*	Oxford	Tues	155	8	–	57	–	14	–	6	–	–		–	–
		Sat	99	5	–	68	–	12	–	2	–	–		–	–
Parkhurst and Stokes (1994)	Oxford[2]	Fri	741	36	31	55	33	–	8	–	–	7		–	–
		Sat	1000	35	20	58	43	–	4	–	–	21		–	–
White (1977)*	Oxford	Tues/Thurs	208	–	30	–	57	–	14	–	–	2		–	–
		Sat	207	–	22	–	68	–	16	–	–	6		–	–
WSA (1998)	Plymouth	Mon-Fri	208	14	32	70	47	–	–	–	–	11		23	77
WSA (1998)	Reading	Mon-Fri	220	28	31	66	43	–	–	–	–	18		31	69
SYPTE (1995)*	Sheffield	Thurs/Sat	176	13	–	64	–	15	8	–	–	–		–	–
Pickett and Gray (1996)	Shrewsbury	Mon-Sat	1000	–	11	–	67	–	–	–	34	17		46	54
WSA (1998)	Shrewsbury	Mon-Fri	205	15	18	71	53	–	–	–	–	14		21	72
Cooper (1993)*	York	N/A[3]	154	19	35	63	59	–	–	12	–	1		–	–

Table 9.1 continued   Park and ride user survey evidence

Source	Centre (Site)	Day	n	Proportion of all Park and Ride users (%)												
				Mode						Didn't Travel to Centre Before P&R (%)	Visited More Since P&R (%)	Wouldn't Travel to Centre Without P&R (%)	of which (%)[4]	Travel Elsewhere (%)	Not Travel (%)
				Public Transport (%)		Car (driver) (%)		(Other) P&R (%)							
				Previous	Alternative	Previous	Alternative	Previous	Alternative						
Parkhurst and Stokes (1994)	York	Fri	288	24	26	66	54	–	–	–	40	11		–	–
		Sat	310	13	9	85	65	–	–	–	48	15		–	–
WSA (1998)	York	Mon-Fri	221	15	26	55	57	–	–	–	–	7		13	87

Notes: * Reported by Parkhurst (1996); [1] Survey of shoppers only. Results weighted for those not previously coming or would not come in the absence of P&R; [2] Only those users previously travelling to centre prior to the introduction of P&R are included in previous modes used; [3] Post survey of users holding payment card; [4] The generated trips reported by EHTF (2000), Pickett and Gray (1996) and Parkhurst (1996) are reweighted assuming all users no longer travelling would either travel elsewhere or not make the trip.

Source: Based on Parkhurst (1996) with additional data from EHTF (2000), Pickett and Gray (1996) and WSA (1998).

The removal (abstraction) of passengers from existing public transport may to some degree negate the mileage savings made from intercepted motorists. This clearly depends on users' access to a car, but if public transport was the preferred mode out of choice rather than need the use of P&R represents generated car journeys for the P&R access trip. The offsetting effect is significant given that these trip legs are typically large when compared with the mileage savings made from P&R bus trips (Parkhurst, 1996). Notably, from the spatial perspective the traffic flow change is not directly comparable as those abstracted from public transport increase traffic flows upstream of sites and intercepted motorists represent savings downstream.

In the UK, the proportion of P&R users abstracted from public transport is generally significant. This is highlighted by the empirical evidence which has been gleaned from user surveys shown in Table 9.1. The surveys conducted show either the mode used prior to P&R and/or the mode that would be used as an alternative if P&R was unavailable.

Trip Generation

In policy terms, at the local authority level at least, economic vitality goals often run counter to those of reducing car use (Banister and Berechman, 2000) and trips generated by P&R would seem to conform to this view. The rationale is that new trips are good for business yet they result in more traffic. Increased mileage is the primary concern here however, as this will affect the degree to which P&R fulfils its policy goal of reducing congestion.

The traffic implications of generated trips are a little more complex than simply categorising trips as extra distance travelled. It is important here to delineate the trips diverted from other centres from the notion of newly generated trips (this is done with the empirical evidence in the far right column of Table 9.1). In the latter instance of course, mileage is *de facto* entirely accumulated. The mileage effects of diverted trips though, are determined by whether trips are shorter or longer than would have otherwise been made. Theoretically of course, P&R reduces the generalised cost of travel through its subsidy support so is capable of inducing longer trips (Parkhurst, 1999). Trip making decisions are much more complex than this however and will depend on the relative perceived quality of the range of available destinations.

The notion of generated traffic also extends beyond journeys made to P&R sites. The relatively elastic demand for cross-centre journeys will result in a replacement of the removed vehicles downstream of P&R sites to some extent (Parkhurst, 1994). This argument is reinforced not only by its clear correlations with the notion of induced traffic (Goodwin, 1996), but also because there has been a lack of overall traffic reduction in host centres despite P&R intercepting up to 25 percent of incoming traffic (Matthew, 1990; Huntley, 1993). This cannot of course be attributed directly to P&R as any discrete measure to alleviate traffic is likely to bring about similar results. Rather, it is the lack of restraint measures implemented alongside that maintains the congestion equilibrium (Parkhurst, 1995). It follows then that when embedded in travel behaviour, a two-fold reliance is built on P&R for both the facility itself and the road space which it frees, meaning that it is essentially a non-reversible policy (Parkhurst, 1996).

Access Trips

The length of trips accessing P&R sites will affect the overall impact of P&R on traffic. P&R shifts the destination of motorists who would have otherwise driven into the urban core towards the edge of the urban area, to the P&R site. Whether these 'new' access trips will be lesser of greater than previously made will clearly depend on the location of the origins of users that are attracted to P&R.

Bearing in mind the subsidy support of P&R schemes, users may detour and make longer journeys to avoid higher parking charges within the urban core. This argument does however depend on the value placed on in-car access time by users which, particularly for commuters, may be high. Yet detouring can take place on radial routes to offer time savings by avoiding congested cross-centre routes. Nevertheless, the empirical evidence on the matter (WSA, 1998; Parkhurst, 1999) does indicate that although some longer trips are made to access P&R sites, this is insufficient as to result in net mileage gains. This does of course exclude the access trips from those abstracted from conventional public transport and those not visiting the centre prior to the introduction of P&R, as discussed above.

Bus Trips

Although the discussion so far has centred around the trips made by cars to access the P&R site, trips between P&R sites and centres should not be regarded as completely removed mileage from the network. In using P&R, these trips are then made by P&R bus services. The problem here is that a fundamental part of the package of benefits offered to P&R users is the convenience of frequent, reliable and dedicated buses. Unlike conventional bus services, waiting time is minimised by the regularity of services and travel time is decreased by the limited number of pick-up and drop-off points.

What this does mean however is that the high-frequency bus services suffer from low load factors. In many cases this results in a higher total distance travelled by users as a result of using P&R, in terms of the car-equivalent distance travelled by bus for each user (Parkhurst, 1999). Within the conventional public transport industries this would generally not be the case as the privatised operations are obviously much more demand-led. This inefficiency with P&R buses however, is effectively enabled by the subsidy support of services.

In terms of the degree to which these P&R buses increase the distance travelled by users, the key factors are the distance between the P&R site and the destination within the host and the load factors of P&R buses. Load factors are in turn related to the size of sites, number of users and space turnover, and therefore the journey purpose of users (Parkhurst, 1999).

What Role for Park and Ride?

P&R has had a somewhat confused position within transport policy which has led to misunderstanding of both what it is capable of achieving and its unintended impacts.

This has perhaps been caused by its promotion within policy as a panacea, able to achieve reductions in congestion, overall car use and traffic-related pollution while benefiting the economic vitality of host centres. Although there has been a retreat in such a view recently within the policy (see for example DfT, 2005), there remains some inertia in that P&R is still perceived by policymakers as a standalone measure. This has been encouraged by both the growth in funding options available for schemes and the pressures on the economic vitality of centres from out-of-town development and neighbouring centres.

P&R is a strong 'carrot' within transport policy and there is little doubt that it is popular. It increases choice for motorists who can enjoy time and cost savings when compared to driving into host centres and parking in the central area and it offers more flexibility than conventional public transport. These benefits however, in the absence of sufficiently rigorous restraint measures on car use, have had a counter-productive effect and encouraged car use for P&R access trips by users otherwise making trips on conventional public transport, to other destinations, or not making trips at all.

Market-based restraint measures are perceived as the most effective in dealing with congestion and traffic-related pollution. Whilst they are notoriously difficult to implement, the chances of success can be maximised if implemented within a package of supply-side 'carrots' (Ison and Wall, 2003). Yet on the other hand, it would appear that although P&R is an acceptable and popular measure to implement, a sufficiently rigorous restraint measure is required for it to be effective.

In terms of the appropriate restraint measures, central area parking charges are typically used on which P&R can offer savings. Yet although this has been effective in attracting motorists, by lowering the marginal cost of travel it has encouraged public transport abstraction, trip generation and the detouring of trips to access P&R sites. A cordon congestion charge on the other hand, such as that operated in London, may be similarly ineffective as P&R generally induces traffic increases for its access trips, upstream of sites and the urban core, outside of where a cordon would typically be placed. Road user charging in a different form however – charging motorists on the basis of car use and the level of congestion – has long since been advocated by economists as an effective instrument in dealing with traffic congestion (Button, 1993). The problems that have arisen as a result of P&R would seem to conform to this view. Road user charging would not only minimise the detouring effect of cars making longer trips to access P&R than would have otherwise been made to the centre, but would also dissuade public transport abstraction and trip generation. Whether or not this would hold true for trip diversion would clearly depend on users' origins in relation to P&R sites and the perceived relative strength of the available destinations.

There has been a lack not only of considering P&R alongside restraint measures, but also its place as a component within a package of supply-side measures. The problem of public transport abstraction for instance, is the result of gearing P&R specifically towards attracting motorists rather than also considering public transport services in host centres in order for them to work in synergy. To prevent public transport abstraction mechanisms could be used that effectively create a hierarchy, through pricing for instance, with the price of P&R being set higher than conventional public transport (Parkhurst, 1995). Yet public transport services operate in a privatised industry, in the UK context at least, so this would involve increasing the price of P&R at the risk of losing patronage. Ideally the cost of car use would be higher than both P&R and public transport in this price hierarchy approach, which returns back to the argument for appropriate restraint measures.

The problems associated with P&R are not only extrinsic and its efficiency is further reduced by low load factors on P&R buses, yet part of the attraction to P&R for motorists is the convenience and reliability of high frequency bus links. Clearly this issue could be addressed by more effectively monitoring the demand for P&R link trips and adjusting their frequency or the size of the vehicles used accordingly.

The impacts of schemes are not fixed and they should be considered temporally. As schemes mature a reliance is built on them to provide increased accessibility to the host centres and they will become embedded in travel behaviour (Parkhurst, 1996). What this does mean then, is that the removal of an embedded P&R scheme would cause increased pressure on parking and road infrastructure within the urban core. Given that the perceived economic benefits of P&R have been an important, perhaps the most important, motivator for policymakers at the local level, there will also be an economic reliance on schemes as they mature. This not only comes directly from the increase in visitors to the centre, but also because of the reduced pressure in central areas for additional parking. The creation of central parking may not only be at the detriment of other land uses but also indirectly to the city environment.

Conclusions

The aims of this paper were firstly to outline how best to implement P&R by identifying the salient issues from the UK experience, and secondly to draw on the evidence from the effectiveness of P&R to highlight its role within transport demand management.

In terms of its implementation, it has been shown that while P&R is not suitable in all contexts, the scope for its use has certainly broadened as a result of worsening traffic congestion and demand for alternative means of access to urban centres. Although the positioning and design of a scheme are key in attracting patronage, so too are the measures used alongside P&R that reduce the attractiveness of its alternatives for motorists.

Regarding the effectiveness of P&R, it is a very strong ‘carrot’ within transport demand management that is able to attract motorists that would otherwise not use public transport. Nevertheless, given the effects of P&R to abstract passengers from conventional public transport, generate and divert trips, and induce detouring of access trips the clear lesson from the UK experience is that P&R should not be viewed as a standalone measure. It is most effective when implemented as a component alongside an effective package of restraint measures on car use. Road user charging would be the most appropriate if motorists were charged directly according to their car use. P&R can be equally effective in balancing such restraint policies and may contribute to their implementation. Yet care also needs to be taken for P&R to work in synergy with other supply-side measures such as public transport.

A key difference between the UK experience of P&R and other international examples where P&R is used as a feeder for existing public transport networks is the use of dedicated buses as the link mode between the transfer facility and the destination. This has perhaps strengthened the ability of P&R to attract motorists because of the reliability, convenience and time savings of the link journey compared to conventional public transport services. Yet this has meant that these buses often operate with low load factors further reducing the efficiency of P&R. Of course some existing conventional public transport networks do operate inefficiently but this is certainly reduced within privatised public transport industries, as in the UK, where services are generally more demand-led. Operators of dedicated link-mode P&R thus need to focus on compromising the attractiveness of dedicated, frequent link-modes with demand.

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Chapter 10

Public Transport Subsidisation

John Preston

Introduction

Public transport subsidisation is a somewhat unusual TDM measure in that it encourages travel by bus, rail and intermediate modes (such as guided bus and light rail), whilst at the same time reducing the demand for rival modes, in particular the car. It is also somewhat unusual in that implementation barriers are relatively modest (although some do exist) and as a result there is a lot of evidence on impacts. This chapter will first of all look at the arguments for and against subsidising public passenger transport. The arguments for subsidising freight services are somewhat different and beyond the scope of this chapter. It will then consider the types and extent of public transport subsidisation, with particular reference to England – although international comparisons will be made throughout. The effectiveness of public transport subsidisation will then be assessed using a variety of approaches. Finally, some conclusions concerning public transport best practice will be drawn.

Why Subsidise Public Transport?

The Arguments for Subsidy

Traditionally subsidy has been seen as a way of correcting market failures and ensuring that net social benefit (or what economists call welfare) is maximised (Gwilliam, 1987). Natural monopoly provides one justification for subsidy. Where there are operator economies of scale, average costs (AC) will be decreasing, as will marginal costs (MC). Moreover, marginal costs will always be below average costs (see Figure 10.1). In order to maximise welfare, price should be set to marginal cost and a lump sum subsidy paid to the operator to ensure that costs are fully covered. The welfare loss from AC pricing is given by the area ABC. This argument has been particularly used to justify subsidising railways as they exhibit economies of density arising principally from the fixed cost of the infrastructure. However, some studies have questioned the magnitude of scale economies in the rail industry (Caves et al., 1985). Moreover, vertical separation of infrastructure and operations has meant that subsidies can be targeted towards the provision of infrastructure rather than train operations, where constant returns to scale may be reasonably expected. Constant returns to scale also seem to be the norm in the bus industry (see, for example, Preston, 1999).

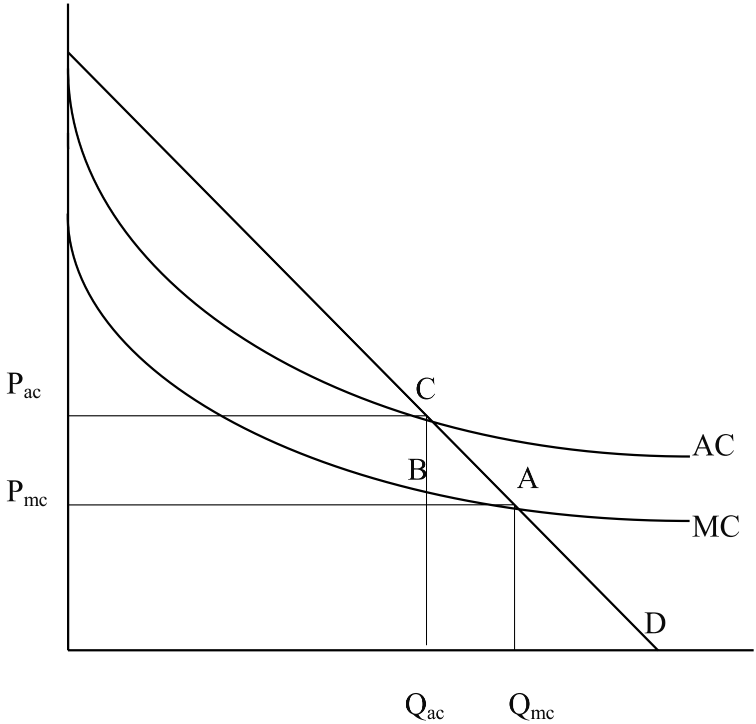

Figure 10.1 Operator economies of scale

Another argument for public transport subsidy stems from user economies of scale known as the Mohring effect (Mohring, 1972; Turvey and Mohring, 1975). As more people use public transport, more services will be provided. More service will reduce the generalised cost of using public transport, principally through higher frequencies leading to reduced waiting times, but also by reduced access/egress times as more public transport routes are provided and by reduced in-vehicle times as more limited stop services can be provided. As Figure 10.2 shows, the upshot of this is that average user cost (AUC) will be expected to decrease as public transport output increases. Marginal social cost (MSC) will also be decreasing but may be expected to be above average user cost. The optimal public transport fare will be the difference between marginal social cost and average user cost, denoted by the distance AB in Figure 10.2. This corresponds to the distance 0D which is only a small proportion of the average operator cost (AOC) which is the distance 0C. This provides a first best case for public transport subsidy. Simulation work by Jansson (1980) and Nash (1988) suggests that an optimal public transport system would probably have higher frequencies, lower fares and smaller vehicles than was the then norm in the UK and would requires subsidies to cover between 50 percent to 75 percent of costs. Interestingly, there are many instances of public transport systems having such subsidisation rates, although not, at least until recently, in the UK.

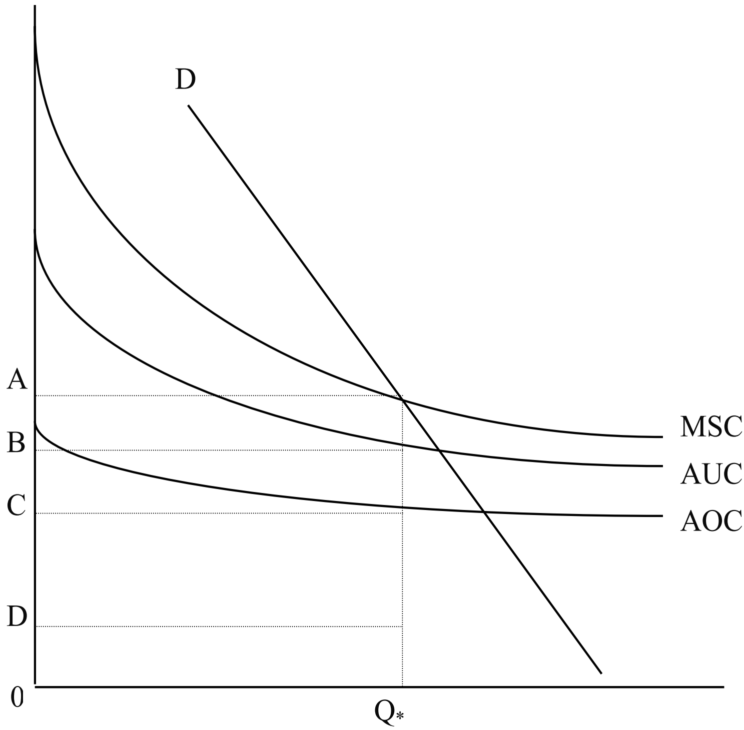

Figure 10.2 The Mohring effect

Table 10.1 Level of subsidy and fares for European urban bus services (1995)

Region	Cost Recovery Ratio	Mean Fare (ECU/Km)
Benelux	0.28	0.05
France	0.25	0.15
Austria and Germany	0.33	0.08
Greece and Italy	0.30	0.04
Portugal	0.61	0.05
Nordic	0.67	0.15
Spain	0.83	0.04
British Isles	0.85	0.08
Average	0.51	0.08

Source: Preston, 2001.

For example, Table 10.1 shows that fares in Britain were at the time the data were collected (1995) around the European average but that revenue accounted for 85 percent of total costs, compared to the European average of 51 percent.

It should be noted that the Mohring effect is likely to be most significant for relatively high frequency, urban services but will be less important for very high demand services where frequency may be determined by capacity requirements. For inter-urban services, where passengers adjust their time schedules to arrive just before the public transport service departs (with an appropriate safety margin) the Mohring effect is likely to be less important. However, network externalities associated with interoperability, intermodality and interconnectivity (and which affect both operators and users) may be more important and provide an argument for subsidising the Trans-European Networks.

There are another set of arguments for subsidy relating to public transport's ability to reduce the negative externalities associated with private transport. This is primarily in terms of congestion relief, but can also include accident reductions and environmental improvements. This is a second-best case for subsidising public transport and whether this constitutes a good case for subsidy has been the subject of investigation by a number of authors (Jackson, 1975; Glaister and Lewis, 1978). Fairhurst (1982) made some interesting calculations for London. He estimated that buses should receive a subsidy of around 12 pence per passenger mile, split between operator economies of scale (4 pence), user economies of scale (6 pence) and non user benefits (2 pence). For underground, the optimal subsidy was estimated at around 14 pence per passenger mile, split 9 pence for operator economies, 1 pence for user economies and 4 pence for non user benefits.

There may also be wider social and economic reasons for subsidising public transport. Many of these reasons arise from the quasi public good nature of public transport. One set of arguments stem from non-use values. People get benefit from public transport even though they don't use the system themselves. This includes the option value of public transport being available as a stand-by in the event that the primary mode of travel (typically the car) is unavailable. It also includes the benefit individuals gain from others being able to use public transport, for either selfish (don't have to give lifts) or altruistic reasons. In extremis, some public transport facilities may have an existence value, particularly heritage and/or scenic services such as San Francisco's cable cars or the Settle and Carlisle railway. Bonsall et al. (1992) have undertaken survey work to determine the extent of non-use values for bus users and found that option value benefits could form around 20 percent of total net benefits to users. It was also found that non-users were willing to pay more to secure services than users, with a value of around £1.50 a week in 1990. Crockett (1992) undertook similar survey work for a rural rail service which suggested a mean non-use benefit for residents of £0.69 per person per week. Non-use benefits amongst those surveyed were found to be 17 percent higher than use benefits, but this reflects the low level of usage of the rail service by local residents. However, this rail service attracts considerable tourist traffic (75 percent of users and a higher percentage of revenue) and the residents' non-use value was found to be equivalent to 15 percent of total revenue.

In many countries in the world, mobility is seen as a merit good. Individuals merit a minimum level of mobility. Public transport is seen as a way of delivering such a minimum standard. Concessionary fares or specialist services, such as dial-a-ride, are used to target particularly needy groups. This leads on to consideration of wider equity or distributional issues. Public transport (and particularly bus) tends to be used by those on low incomes. Subsidising bus services is likely to be progressive in terms of income redistribution and there has been great interest in recent years in using public transport as a tool to promote social inclusion (see, for example, TRaC, 2000).

Another set of arguments relate to the wider economic benefits of public transport. It has long been argued that good public transport can promote economic regeneration but the evidence for this is patchy and even where economic regeneration does occur it may largely be a transfer from one area to another (see, for example, Hall and Hass-Klau, 1985). This will do little for economic efficiency (in fact it might even reduce it) but could be advantageous in spatial equity terms. More recently, arguments have emerged that public transport projects, particularly rail projects serving large city regions, can promote agglomeration benefits and that these benefits are additional to those usually considered in a cost-benefit analysis. For example, examination of the East-West Crossrail scheme in London suggests that these wider economic benefits could lead to an almost 60 percent uplift in net economic benefits (Department for Transport, 2005).

The Case Against Public Transport Subsidy

There are though some counter arguments that in some respects may be thought of failures of the regulatory system used to administer subsidy. The first is that, if subsidy is administered via a system of state owned enterprises that are protected from competition, subsidy will leak into higher costs and lower productivity. For example, Turk and Sullivan (1987) estimated that for a cross section of 18 British towns and cites between 1975 and 1981, every 10 percent increase in the proportion of cost covered by subsidy raised average operating costs by around 5 percent. The solution in Britain (and elsewhere) has been to administer the subsidy by a competition for the market in the form of tendering. The elimination of x-inefficiencies resulted in unit operating costs declining by up to 50 percent and largely eradicated the leakage problem (Preston, 2005).

A second, and more permanent, problem relates to the shadow price of public funds. Lump sum subsidy assumes that subsidy has no economic costs. This is not true. Taxes have to be levied and the subsidies allocated and there are bureaucratic collection and distribution costs involved. Moreover, the taxes themselves introduce distortions into the economy – sales taxes affect purchasing decisions, property taxes distort land markets and income taxes distort labour markets by reducing the incentives to work. There are also the opportunity costs of the benefits foregone by spending public money on public transport rather than other sectors of the economy such as private transport, health care and education. Dodgson and Topham (1987) estimate the shadow price of public funds to be 1.11 in the UK if raised by property taxes and 1.21 if raised by income tax. As income tax is more important than property tax, values around 1.2 have been used, both in the UK and in Sweden (where this is referred to as a deadweight loss). More recently, attention has focused on the opportunity cost aspects, with shadow prices of 1.5 or more suggested (DfT, 2006a).

A third issue relates to the likely misallocation of resources. Following a detailed study of Chicago, Savage (2004) notes that as well as leakage, state intervention may lead to misallocation of resources, with decision makers having a preference for raising fares rather than cutting services. Glaister (1987b) noted a similar phenomenon for some parts of Britain, as did Dodgson (1987) in Australia.

Types and Extent of Subsidy

Types of Subsidy

Public transport subsidy can be categorised in a number of ways. The first distinction is between one-off capital grants and recurrent operating subsidy. This chapter will focus on the latter but in many cases it is difficult to make a clear distinction. In general capital grants can be problematic in that they can lead to excessive and inefficient capital investment (Wachs and Ortner, 1979; Li and Wachs, 2004). For example, it has been argued that the new bus grant in Britain encouraged the adoption of more expensive rear engined buses (Kerridge, 1974). Tye (1973) noted that the existence of similar capital grants in the US led to the scrapping age of buses to decrease from 25 to 13 years. In essence, this was due to capital purchases replacing maintenance as depreciation costs are artificially lowered. Tye estimated that this led to up to 25 percent of the value of the capital grant being dissipated. Where there is competition for central (or federal) government funds, there will be incentives to understate costs and overstate revenues in order to ensure a ‘windfall’ gain. This is a phenomenon that has been observed on a global scale but has been particularly prevalent in the US (Flyvjberg et al., 2003; Pickrell, 1990). The response to this in the UK has been to add an optimism bias factor to cost estimates in the appraisal of capital grants but this has the obvious risk of leading to schemes being rejected that should be taken forward whilst there is also a moral hazard that an optimism bias adjustment may encourage cost over-runs.

With respect to recurrent subsidy, an important distinction can be made between operator and user subsidies. Operator subsidies include preferential treatment in terms of taxation (such as the Fuel Duty Rebate (FDR) in the UK) and revenue support for secured services. This revenue support may be a blanket subsidy covering a whole network or a targeted subsidy focusing on a specific route (or part of a route). Such subsidy will often be related to a Public Service Obligation (PSO) so that it is clear what services Government is purchasing from operators. Although targeted subsidies should be preferred to blanket subsidies on accountability grounds, there is a practical problem that the determination of the subsidy at a route level is highly contingent on the methodology used to allocate costs and revenues. This was highlighted by the Market Analysis Project undertaken by the National Bus Company (Barrett and Buchanan, 1979; Mackie and Preston, 1996, 38–48). Such studies tended to show that internal cross-subsidy was often higher than external subsidy. An advantage of net cost route based competitive tendering means such subsidy flows become transparent and hence more accountable, particularly if operators pay premia for certain routes, whilst receiving subsidies for others.[1]

Historically, services were only vaguely specified by subsidising bodies and subsidy paid ex post so as to balance budgets. In countries such as Germany, the profits from local government owned energy utilities were used to cross subsidise public transport operations. However, with the liberalisation of energy markets the scope for cross-subsidisation was reduced. Moreover, there was a growing awareness that public deficit financing promoted inefficiencies (Nijkamp and Rienstra, 1995). As a result, the ex ante determination of subsidy for a specified set of services is now much more the norm, although this can result in public transport operators lurching from one financial crisis to another and, without competitive tendering, does little to reduce the scope for leakage. To overcome these problems, negotiated performance-based contracts have been developed which incentivise cost efficiencies and service quality and hence give some scope for ex post adjustments (Hensher and Houghton, 2005).

Proponents of the free market and the principle of consumer sovereignty would prefer user to operator subsidies. The philosophy is partly responsible for the growth in the importance of concessionary fares schemes, particularly those targeted at the elderly and the disabled. However, these schemes may not be particularly well targeted so that much of the benefit goes to those with least need, whilst they can also have a heavy administrative burden. Concessionary fares schemes can therefore be portrayed as good politics (in that a visible constituency benefits and there are no visible losers) but a potentially poor policy. One issue is that as concessionary schemes have been extended, particularly to the elderly, the increase in usage has not been as great as expected largely because the cohort effect means that levels of car ownership are increasing amongst the elderly and people are keeping their licences longer into old age (Rye and Scotney, 2004). Furthermore, concessionary groups tend to have low elasticities of travel and hence fare reductions have only limited benefits (Preston and Mackie, 1990). This is an issue that is examined further in the next section.

The Extent of Public Transport Subsidies

England provides an illustration of the different types of public transport subsidies and the difficulties in calculating the extent of such subsidisation – which has been exacerbated by changes in governance structures related to devolution. Many of the numbers come from work by Johnson et al. (2006). Table 10.2 shows support for local bus services in England for 2003/2004. This shows almost £1.6b of subsidy, split between London (45 percent), the PTEs representing the six largest city regions

1 Such a configuration does not exist in Great Britain for bus, although it does exist to an extent for rail. In London, bus tenders are awarded on a gross cost basis. The composition of internal and external subsidy could only be determined by allocating network revenue to routes. Outside London, external bus subsidy is directed at socially necessary services secured by competitive tender. However, the commercial network is likely to have significant levels of cross subsidy.

outside London (32 percent) and the Shires, representing the rest of England (23 percent). As with many other countries, it is the largest cities that attract the bulk of public transport subsidy. In terms of subsidy types, 47 percent is support for services, 28 percent is for concessionary fares[2] and 13 percent is for capital spend. Other services (principally dial-a-ride and park and ride) account for 4 percent and administration (and this is probably an underestimate) accounts for 7 percent. In addition, FDR of £332.8m was paid to bus operators in England in 2003/2004, although this is now, somewhat disingenuously, referred to as Bus Service Operators Grant (BSOG). In total, the local bus industry in England received subsidy totalling £1,923m, compared to receipts for 2003/2004 of around £2,846m. The bus industry in England is often perceived to be a commercial activity. Indeed 80 percent of services outside London operate without direct support. However, total subsidy represents an addition to the farebox of over 68 percent. Moreover, this does not include schools transport. The Department for Education and Skills indicates expenditure of £872m on transport in 2003/2004. Although much of this expenditure will not be on school services available (or potentially available) to the public (such as special needs services), statutory schools services will provide the main form of support for public transport in many rural areas. LEK (2000) estimated that education services contributed around £206m to the total bus subsidy of £1,100m in England outside London in 2000/2001.

Table 10.2 Support for local bus services (£m, 2003/2004)

	Secured services	Concessionary fares	Other services	Admin and support	Capital spend	Total
London*	560.0	153.5	7.5	1.0	–	722.0
PTEs	72.5	185.0	30.2	79.5	139.3	506.5
Shires	122.5	109.2	24.0	32.4	73.6	361.7
Total	755.0	447.7	61.7	112.9	212.9	1590.2

Notes: * Omits some costs associated with the Greater London Assembly and Transport for London.

Source: Johnson et al., 2006.

There has been a tendency to switch from operator to user subsidies, particularly in the bus industry. For example between 1981/1982 and 2001/2002, concessionary fare reimbursement for bus services in Great Britain increased by 16 percent, whilst revenue support decreased by 50 percent. Whereas concessionary fare reimbursement was only 43 percent of revenue support in 1981/1982, by 2001/2002

2 It should be noted that concessionary fares reimbursement is not a subsidy to operators – operators are reimbursed on the basis that they are neither better nor worse off as a result of participating in the concessionary fare scheme (although in practice this may not be the case). However, it is a subsidy to users given that concessionary groups are paying lower fares than otherwise would be the case.

it was 99 percent, although this has since gone down given the dramatic increase in revenue support for bus services in London.

Subsidy for national rail services in Great Britain[3] in 2003/2004 totalled £3,413 of which £1,391m (41 percent) was Central Government support to passenger train operators, £369m was Local Government support (principally from the PTEs) (11 percent) and £1,653m (48 percent) was support to Network Rail and for capital projects (including the Channel Tunnel Rail Link). This compares with total passenger receipts of £3,901m. In this instance, subsidy represents an uplift on fare box of over 87 percent. The average subsidy to passenger train operators is equivalent to an average subsidy of 5 pence per passenger kilometre. However, there are large variations in this figure. For example, the Island line (a small line on the Isle of Wight) received a subsidy of 47 pence per passenger kilometre in 2003/2004, whilst Northern Rail (serving Northern England) received 25 pence per passenger kilometre. By contrast, Gatwick Express was paying Government almost seven pence per passenger kilometre (in other words the subsidy is negative).

The other main recipient of public transport subsidy in England is London Underground. In 2003/2004 fares revenue totalled £1,277m, whilst the grant from the Greater London Authority totalled £1,218m. In addition, there are a number of light rail systems in England, although revenues are modest (around £125m in 2003/2004). The extent to which such systems are subsidised are difficult to determine, given the complex public private partnership arrangements that have been used to deliver these systems. However, the National Audit Office (2004) noted that since 1980 some £2.29b has been invested in light rapid transit, of which 54 percent has been funded from Central Government, with much of the rest funded by Local Government. Moreover, even with capital costs written off, in 2001/2002 four systems were operating at a loss (Sheffield Supertram, Manchester Metrolink, Croydon Tramlink and Midland Metro) which in total amounted to over £16m.

What is clear is that public transport subsidy, even in commercially minded England is big business, with flows of some £6.5b identified in 2003/2004 (although this includes national rail support in Scotland and Wales). It is also an uncertain business as Figures 10.3 and 10.4 illustrate. Figure 10.3 shows that subsidy for bus services in Britain peaked in the early and mid 1980s. The next ten years saw the pursuit of a neo-liberal agenda of privatisation, deregulation (outside London) and comprehensive tendering (London) that drove down subsidy levels by some 50 percent, although more recently there have been increases. Figure 10.4 shows that there have also been large variations in rail subsidy. In the 1980s commercialisation led to reductions in subsidy but this was halted firstly by the recession of the early 1990s and secondly by the privatisation process. However, subsequent to privatisation in the mid 1990s, subsidy came down sharply, only for the Hatfield accident (October 2000) to expose financial fault lines in the new structure and for subsidy to go up again.

3 It is not straightforward to determine the proportion of this support that goes to England. There are also some difficulties in disentangling some support to freight services.

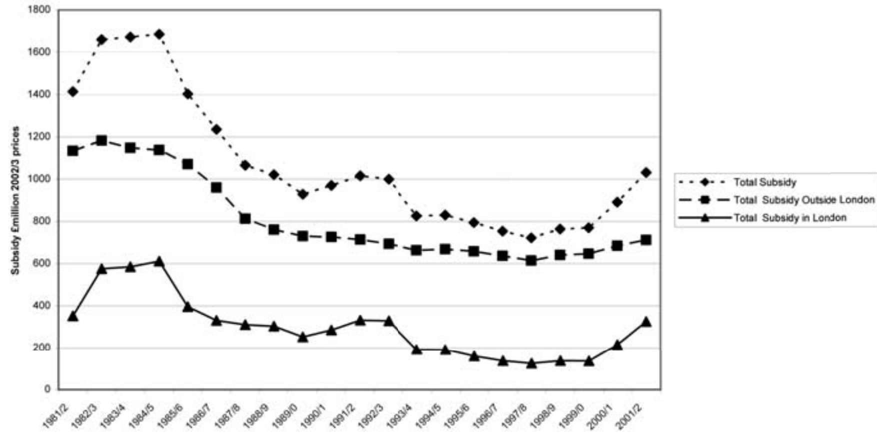

Figure 10.3 Support for bus services in Great Britain (revenue support and concessionary fares)

Source: Preston, 2004.

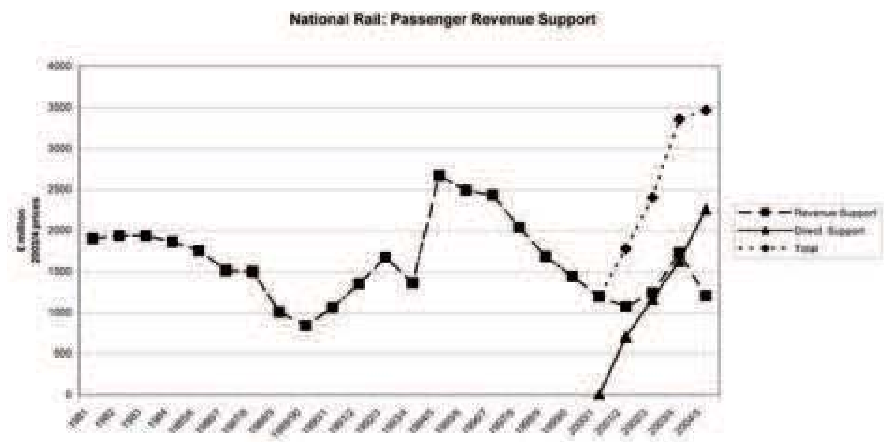

Figure 10.4 Subsidy for national railways

Source: Preston, 2004 (updated).

The Effectiveness of Public Transport Subsidy

In this section, we will look at the effectiveness of public transport subsidies. Firstly, the impact on car use will be examined. Secondly, more general welfare measures will be examined, at a variety of scales including meso (city regions), micro (routes) and macro (national). Thirdly, some non-welfare measures will be briefly discussed.

The Impact on Car Use

From a TDM perspective the effectiveness of public transport subsidy largely stems from the extent to which it leads to reductions in car use. A key measure is then the cross elasticity of car use with respect to public transport price or service levels. Recent evidence on this has been collated by Balcombe et al. (2004). The key finding is that cross elasticities are context specific and in particular are determined by market shares. The most recent estimates for the UK suggest an average cross elasticity of car use with respect to public transport fares of around 0.04, with values deduced from economic theory tending to be even lower (around 0.02). In very broad terms, this would suggest that injecting subsidy into the public transport system that would enable fares to be reduced by 10 percent would only lead to a 0.4 percent reduction in car use. However, the UK context is one in which car use constitutes 88 percent of the market and public transport 12 percent (in terms of passenger kms – DfT, 2006b) and those few car users switching to public transport would represent a 3 percent uplift in public transport use.

The literature suggests cross elasticities of a similar order of magnitude exist for car use with respect to public transport service attributes. This evidence also indicates that cross elasticities are higher where public transport has a significant market presence, such as big cities, and lower elsewhere. Diversion rates are another potentially useful measure to examine TDM effectiveness. These suggest that for urban bus services in the UK around 31 percent of demand comes from car, with the figure for urban rail being only slightly higher at 33 percent. However, 42 percent of new bus use typically comes from cycling and walking. The reduction in use of these modes is not usually an objective of TDM policy. For inter-urban services, coach attracts around 22 percent of new demand from car, whilst for rail it is 60 percent (Balcombe et al., op cit., Tables 9.9 and 9.10).

An alternative measure would be to determine the subsidy cost per incremental passenger or per incremental passenger switching from car. This was the approach adopted by LEK (2002) in a study to determine the best value for public subsidy of bus services outside London. They found that the incremental cost of an additional passenger as a result of switching away from FDR to a subsidy per passenger of 10 pence plus some additional support for rural and inter-urban services was around 22 pence. The cost for what was referred to as a modal shift incremental passenger (that is, a passenger shifting from car) was 44 pence. By contrast, the incremental cost of an additional passenger as a result of extending the 50 percent education concessionary fares for under 16s to all non PTE areas was estimated at £1.51 with the modal shift equivalent being £4.91 (as a lot of the gains are from walking and cycling). Policies of this type are similar to the Student Pass that has been in operation in the Netherlands for a number of years (Cheung and Kroes, 1993; Cheung et al., 1996). Introduced in 1991, this free pass led to public transport's market share of the student market increasing from 20 percent to 33 percent. About 80 percent of this increase was at the expense of bicycle and 20 percent at the expense of car use. The card led a 10–20 percent reduction in the share of students living away from home and large increases in long distance rail travel. In 1994, a number of restrictions were introduced which led to some reduction in the gains made by public transport.

Clearly, the subsidy per passenger policy appears to be a more effective TDM measure than the extension of concessionary fares but should it go ahead? One approach would be to undertake a welfare assessment using cost benefit analysis. LEK's analysis suggests that the per passenger subsidy would have very substantial welfare gains (with a benefit cost ratio of in excess of nine) but that the concessionary fares scheme extension would be more marginal (with a benefit cost ratio of around 1.25). A related approach would be to determine the extent to which road prices are below marginal social cost. For example, Sansom et al. (2001) estimate this to be around 11 pence per passenger kilometre (based on the high estimate, although the calculations are conflated by the joint consideration of bus and car use). Nonetheless, this would suggest that the per passenger subsidy was welfare enhancing provided the mean trip length exceeded 4 kilometres. The National Travel Survey suggest that the mean trip length for local bus outside London was over 7 kilometres and hence the per passenger subsidy would appear to be an effective TDM measure.

Welfare Analysis – Meso Level

As indicated in the introduction, public transport subsidy is more than just a TDM measure and hence has broader objectives. Welfare assessments are thus relatively commonplace. One of the earliest examples is the Model for Evaluating Transport Subsidy (METS) which traces the effects of changing public transport fares and services on the overall urban transport system (Department of Transport, 1982; Glaister, 1987a, 1987b). It was calibrated for Greater London plus the six English metropolitan counties. There is competition between modes but not within. The overall structure has demands, user costs, waiting times, travel times, traffic speeds and traffic volumes determined simultaneously. A feasible equilibrium is determined and revenues, costs, subsidy requirements, economic benefits and marginal net social benefits are computed. A similar approach has been adopted by others not least the work of Dodgson (1987) in Australia and Bly and Oldfield (1987) in Britain, although both these models are solved analytically rather than numerically and therefore are

Table 10.3 Marginal returns to subsidy (1980/1981)

Area	Net benefit per £ of subsidy		% Change to equate returns		Marginal net benefit if equated
	Fares	Services	Fares	Services	
West Midlands	0.21	0.41	+5	+4	0.24
West Yorkshire	0.29	-0.19	-24	-13	0.18
Greater Manchester	0.33	-0.29	-23	-17	0.19
Merseyside	0.31	0.15	-6	-3	0.26
South Yorkshire	0.03	0.03	0	0	0.03

Source: Glaister, 1987b.

restricted to examining tractable relationships. However, further disaggregation of the METS model by area and by user group would be desirable, whilst METS omits accident and environmental impacts and does not address concerns about the shadow price of public funds and leakage into higher costs.

Some results of the initial model for 1980/1981 are shown by Table 10.3. They suggested that South Yorkshire had achieved an optimal balance between fare subsidy and service subsidy and overall subsidy levels were close to optimal (but note the caveats above). In West Yorkshire, Greater Manchester and to a lesser extent Merseyside subsidy had been excessively focused on service. This would be consistent with the public sector pursuing an objective of output maximisation. An optimal policy would involve reductions in fares and service levels. In the West Midlands, the balance was slightly different in that fare and service level increases would be beneficial. In all areas, a marginal increase in subsidy would lead to benefits. However, if a shadow price of public funds of 1.2 is assumed, marginal increases in subsidy would have been justified in the West Midlands and Merseyside, marginal reductions in West Yorkshire and Greater Manchester and more substantial reductions in South Yorkshire.

Table 10.4 Incremental returns to bus subsidy (1997) – based on 10% fares reduction or 10% service increase

Area	Net benefit per £ of subsidy	
	10% fare reduction	10% service increase
Greater Manchester	1.10 (0.38)	-33.9 (0.41)
West Midlands	0.80 (0.35)	-13.8 (0.58)
West Yorkshire	0.68 (0.39)	-9.1 (0.70)
South Yorkshire	1.06 (0.42)	107.0 (-0.41)
Merseyside	0.51 (0.89)	-58.6 (0.18)
Tyne and Wear	0.20 (-0.42)	-29.5 (0.30)

Notes: Figures in brackets refer to proportionate change in results if assume no modal transfer.

Source: Glaister, 2001.

Table 10.4 shows a later application of the METS model. Data for 1997 indicate that there may be large benefits from fare reductions, with the possible exception of Tyne and Wear if a shadow price of public funds of 1.2 is assumed. The benefits from service increases also appear substantial. With the exception of South Yorkshire, such an expansion appears commercially worthwhile because subsidy requirements actually decline whilst there are also substantial societal benefits thus leading to negative values for the net benefit per £ of subsidy indicator. This begs the question as to why commercial operators are not providing these services in the first place. This may be due to resource constraints (for example, shortages of drivers) or simply inertia. Sensitivity analysis was undertaken in which it was assumed there were no cross effects that is, no transfer to bus from car or other modes. This did not lead to a change in the sign of most of the bus miles indicators but did reduce their absolute value (for example, Greater Manchester's indicator declined from -33.9 to -13.9). The exception is again South Yorkshire where the sign does change. With modal transfer, there is a slight decrease in net public transport revenue. With no modal transfer, there is a slight increase, because some travellers are prevented from switching from the more expensive Supertram to the cheaper bus. Overall, the results suggest that the local bus market in the English Metropolitan areas may be monopolised with too high fares and too low service levels, which is plausible given that these markets tend to be concentrated in the hands of one or two large operators (NERA, 2006, Figure 10.2.3).

Welfare Analysis – Micro Level

Figure 10.5 shows the results of welfare analysis undertaken at a route level for a Passenger Transport Executive (PTE) area (Huang and Preston, 2004).

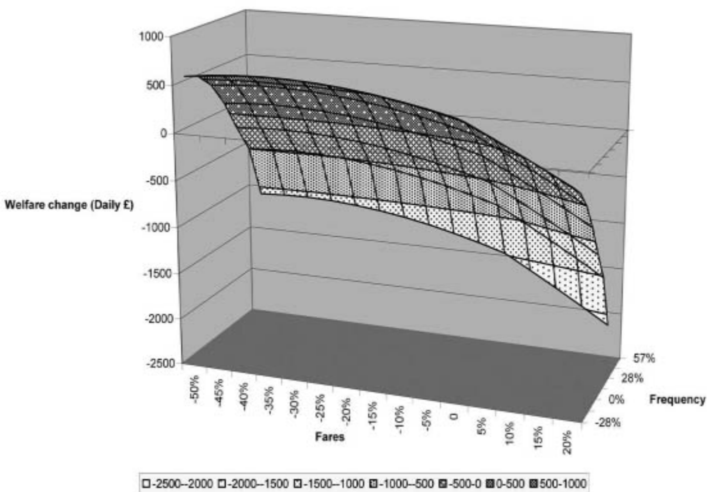

Figure 10.5 Change in welfare (large radial, competed route (incumbent five buses an hour, entrant two buses an hour))

Source: Huang and Preston, 2004.

This is a competed route where on average the incumbent has five buses an hour and the entrant has two buses an hour. The Figure shows that as fares are reduced welfare increases, with welfare maximised at around a 35 percent fares reduction. The graph also suggests that frequency reductions can increase welfare, with welfare optimised by a 28 percent reduction in service. Further analysis indicated that quality improvements (including CCTV and real time information) and journey time reductions of 5 percent (from bus priority measures) would also be beneficial. Overall, in the short run there would be a 10 percent increase in patronage, a 35 percent reduction in profits but an overall increase in welfare equivalent to 30 percent of base profits. More substantive benefits may be expected in the longer run.

Table 10.5 Welfare maximisation subject to existing budget constraints: Illustrative fares and service level changes

	Fares	Service levels	Patronage	Welfare
GB Bus Services outside London	-55%	-7%	+23%	+13%
Bus Services in London	-54%	-2%	+35%	+16%
GB National Rail Services	-36%	-24%	+19%	+25%

Source: Preston, 2004.

Two other routes were examined in detail using this model. For one of the routes, the welfare optimal package involved a 40 percent fare reduction, maintenance of current frequencies and the introduction of a high quality package that excluded bus priority. The result would be a 21 percent increase in patronage. For the other route, a 25 percent reduction in fares, a 50 percent reduction in frequency and a high quality package, excluding bus priority, was welfare optimal, increasing patronage by 3 percent. Overall, this work suggests that appropriately specified Quality Contracts might lead to net economic benefits of around £13 million per annum. These contracts would involve a reduction of the subsidy given to current tendered services and an increase in subsidy given to some of the less well-used commercial services. Overall revenue support could fall by as much as 37 percent, although this calculation is crucially contingent on what constitutes an appropriate operator rate of return.[4] As the subsidy paid in respect of tendered bus services in this PTE was £12 million in 2002/2003, this could represent a subsidy saving of over £4 million per annum.

Wider Welfare Analysis – Macro Level

Analysis can also be undertaken at a macro level. Table 10.5 examines the welfare maximising configurations for the bus industry in London and outside London, as well as the rail industry in Great Britain, given existing levels of subsidy. The model assumes no externalities and welfare is simply the sum of producer and consumer surpluses. A key issue is the treatment of vehicle capacity. This model assumes no such constraints exist which is unrealistic, particularly for London buses. For national rail, longer vehicles are a possibility but there are infrastructure constraints, particularly at stations. The optimised mean loadings are 32 for buses in London, 11 for bus outside London and 146 for rail services, whereas the base loadings are 23, 8 and 93 respectively. This does suggest that there is some spare capacity in aggregate particularly for bus services outside London. For rail, another issue is the variability

4 Returns on Sales (ROS) for the local bus industry were around 0 percent in 1985/1986 but had risen to almost 15 percent by 1998/1999 (White, 2001). For routes considered here ROS were initially 21 percent but reduced to 17 percent with the re-configuration. Returns on Capital Employed would be a better measure of profitability – NERA (2006) estimate this to be around 11 percent for the large bus groups.

of train operating costs. In the calculations in Table 10.5 they are assumed to be 100 percent variable – which is only realistic in the extreme long run. If they are assumed to be only 50 percent variable, the current configuration is close to optimal. In any event this analysis suggests that there could be a strong case for cutting both fares and service levels. For bus markets this is partly achieved by eliminating what might be considered excess profits as current Returns on Sales (ROS) were found to be between 17 percent and 29 percent. An important issue is then what constitutes a normal profit. In this instance if a normal profit is represented by a substantially positive ROS the case for subsidy will be weakened.

Non-Welfare Assessments

A survey undertaken by Bristow et al. (1992) of local authorities preparing for competitive tendering of socially necessary services indicated that relatively little use was made of welfare analysis. Instead the most common subsidy appraisal criteria were standards or targets; priority scores or ranking; and demand related financial critieria. Standards or targets were often set regarding the frequency of services serving settlements of a certain size or population density. In addition, walking distance to the nearest bus stop was often used, with a target of a given percentage of the population being within 400 metres of a bus service. However, this type of accessibility measure can result in low frequency, circuitous bus services which are little used in practice. Point scoring techniques tended to focus on journey purpose and the availability of alternative public transport services. The most common financial criteria in use were support cost per passenger, support cost per passenger mile and revenue as a percentage of operating cost. The methods were often used to identify services for review. Recent work by the author for Hampshire County Council indicates that these three methods continue to be widely used in practice. In particular, accessibility measures have been encouraged by the computerised planning tool Accession.

Since 1986 Hampshire County Council have used a benchmark figure of a maximum of £2.50 subsidy per passenger km (Hampshire County Council, 2007). This has resulted in bus support per resident of £4.30, compared to £3.38 in Kent and £8.70 in Surrey.

Subsidy policies can be assessed against this benchmark – of which two will suffice here. The first is what is referred to as a dedicated educational product. Work by LEK (2002) suggested a big potential passenger uplift from improvements to school transport, through the use of US-style yellow buses. Demand uplifts of between 6 percent to 19 percent, with over half coming from car and an incremental modal shift subsidy of £1.60 per passenger, suggest that this policy should be further investigated. The second is various forms of Demand Responsive Transport which although providing an important service, particularly to rural areas, appear to be expensive in subsidy terms. A survey of seven such services, undertaken for Oxfordshire County Council (2002), indicated subsidy per passenger of between £4.70 and £17.

Conclusions

There are three main economic efficiency arguments for subsidising public transport. These relate to operator economies of scale, user economies of scale and reducing the externalities of private transport. For urban rail, the operator economies of scale and externalities arguments appear most important, whilst user economies of scale are important for many bus services. As a TDM measure public transport subsidies are clearly a second-best policy. The first best policy is to introduce some form of road pricing. However, even with such a policy there will still be a case for subsidising public transport on first best grounds related to operator and user economies of scale. Furthermore, subsiding public transport can have social and spatial equity benefits, with bus particularly helping social equity and rail spatial economic equity.

Our review of the evidence base has also highlighted some areas of best practice. Subsidy should focus on recurrent support for operations rather than one-off capital grants that can have unintended distortionary effects. There should be competition for subsidy by some form of tendering arrangement – otherwise the leakage of subsidy into productive inefficiencies is very likely. This will result in subsidy being determined ex ante which avoids the moral hazards of ex post awards. Renegotiation of tenders should similarly be avoided. Generally, targeted subsidies are preferable to blanket subsidies, but, in the absence of smartcards, targeted subsidies are generally easier to determine for services than users. There are dangers of subsidies being misallocated, particularly in terms of the provision of too much service at too high prices. Accessibility planning tools may exacerbate such outcomes. Although not unproblematic, welfare assessments based on cost benefit analysis are required to ensure allocative efficiency.

Such welfare analyses seem to show that the replacement of the Fuel Duty Rebate (or the Bus Service Operators Grant as it has become known), which has perverse environmental incentives, with a per passenger subsidy could be beneficial, but it would have important spatial implications, with urban areas gaining and rural areas losing. There may also be unintended consequences such as route splitting and enforced interchange. Welfare analysis also shows that there can be benefits from subsidies that are targeted to reduce fares and increase quality. However, the evidence on service levels is more mixed. The case for the extension of concessionary fares schemes, although often welfare enhancing, is more marginal in economic efficiency terms and can be in equity terms too. Such measures could lead to large increases in public transport use of 20 percent or more (and in combination this could be substantially higher). Around a third of this new demand might reasonably be expected to come for car travel.

So why haven't policies of the type highlighted above been implemented? One reason is financial constraints. We have seen that even in commercially minded Great Britain public transport already receives substantial sums in Government support – further increases are often deemed politically unacceptable. A second reason relates to institutional factors. In Great Britain, much of the public transport market is provided by large, commercially oriented private operators who wish to control fares and service policy, making the introduction of, for example, environmental travelcards to promote a more widespread lowering of fares, as occurs in some cities in Germany and Switzerland, difficult (FitzRoy and Smith, 1998). Where authorities invest in upgrading public transport quality, there is a concern that this will be captured by higher profits. Outside Great Britain, where public transport services remain largely publicly owned and operated, the more conventional concern about subsidy leaking into higher costs remains. The third reason is pragmatic – although public transport demand uplifts of 20 percent seem impressive the relative size of private and public transport markets should be borne in mind with, in advanced economies, the former being several times larger than the latter. For example, given a cross elasticity of 0.04, fare reduction of the order of 50 percent suggested here would lead to only a 2 percent reduction in car use, which might be little more than one year's growth. Given this, it is clear that public transport subsidies will only be effective in reducing car use if used in conjunction with other TDM measures.

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Chapter 11

The Substitution of Communications for Travel?

Glenn Lyons, Sendy Farag and Hebba Haddad

Introduction

Typically an individual travels somewhere in order to engage in an activity at the destination. The travel itself is commonly considered a means to an end (though this can be challenged, as noted later). Patterns of travel then arise because activities are often spatially and/or temporally dispersed and constrained. People face what have been referred to as coupling constraints (the need to be at a certain place at a certain time to meet other people) and authority constraints (the need to perform activities before closing time) (Hägerstrand 1970) – one must be in the city centre for work at 8am; the children must be collected from school at 3pm; the cinema showing starts at 7pm; and so on.

What has long been appealing to transport planners is the prospect that by being able to change where one participates in an activity it may be possible to reduce or remove the derived travel. Much of the reason for travel is or has been the need to be co-present with other people or objects. In turn, the need for co-presence is associated with the need to access and exchange information – talking to friends, colleagues or clients; studying documents or watching presentations or shows; examining products for possible purchase. With a proliferation of information and communications technologies (ICTs) in modern society, information exchange can (in principle) increasingly take place without the need for co-presence and thus without the need for (as much) travel. From a transport demand management perspective the following question arises: can communications be used as a substitute for travel?

This chapter explores this question, drawing upon international evidence and literature but making particular reference to the situation in the UK. It begins with a broad consideration of the issues associated with travel, communications and the relationships between them and thus possibilities for demand management. Following this, two common activities are considered which give rise to substantial amounts of travel but which might also be a focus for significant if not substantial amounts of substitution, namely working and shopping.[1] The chapter ends with its reflections upon the potential significance of ICTs and substitution for transport demand

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1 In the UK, for example (as at 2005, DfT 2006a), commuting/business accounted for 19 percent of all trips (71 percent of which were by car) and shopping accounted for 20 percent of all trips (64 percent of which were by car). In terms of distance, commuting/

management and some of the challenges that are posed. However, to conclude the introduction, an important caveat concerning context is called for.

As with other measures that potentially contribute to transport demand management, it would be inappropriate to consider a single measure and its effectiveness in isolation. Effective transport demand management is about the combined use of carrots and sticks. If we focus upon phenomena such as teleworking and e-shopping in the absence of considering a wider context (which has perhaps been the case in the past) then our deductions and conclusions may be misplaced. The (future) level of uptake of teleworking or e-shopping and associated transport demand impacts may be very different depending upon the extent to which restraint measures such as road pricing are put in place.

Understanding Travel and Communications

Travel

The UK has seen a substantial increase in the amount of passenger distance travelled in the last quarter of a century – 62 percent from 1980 to 2005 (DfT 2006b). However, much of this increase occurred between 1980 and 1990 with growth slowing subsequently (ibid.). Use of the car accounted for 678 of the 797 billion passenger kilometres travelled in 2005 (ibid.). Between 1996 and 2004 the average distance travelled increased by 3 percent (to 7,208 miles per person per year); meanwhile the average time spent travelling per person per year increased by 4 percent (to 385 hours). However, the average number of trips per person *fell* by 5 percent (to 1,044 trips per year) – could this be explained (in part) by the growth in the use of telecommunications (that is, virtual accessibility/mobility as opposed to physical accessibility/mobility)?

The amount of travel has been linked with the level of a country's economic activity (DETR 1999; Gilbert and Nadeau 2002; Banister and Stead 2003). In the UK in 1999 it was noted that 'the "transport intensity" of the economy has been increasing, that is, each unit of output is associated with a greater amount of movement of people or goods' (DETR 1999, 3). With an apparent 'coupling' between travel and economic activity there can be concerns that if travel is reduced (desirable in terms of transport demand management) economic activity might also be reduced. However, intriguingly, while transport intensity in the UK increased between 1980 and 1992, since 1992, the percentage increase in GDP (45 percent) has been greater than that in both road traffic (21 percent) and in overall travel (16 percent) suggesting that 'there has been some uncoupling of traffic and travel growth from economic growth' (DfT 2006b, 5). From 1995 to 2004, annual economic growth in Europe was on average 2.3 percent while annual growth in passenger transport was 1.9 percent (CEC 2006).

business accounted for 29 percent of all travel (77 percent of which was by car) and shopping accounted for 12 percent of all travel (83 percent of which was by car).

Could the modest decline in overall numbers of trips and this indication of some decoupling be attributable to substitution effects arising through the availability and use of telecommunications?

Telecommunications

The ability to communicate at a distance, without the need for the individual(s) concerned to travel, is not new. The postal service and land-line telephone have been longstanding features of modern society. However, from the 1990s onwards (coincident, in the UK, with the signs of reduced numbers of trips and reduced transport intensity of the economy noted above) a revolution in information and communications technologies (ICTs) has been taking place. The Internet has emerged (see again later) as a major new mainstream communications medium and mobile phones have not only overtaken land-line telephones in terms of shear numbers in some countries but have been rapidly transforming from mere telephony devices into mobile multimedia communications devices. This revolution appears to be bringing with it a '24/7' society and an 'anytime, anyplace' culture. Commentators have referred to the 'death of distance' (Cairncross 1997) (though overall distance travelled, in the UK, has continued to increase) and point to the fact that where you are is increasingly a less reliable guide to what you are doing. Many of us are incorporating this communications revolution into our everyday lives. Consider for a moment what it is already technologically possible to do. Email is pervasive in both working and private lives (billions of messages are sent globally every day); documents, images and videos can be exchanged at increasing speed; Internet-only television channels are being established; multi-way conference calls can be set up involving people on the move; booking, purchasing and payment for goods and services can be done online; a global 'library' of information can be searched thanks to a myriad of websites and services such as Google and Wikipedia; social networks can be created involving people who have never met (such as MySpace) and who have previously met and want to meet again (such as Friends Reunited and more recently Facebook); and people can even 'live', interact, socialise, do business and make (real) money inside 'virtual' three dimensional worlds such as Second Life (which has over 8.6 million 'residents' and rising) (http://secondlife.com/). This has all emerged in the space of a few years. The theory of innovation diffusion (Rogers 2003) points to the prospect that while some of the above is currently associated with 'innovators', 'early adopters' and the 'early majority', over time these people will be joined by the 'late majority' and 'laggards' such that this growing array of telecommunications use will become increasingly commonplace.

Travel is undertaken to access people, goods, services and opportunities. Telecommunications is evidently enabling some people on some occasions to gain such access *without* the need to travel – virtual mobility instead of physical mobility (Kenyon et al. 2003). However, one of the major challenges in this rapidly evolving 'information age' is for empirical evidence to be gathered and research to be conducted to monitor and understand what is happening in terms of the nature and scale of the influence of ICTs on access and mobility. What communications has made possible does suggest that *opportunities* for substitution could be increasing – but to what extent are these opportunities being exercised in practice?

Telecommunications Changing Travel

There is a long established and developing field of research literature examining how telecommunications use and travel interact. A notable point of reference is the early work of Salomon and Mokhtarian (Salomon 1986; Mokhtarian 1990) who identified four different kinds of relationships:

- the *substitution* of telecommunications use for travel (leading to a decrease in travel);
- the *stimulation* of more travel because of telecommunications use;
- the improvement in *operational efficiency* of the transport system through the use of telecommunications; and
- *indirect*, long-term impacts upon travel via other changes (for example, to spatial configurations of people and activities) encouraged through telecommunications use.

The important and enduring empirical questions concern to what extent, at the level of the individual and at the aggregate, these relationships are at work. Mokhtarian (1997) notes (at the aggregate) that ‘Historically, transportation and communications have been complements to each other, both increasing concurrently, rather than substitutes for each other. And we have no reason to expect that relationship to change.’ This view has been echoed in other commentaries. Adams (2000) suggests that electronic mobility and physical travel are highly correlated over space and time and states that ‘The hope that extensive use of telecommunications will obviate the need for travel and the movement of goods, rests upon a decoupling of the trends of electronic and physical mobility for which there is no precedent.’

To the relationships above should be added a number of others:

- telecommunications can *supplement* travel (increasing levels of access and social participation without increasing levels of travel – that is, telecommunications can substitute for an increase in travel) (Kenyon et al. 2002; Kenyon et al. 2003);
- telecommunications can *redistribute* travel – even if the amount of travel (measured in vehicle or passenger miles travelled) does not change at the level of the individual or at the aggregate, when and between which locations travel takes place can be changed (with implications for levels of traffic flow and thus congestion) (for example, Lyons et al. 2006); and
- telecommunications can *enrich* travel – whereby, through the support of telecommunications, travel time itself is used fruitfully, generating a ‘positive utility’ (Mokhtarian and Salomon 2001; Lyons and Urry 2005).

Recognising these many different relationships and the growing presence of telecommunications use in our everyday lives, it can be taken as a given that telecommunications impacts upon transport demand. However, with so many relationships potentially at work it is much less clear whether or not substitution does or could predominate. There has been past optimism that this might be the case.

However, Geels and Smit (2000) suggest that past optimism may have neglected a greater appreciation of social context. Functional thinking would suppose, for example, that the reason one goes shopping is to purchase goods that are needed and if this can be done via the Internet there would be no need to travel thanks to substitution. However, in practice going shopping may serve other important goals, such as social engagement, which cannot be provided through e-shopping. In addition, use of telecommunications may change pools of social practice such that while some travel is substituted for, virtual interactions generate other new travel.

Transport intensity in the UK and Europe has been decreasing but there is not, it appears, an acknowledgement of whether this may be attributable to telecommunications increasing levels of access and participation in society without the need for (as much of) an increase in physical mobility. So, what then has been the transport policy response to the possibilities of telecommunications impacting upon transport demand and of it potentially acting as a substitute for travel?

Telecommunications and Demand Management

Lyons (2002) has argued that in a multi-modal transport system, transport policymakers should think in terms of modes of access rather than modes of transport and, as such, telecommunications as one of the former should be accounted for in an integrated transport policy.

The European White Paper on transport (EC 2001) made only the briefest of references to telecommunications as a means to manage transport demand and in its mid-term review of 2006 (CEC 2006) little appears to have changed in this respect. In the UK, in its ten year spending plan for transport (DETR 2000) to support its integrated transport policy (DETR 1998), the government stated that 'social and technological changes will also alter patterns of behaviour in unforeseen ways' (DETR 2000, 9). However, there is little mention of the Internet. Its only explicitly identified role is as a medium for the provision of multi-modal traveller information. The spending plan acknowledged that 'the likely effects of increasing Internet use on transport and work patterns are still uncertain, but potentially profound, and will need to be monitored closely' (DETR 2000, 69). In 2004 a new UK White Paper 'The Future of Transport – a network for 2030' was produced (DfT 2004). This makes not a single direct reference to telecommunications, teleworking or e-shopping.[2]

So, it seems questionable whether transport policy recognises telecommunications as a transport demand management measure. It can be suggested that any policy standpoint on such a measure can either be:

- *proactive* (recognising or believing in the possibility that telecommunications can reduce travel and taking steps to bring this about);

2 Though reference is made to government research published in parallel concerning 'smarter choices' (Cairns et al. 2004) which does review research evidence concerning teleservices such as teleworking and e-shopping and examine their (potential) transport demand impacts.

- *reactive* (responding to trends being brought about through market forces so as to accentuate trends concerning telecommunications use substituting for travel); or
- *inactive* (deciding that telecommunications use is outside the purview of transport policy, whether or not it may be impacting upon travel).

It would appear that to date (as indicated above for the EU and UK) the policy standpoint is at best reactive but tending towards inactive. This may in part be because of the uncertain and dynamic nature of the relationships between telecommunications and travel as the information age continues to unfold.

The chapter will return at its conclusion to a consideration of whether and how telecommunications might play its part in transport demand management. However, first a closer look is now taken at teleworking and e-shopping.

Teleworking

The journey to work remains a dominant feature of people's daily lives (Lyons and Chatterjee 2008) and this element of transport demand is the principal source of peak period congestion in urban areas. An upwards pressure on overall demand could be attributable to employment levels: the number of people in employment in the UK since 1971 has increased by 4.1 million to 28.7 million in 2005 (ONS 2006a, 50). However, while the number of people in employment has been increasing, the average number of (one-way) commute journeys made per worker per year in the UK has *decreased* from 374 in 1989/1991 to 321 in 2002/2003 (DfT 2005). It is suggested that fewer commute journeys can be explained in part by more people teleworking (ONS 2006a).

Teleworking (a term first coined in the 1970s by Nilles (1975)) is a form of flexible working. The latter in its broadest sense can mean time (such as flexitime, allowing the banking of hours worked) and space (such as the place of work) freedoms. Teleworking can be seen as an umbrella term which encompasses working at different locations to the conventional workplace – Nilles (1991) describes teleworking as an alternative to work related travel. However, as a term it is commonly associated with working from home when the term 'telecommuting' is also used. Handy and Mokhtarian (1996a) define telecommuting as 'the substitution of working at home for commuting to a usual work site, or the substitution of commuting to a telecentre, for commuting to the more distant usual work site'. Teleworking reinforces the notion that 'work is what you do, not a place where you go' (Davenport and Pearlson 1998).

Defining and Quantifying Teleworking

The scale of transport demand impacts of teleworking clearly relates to the extent to which it is undertaken. This relates in turn to how many people are teleworkers and how much they telework. However, to quantify the scale of teleworking first requires that teleworkers and teleworking are defined. Notwithstanding some reference to this above, matters of specific definition have spawned a range of interpretations across the literature (Mokhtarian 1991a; Sullivan 2003). Two factors are often evident across definitions, namely that telework is 'remote' work and that it involves the use of ICTs (for example, Gillespie et al. 1995; Huws et al. 1996; Kerrin and Hone 2001). Lyons (2002) points out that working from home may not always require the use of ICTs but notes that since ICTs are now integral to modern working environments it is increasingly likely that they become a prerequisite for teleworking. Varying definitions of teleworking make cross-national, international and/or longitudinal comparisons difficult to undertake (Mokhtarian et al. 2005; Pratt 2005). However, there are longitudinal national surveys which have begun to consistently use definitions to allow comparison over time – for example, the UK Labour Force Survey (LFS).[3]

The LFS defines homeworkers as 'people who work mainly in their own home, or in different places using home as a base, in their main job' (Ruiz and Walling 2005). As a proportion of all workers, homeworkers have increased from 9 percent to 11 percent between 1997 and 2005 with over 3 million homeworkers in 2005. The LFS also defines a subset of homeworkers which it calls 'TC teleworkers' and defines as individuals 'who could not work at home, or in different places using home as a base, without using both a telephone and a computer' (ibid.). As a proportion of all workers, TC teleworkers have increased from 3 percent in 1997 to 7 percent in 2005. The majority of teleworkers (62 percent) in 2005 were self employed. However, these figures refer to individuals who use home as their base and, as such, do not have a daily commute. The LFS does also ask individuals to report if they worked at least one full day at home in the reference week of the survey. Such 'occasional teleworkers' (who do not *mainly* telework) are not included in the figures above but are said to have numbered around 1 million workers in 2005 (ibid.). Earlier figures for occasional teleworkers (see Hotopp 2002; Lyons 2002) suggest they numbered some 357,000 in 1999 and 513,000 in 2001 and occasional teleworkers (as at 2001) are predominantly employees (82 percent) (as distinct from self-employed) and most are in full-time paid employment (90 percent) (ONS 2001). Thus increases in the number of occasional teleworkers have been particularly dramatic.

Pratt (2005) provides a comparison of UK data with that collected from other official Labour Force Surveys in Hungary, Ireland, the Netherlands, and the US. This suggests that 'the incidence of work at home at least one day per week ranges from 8.9 percent of all employed persons in Ireland to 11.1 in the UK and 15 percent in the US' (Pratt 2005).

Given the notable proportions of teleworkers or homeworkers in national workforces, what then are considered to be the transport demand impacts of teleworking?

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3 'The Labour Force Survey (LFS) is the principle source of statistics on teleworking in the UK' (Ruiz and Walling 2005). The LFS in fact covers Great Britain (GB) (England, Scotland and Wales) as opposed to the whole of the UK (England, Scotland, Wales and Northern Ireland).

Transport Demand Impacts of Teleworking

The implications of teleworking for transport have been the focus of research for more than twenty years with notable work through the 1990s in the US by Mokhtarian (for example, Mokhtarian 1991a; Mokhtarian 1991b; Lund and Mokhtarian 1994; Mokhtarian et al. 1995; Handy and Mokhtarian 1996a; Handy and Mokhtarian 1996b; Mokhtarian 1996; Mokhtarian 1997).

Travel substitution – the removal of the commute trip – is the primary direct impact of homeworking. Commute removal may either be on the given days when occasional homeworking is undertaken or could be the complete removal of all commute trips where an individual changes from being an employee at an 'office' to a self-employed home-based worker. Allied to commute removal (or its reduction in length where an individual is not working from home but from a telecentre) there can be implications for vehicle emissions (Mokhtarian et al. 1995; Henderson and Mokhtarian 1996; Glogger et al. 2003; Kitou and Horvath 2006).

However, taking substitution as given, there are potential secondary impacts of homeworking that could arise and which could offset the benefits of commute removal. Individuals may make additional trips on homeworking days that would previously have been combined with their commute or another household member may switch transport mode because a free vehicle is available at the house. A potential indirect effect of occasional homeworking could be that an individual is able to live further away from the conventional workplace such that longer commutes are compensated for (in terms of vehicle miles travelled) by there being fewer of them (Lund and Mokhtarian 1994; Mokhtarian et al. 2004).

In an examination for the UK Department for Transport of the potential transport demand implications of teleworking, Cairns et al. (2004) assessed reported international evidence of the impacts noted above. They concluded that (Cairns et al. 2004, 258–9):

> Teleworking does reduce the car mileage travelled by teleworkers, even allowing for some extra non-work car trips.
>
> There is rather little evidence about the impact of teleworking on other household members. However, the evidence that is available points towards their travel remaining the same or perhaps even falling slightly, rather than increasing.
>
> There is little evidence about the impact of teleworking on people's choice of where to live. What there is, points towards teleworking being of rather little importance in choice of home location, although there are links between teleworking and trip distance that may indicate long run effects, as yet not understood.

This review of evidence has led to the suggestion (accounting for transport impacts and the current and (speculative) projected levels of uptake of teleworking) that 'teleworking has the potential to deliver substantial reductions in car travel at peak hours' (Cairns et al. 2004, 275).[4]

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4 In their review of evidence, Cairns et al. (2004, 259) noted that 'If growth rates of 12–13 percent p.a. continue for about 10 years, this would result in approximately 30 percent

A Shift in Thinking, a Shift in the Commute

Ongoing work by Lyons and colleagues (Lyons et al. 2006; Lyons and Haddad 2008) is revisiting the matter of how teleworking or specifically homeworking is defined and in turn is highlighting that homeworking has the potential to redistribute travel by temporally *displacing* rather than (only) replacing the commute. They suggest that alongside occasional homeworking as considered earlier, individuals may also work at home for *part of a day* combined with working at their normal workplace. This form of homeworking they term 'varied-spatiotemporal working' (VST). In this research, a VST day is taken to be one in which at least 30 minutes of continuous work takes place at home and in the usual workplace.

Key findings from c1,000 responses to a UK national Internet-based survey of full-time paid employees in 2005 were as follows (Lyons et al. 2006). The proportion of workers who undertake some VST is more than double that for full-day (occasional) homeworking (14 percent compared to 6 percent) and the number of days of VST occurring overall is also more than twice that for full-day homeworking. Blue collar workers practice more VST than full-day homeworking. Women are more likely to undertake VST compared to men while the reverse is true for full-day homeworking. VST, when compared to full-day homeworking, is associated with those living closer to the workplace. There is evidence of some temporal displacement of the commute on VST days (see below).

Subsequent qualitative research (Lyons and Haddad 2008) has looked more closely at the practice of VST and the attitudes of individuals towards it; and has also brought to light another significant form of part-day homeworking which has been termed 'business varied spatio-temporal working (BVST): a working day in which at least 30 minutes of continuous work is undertaken at home as well as work being undertaken at business location(s) which may not include the usual "workplace" (such as offsite visits, external meetings and so on)' (Lyons and Haddad 2008, 5). This research has revealed that the nature of VST is mainly ad hoc (though sometimes planned) while BVST tends to be planned. Three key themes emerged as drivers for VST, namely work (for example, the need for a different or quieter working environment), domestic (for example, childcare responsibilities) and travel (for example, avoiding congestion) factors; whereas BVST is predominantly driven by travel (and indirectly work) reasons – notably a wish to avoid 'excess' driving. The ad hoc nature of VST may in part explain why it is more commonly practiced across the workforce overall than full-day homeworking. The presence of arranged meetings in people's weekly schedules appears to be a particular barrier to full-day homeworking whereas VST can be engaged in at short notice because it can still accommodate such spatio-temporal constraints. This qualitative research underlines a clear temporal displacement of the commute at the individual level because of VST and this displacement is more evidently associated with the afternoon rather than the morning commute.

This research suggests that ICTs are facilitating changes to work practices and the communications culture of the workplace such that spatial and temporal

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of the UK workforce teleworking for at least some of the time by the end of the period.'

constraints or traditions are becoming less rigid with consequences in turn for transport demand and travel patterns.

Discussion

It would appear that growing numbers of people are afforded some opportunity to telework. Being able to do so can allow them to respond more flexibly to the situations facing them in their everyday lives: juggling work and home lives and commitments; choosing different work settings for different tasks; and avoiding some of the negative effects of commuting, either through not making a commute trip or doing so at a time which allows the avoidance of encountering as much traffic and thus delay. Transport concerns may not necessarily be the primary motivation for teleworking but the transport consequences (for the individual and for the transport system) nevertheless occur.

The scale of transport demand impacts of teleworking at the aggregate is not clear. Research studies which have sought to examine this have tended to deal with small samples of individuals over limited time periods which certainly identify the primary benefit of commute substitution (Cairns et al. 2004). However, the difficulty in gauging the overall impact of teleworking on car use and congestion arises because of at least two dynamic factors: the size of the workforce is changing over time and the number of people who can and do practice teleworking is changing over time. The key question in considering developments to date is: would (peak period) traffic congestion be worse than it is today if teleworking were not possible? It seems reasonable at least to suggest that the rate of increase of traffic levels would have been greater in its absence.

If teleworking is seen to be a measure that can positively contribute to transport demand management then of key interest is how the effectiveness of this measure can be maximised. This will relate to the amount of teleworking that takes place but also to where and when it takes place. The amount of teleworking that is possible will be a function of:

- the proportion of work tasks that can be undertaken (through the use of ICTs) remote from the workplace;
- the propensity of individuals to telework and for what proportion of a working week they are prepared to do so; and
- the willingness of employers to allow and to support and encourage their employees to telework.

In relation to the first point it should be noted that the makeup of economies is changing. For example, in the UK ‘Employment in service sector jobs grew from 61 percent of the total in 1978 to 82 percent in 2005. Over the same period employment in manufacturing fell from 28 percent to 12 percent’ (ONS 2006b, 5).

In terms of the second point, December 2003 survey results cited by Cairns et al. (2004) concerning Internet users revealed that ‘for those Internet users who are in employment but don’t currently work from home (estimated to be 12 million employees), the NOP survey suggested that 77 percent do not want to telework, 17 percent want to but would not be allowed to and only 7 percent want to and would be allowed to.' (Cairns et al. 2004, 262). However, these stated views are in the context of what survey respondents understood 'teleworking' to mean and would almost certainly have not accounted for part-day homeworking (even if part-week homeworking was in scope). Such results nevertheless suggest the potential for a significant further increase in the proportion of the workforce who telework. There is also the matter of an individual's frequency of teleworking. On average occasional homeworking appears to be practiced for about 1–2 days per week (DTLR 2002). While this will in part be a reflection of the proportion of work tasks that can be undertaken at home, the importance people attach to being co-present with work colleagues at the workplace will be another influencing factor. The research by Lyons and Haddad (2008) also indicates that teleworkers would make greater use of full and part-day homeworking as a response to worsening traffic congestion or the introduction of congestion charging.

Employers' principal attraction to teleworking (at least in the private sector) is likely to be financial – concerning employee productivity and retention. This is very much compatible with the motivations for employees who are seeking an attractive working regime to fulfil their role both at work and at home. From a transport demand management perspective, employers represent important agents for change in relation to teleworking such that policy carrots and sticks might be targeted at them as well as or instead of at individuals directly. Employers could receive greater encouragement and support to in turn facilitate and influence how much and where and when (times of day and days of week) teleworking and specifically homeworking takes place thus influencing transport demand.

E-shopping

In 1992, Hepworth and Ducatel observed that 'teleshopping in Britain is still at an experimental stage … the number of households equipped with the technology for teleshopping – a computer terminal – is a minute proportion of the shopping population' and suggested that 'there is no natural way for grocery teleshopping to evolve alongside superstore retailing'. Yet a year earlier in 1991, the World Wide Web was launched, triggering the emergence of easy access to any form of information (documents, sounds, videos, and so forth) anywhere in the world. Commercial interest in the Web arose around the mid-1990s; the first virtual shopping mall and online bank were established in 1994. Powerful search engines made information gathering about products and services via the Internet ever easier. Nowadays, more than half (57 percent) of the households in Great Britain can access the Internet from home, while more than two-thirds (69 percent) of the households with Internet access have a broadband connection (ONS 2007). One of the increasingly popular uses of the Internet is for shopping purposes. 'E-shopping' can be defined as an activity to buy or to get information about consumer goods via the Internet (Mokhtarian 2004). A leader in Europe for Internet shopping, in 2005 the online retail market (for sale of online goods excluding services) in the UK was valued at £7.28 billion with online sales representing 3.26 percent of all retail sales – popular products to purchase online are travel tickets and holidays, books, CDs/DVDs/videos, and clothing (OFT 2007). In terms of trends – 'the value of Internet sales by businesses to households was £21.4bn – an increase of 30 percent on the previous year, and more than four times higher than sales of £5.0bn in 2002' (OFT 2007, 17). As the popularity of e-shopping increases, people's travel behaviour and, ultimately, the use of transport systems and the spatial configuration of shops could change fundamentally. However, there is considerable uncertainty about the potential outcomes of e-shopping in the policy areas of transportation and spatial planning.

Conceptualisations of the Relationships Between E-shopping and Travel

Like other forms of ICT use, e-shopping could substitute, modify, or generate personal trips. The substitution of trips occurs when e-shopping replaces a (shopping) trip and no other trips are undertaken. The modification (or redistribution) of trips may happen when the destination choice, mode choice, or timing of the trip is adjusted because of e-shopping. The generation of trips occurs when e-shopping produces a trip that otherwise would not have been made. Additionally, a hybrid form of e-shopping and (physical) in-store shopping could occur (complementarity), such as searching for product information online, evaluating the chosen product in-store, and purchasing it online. Increasingly, people start their shopping process with an information search on the Internet before they go to the store and vice versa (Weltevreden 2007). Thus, e-shopping could relax the time and space constraints of the shopping process and bring more flexibility, leading ultimately to a fragmentation of the shopping activity in time and space (Couclelis 2004).

Both e-shopping and in-store shopping have certain advantages and disadvantages. Thanks to the capabilities of the Internet for handling information, e-shopping greatly facilitates price comparison and bargain hunting. E-shopping also provides almost unlimited selection across different websites (in contrast with the available stock in a store), convenience (no need to travel to a store), and speed (an e-shopping episode can typically be quicker than an in-store episode since no travel is involved) (Mokhtarian 2004). Time-pressured individuals in particular are likely to appreciate these features of online shopping, but so might people who like to find bargains, or who appreciate the comfort of shopping without going to a store. Meanwhile, in-store shopping provides certain advantages which e-shopping lacks, such as: sensory information about the products; the tangibility of the shopping environment (which could have entertainment aspects); the immediate possession of purchases made; the opportunity to socialize with other people; and the physical activity. It is assumed that e-shopping does not satisfy the social-recreational functions of in-store shopping (Couclelis 2004).

The debate in the literature has mainly been centred on the substitution and generation effects between ICT use and travel (as noted earlier). Although many researchers acknowledge that the net impact of e-shopping on travel is difficult to assess, they expect, however, e-shopping to increase or modify travel rather than decrease it (for example, Dijst 2004; Visser and Lanzendorf 2004; Mokhtarian 2004). They argue that, if trips are substituted, the saved travel time can be used to make other trips. This effect could be explained by an intrinsic desire for mobility

(Mokhtarian and Salomon 2001). Another reason why the substitution of travel is not likely to occur is that people like to socialize (Geels and Smit 2000; Couclelis 2004; Dijst 2004). Shopping has a recreational function and can serve as an opportunity to meet people. Also, trip chaining makes it easy to combine shopping trips with other kinds of trips, which would also impede a decrease in travel. If the shopping trip is part of another trip, or if the electronic purchase replaces some, but not all of the items purchased in the store, the Internet purchase saves hardly any travel (Mokhtarian 2004). Finally, there is a need to sense a place directly and to experience the physical space (for example, sauntering round a shopping mall, exploring a bookstore) (Urry 2004). All this said, it is important to distinguish between grocery shopping and other forms of shopping (see below). Purchase of groceries accounts for nearly half of average household expenditure on goods in the UK (Cairns et al. 2004).

Empirical Findings: Stated and Revealed Preference Studies

In comparison with other forms of ICT-use such as teleworking, empirical studies of e-shopping and (shopping) travel are very scarce – and tend not to distinguish between grocery and non-grocery shopping. A methodological distinction in empirical studies that do exist can be drawn between stated preference (people's potential behaviour is investigated by asking them how they would act in a given situation) and revealed preference (people's actual behaviour is investigated, either by letting respondents keep a diary or by asking retrospective questions).

Some stated preference studies that deal with the potential effects of e-shopping on travel expect a reduction in the number of shopping trips and kilometres travelled (Lenz et al. 2003; Papola and Polydoropoulou 2006). Only a slight reduction in the number of grocery and non-grocery shopping trips is expected, however, ranging between 0.5 percent and 5.4 percent, depending on the adoption of e-shopping (Lenz et al. 2003). The greatest reduction in shopping trips is expected to occur for groceries, since this is the kind of shopping most frequently done; the smallest reduction is expected to occur for shopping trips for computer software and electronic goods such as computer hardware, mobile phones, and household appliances (Papola and Polydoropoulou 2006). Mixed results were found in a stated preference study when people were asked about their willingness to substitute their grocery and non-grocery shopping trips (Krizek et al. 2005). A quarter of the respondents indicated they would be least likely to substitute grocery shopping, whereas nearly another quarter of the respondents (23 percent) said they would be *most* likely to substitute grocery shopping. Similar results were found for non-grocery shopping with 13 percent of the respondents stating they would be most likely to substitute it and 16 percent saying they would be least likely to substitute it. The study was carried out in three metropolitan areas in US (Seattle, Kansas City, and Pittsburgh) using a questionnaire that was completed by 800 households. Even if substitution did occur, its effect on the frequency of shopping travel was believed to be small, mainly because e-shopping is not (yet) as widely used for shopping purposes compared to physical travel (Lenz et al. 2003; Krizek et al. 2005). An Australian study of stated preference estimates that about one-third of purchases made via the Internet replace a shopping trip.[5] Half these trips would have been undertaken solely for the purpose of shopping, without being chained to other trips, thus leading to a potential 15 percent of Internet transactions directly substituting for a shopping trip (Corpuz and Peachman 2003). No distinction was made between grocery and non-grocery shopping in this study.

A revealed preference study of Internet users reports a complementary relationship between e-shopping and city centre shopping for grocery and non-grocery products (Weltevreden 2007), but also found that a minority of e-shoppers made fewer trips to the city centre as a result of e-shopping. The following empirical studies did not distinguish between grocery and non-grocery shopping. A study using travel diaries conducted in California, US, showed that people who search and/or buy online tend to make more trips than non-e-shoppers (Casas et al. 2001). The authors concluded that people were changing their shopping behaviour (using the Internet as an additional shopping mode), but not necessarily changing their travel behaviour. A different conclusion was drawn by Douma and colleagues (2004), who found that people seem to use the Internet to modify their shopping behaviour, either by browsing for products before leaving home, or by using the Internet to make their trip more efficient. A Dutch study discovered that frequent online searchers tend to make more shopping trips, and frequent in-store shoppers tend to buy more frequently online (Farag et al. 2007). These findings support the notion of a hybrid form of shopping in which online and in-store shopping are combined. Another empirical study conducted in the US and the Netherlands showed that in both countries, searching for products online and buying them in-store seems to be a popular combination of shopping modes (Farag et al. 2006a). Also, it was found that in both countries very few people visit new stores they have come to know via the Internet, implying that currently e-shopping generates very few trips to new activity destinations. However, this situation might change in the future. Finally, a study about the influence of residential environment and shop accessibility on e-shopping tested the following two hypotheses empirically: (i) e-shopping is a predominantly urban phenomenon, because new technology usually starts in centres of innovation (innovation-diffusion hypothesis); and (ii) people are more likely to adopt e-shopping when their accessibility to shops is relatively low (efficiency hypothesis). The following three products were analysed in-depth: travel tickets, CDs/videos/DVDs, and clothing. Both hypotheses were confirmed by the findings, showing that people living in a (very) strongly urbanised area have a higher likelihood of buying online, but that people with a low shop accessibility buy more often online (Farag et al. 2006b). Thus, the benefits of e-shopping seem to be greater for people with low shop accessibility than for people who have easier access to stores from their homes.

Overall, mixed results have been found concerning the relationships between e-shopping and (shopping) travel with stated preference studies mainly showing (small effects of) substitution, while revealed preference studies mostly point at complementarity or generation. These varying outcomes might be partly attributed to the diversity of research contexts. This said, in reviewing a number of small

5 A household travel survey and a supplementary Internet survey were completed by 6,785 people in and around Sydney, Australia.

scale studies of grocery shopping (and noting the lack of mainstream research or literature on the topic), Cairns et al. (2004, 316) have suggested that 'while home shopping for groceries may generate some offsetting travel for other purposes, in general it is likely to reduce personal car-use; with motivations for using home shopping grocery services often being about reducing hassle and having more time for other activities'.

Discussion

E-shopping and in-store shopping probably mutually influence each other. Since we do not know how people who now e-shop travelled before they started doing so, the 'generation or substitution?' question regarding e-shopping and transport demand is difficult to answer.

Therefore it is better to recognise the complexity and context-dependency of these relationships. Individuals operate and make their decisions in certain social and time-space contexts. These contexts, together with individual characteristics (such as Internet experience and income), form a person's individual decision context. Shopping behaviour (either online, in-store, or some hybrid form of these two) is shaped by such a decision context, which varies for each individual. This variation could cause different outcomes for interactions between e-shopping and in-store shopping, rendering it difficult to assess a net outcome. E-shopping and in-store shopping interactions could also differ between various groups in society. For example, people with sufficient time for shopping and a high income could use e-shopping as extra shopping next to their in-store shopping, while for time-pressured people and people with a low income, e-shopping might replace shopping trips.

Findings from empirical studies suggest that Internet users and e-shoppers make more trips than non-Internet users and non-e-shoppers (Casas et al. 2001; Corpuz and Peachman 2003). Perhaps e-shoppers would travel even more than they already do if they did not shop online, suggesting that there might be relationships of substitution between e-shopping and in-store shopping (leading e-shopping to supplement travel). Furthermore, some shopping might occur that could not have taken place without the Internet – some products can only be bought online. Or one may make impulse purchases online; these purchases do not replace a shopping trip, since a trip to the store would not have been made in any case. Also, home shopping (ordering products via a catalogue, by telephone, and so forth) might be replaced by e-shopping rather than shopping trips. Finally, another factor that might influence the interaction between e-shopping and in-store shopping is product type. The purchase frequency of products that are bought online also shapes the relationship with travel behaviour.

E-shopping might affect indirectly, in the long term, the existence, function, and location of brick-and-mortar stores. Stores that sell information products that can be readily digitalized such as CDs and computer software might run the risk of closure in the long term unless they sell specialized niche merchandise or transform to provide showroom, pickup or aftersales functions for goods sold online.

Compared to teleworking, e-shopping is more difficult to address by government policy, since it is a discretionary activity. However, regulations concerning the efficiency of the delivery of products ordered online may be appropriate. Virtual retailers are faced with logistic problems that centre on finding a balance between keeping distribution costs low and customers satisfied (Murphy 2003). A possible solution could be to develop distribution centres near consumers' homes (Visser and Lanzendorf 2004). Further to reviewing a number of modelling assessments concerning the traffic impacts of grocery home delivery services, Cairns et al. (2004, 313) summarise that 'If delivery vehicles directly substitute for car trips, the kilometres saved per shopping load are likely to be substantial – with reductions in the order of 70 percent or more.'

The travel impacts of C2C (Consumer to Consumer) e-commerce (for example, Ebay) could be greater than B2C (Business to Consumer) e-commerce. An increase in the popularity of C2C-commerce could cause more travel over longer distances, since individuals who 'meet' each other via the Internet may well visit each other in order to complete the transaction and deliver or pick up the product(s). Additionally, the recreational function of in-store shopping might become more important when people shop more often online, as consumers like to feel the added value of in-store shopping compared with e-shopping.

Future studies face the challenge to further unravel the relationships between e-shopping and travel. In doing so, they might discover new forms and combinations of shopping that have evolved gradually, because of the incorporation of new habits into the usual ways in which activities are being carried out. In general as well as specifically in relation to e-shopping, individuals might adapt new technologies in unforeseen ways, thereby creating whole new types of activity- and travel-patterns.

Concluding Discussion

This chapter has introduced and examined the following question: can communications be used as a substitute for travel? Through considering the cases of teleworking and e-shopping, it is evident that the answer to this question is 'yes'. Increasing numbers of people are undertaking working and shopping from their homes without a need to travel. It can be said that substituting for travel is becoming increasingly accessible as more people have access to ICTs and as technologies, services and communications formats continue to evolve in terms of usability and acceptability. Thus the opportunities for substitution are substantial or at least significant. However, the question then becomes: if we *can* use communications to substitute for travel, to what extent *will* we do so?

That increasing numbers of people (though far from everyone) can use communications to substitute for travel suggests that the *technological barriers* to substitution are becoming progressively less significant. However, *social barriers* and *institutional barriers* are likely to remain significant. Social barriers concern individuals' receptiveness to substitution, accounting for: their familiarity with and understanding of opportunities for substitution; their inherent needs and desires associated with physical mobility and co-presence; and habitual behaviours, norms and perceptions of the attitudes of significant other people towards them. Institutional barriers concern the other actors associated with the activities for which travel substitution could occur – for example employers and retail service providers in the case of working and shopping; and transport system providers in relation to both. Institutional barriers concern the extent to which such actors impede substitution through operating practises and expectations.

However, where reference above is made to barriers, it could equally have been made to corresponding *opportunities*. Technology is certainly creating more opportunity for substitution. There are opportunities for social benefits from substitution in terms of more space-time flexibility, saved travel time for use in other activities and opportunities to better manage daily schedules of activities – both work and domestic. Perhaps most notably there are opportunities for institutional change – reorienting the relative attractiveness of co-presence and its associated physical travel and of virtual presence and its associated virtual mobility. Herein, as has been noted earlier, there are opportunities for Government to influence, through legislation or fiscal incentives, the likes of employers and retail service providers. Such organisations can be agents for change in behaviour at the level of individuals in relation to choices between physical and virtual mobility.

Virtual mobility can be considered another mode of travel – or more appropriately another mode of access. It is important to recognise that the case for substitution does not imply wholesale replacement of physical mobility by its virtual counterpart. Virtual mobility should form part of the mix, securing a mode share in travel or access such that dependence on other modes (notably the car) is lessened.

At the average the amount of time spent travelling per person per year has changed very little in the UK over the past 30 years: 353 hours in 1972/1973, 360 in 1998/2000 (DTLR 2001) corresponding to a suggestion of the existence of travel time budgets (Schafer 1998). This could imply that substitution will be perfectly offset by generation. However, Mokhtarian and Salomon suggest that 'people seek to decrease their travel if it exceeds the desired optimum, but seek to increase travel if it falls short of their ideal amount' (2001, 712). Thus for some people, the mode share of virtual mobility will increase in order to reduce their travel; for other people either the virtual mobility mode share will remain low because (more) travel is desired or if the amount of virtual mobility increases, this will be offset by the generation of other travel. In the case of the latter, mode share remains important – if virtual mobility initially substitutes for car use or other motorised modes, the benefits of substitution can still be 'locked in' if the newly generated travel is by more sustainable modes such as walking or cycling.

The discussion above and prior considerations in the chapter highlight that the ability overall to 'simply' reduce total travel through substitution or to know by how much it could be reduced is unclear. However, an important caveat was set out at the start of the chapter, namely that the prospects for telecommunications and substitution must be set in a wider transport demand management context. It seems increasingly acknowledged that the problems of motorised mobility and congestion for economic and environmental reasons cannot persist unabated (Eddington 2006). Accordingly in the UK the possibility of national road pricing to combat congestion is now receiving serious attention. With an intention to discourage people from travelling at congested times and places it could well be the case that this dovetails extremely well with opportunities for travel substitution or indeed the displacement of travel that telecommunications can help make possible. Indeed such a dovetailing could further raise the prospect of being able to increase the cost of travel (especially by car) to discourage such travel and thereby encourage more substitution such that total travel is reduced, while economic and social activity is maintained.

To date there appears to have been a reluctance for transport policy to explicitly acknowledge and respond to the role of telecommunications in transport demand management. It may be argued that this has in part been because of a lack of empirical understanding upon which to base policy formulation. However, given the growing importance of and need for transport demand management and the challenges it faces in reconciling economic, social and environmental objectives, a counter argument could now be put forward. To ignore the role of substitution (and displacement) in transport demand management is no longer an option – either greater resource must be urgently invested in research to advance empirical understanding or policy formulation will need to proceed on the basis of existing evidence and expert judgement.

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Chapter 12

Travel Plans

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Introduction

Travel plans are unlike any of the other TDM tools described in the chapters of this book since they are a means of delivery and not a TDM instrument in themselves. This chapter therefore provides a suitable way of bringing together some of the wider considerations that need to be addressed in planning and implementing TDM measures.

The purpose of this chapter, is to introduce the concept of the travel plan as a means of delivering TDM measures. To do this, definitions are offered of what travel plans are and how they operate as a transport planning and mobility management measure predominantly in the UK context. In addition, examples of travel plans measures are described and the evolution of the travel plan since its introduction in the UK just over a decade ago is described. Finally a framework is constructed so as to help suggest how travel plans may develop in the future.

The chapter draws on existing literature and the experience of the authors to suggest that travel plans are gradually shifting from being predominantly a niche product towards being an integrated, comprehensive yet still focused tool in three senses: segment, scale and scope.

An Introduction to Travel Plans

This section will review travel plan definitions, types, and measures adopted. It will also explain the benefits of travel plans to organisations, member employers, governments and the wider community and the impact of travel plans.

Definition

EEBPP (2001) defines a travel plan as being 'a general term for a package of measures tailored to meet the needs of individual sites and aimed at promoting greener, cleaner travel choices and reducing reliance on the car. It involves the development of a set of mechanisms, initiatives and targets that together can enable an organisation to reduce the impact of travel and transport on the environment, whilst also bringing a number of other benefits to the organisation as an employer and to staff'.

This definition could be further split into two separate but interrelated terms, travel plans and travel planning. A travel plan[1] is therefore 'a package of measures aimed at reducing the impacts of travel to a particular site' (Bradshaw, 2001). From the term travel plan is derived 'travel planning'. Travel Planning[2] involves 'the development of a set of mechanisms, initiatives and targets aimed at influencing people's behaviour by mode, cost, time, or route in such a way that alternative mobility options are presented and/or congestion is reduced' (EEBPP, 2001; Meyer, 1999; NCTR, 2004). In other words, travel planning is the action of applying a travel plan.

Travel Plan Applications

Most commonly travel plans apply to worksites and schools, and these are the areas where most research has been conducted. However, they can also be applied to other travel generators such as for events, leisure facilities and residential developments.

Travel Plan Measures

According to Meyer (1999) measures of the travel plan can be grouped into three broad categories to address different transport aspects covering commute travel, business travel and fleet management. These are:

- offering travellers one or more alternative transport modes or services that result in higher per vehicle occupancy;
- providing incentives/disincentives to reduce travel or to push trips to off-peak hours, and
- accomplishing the trip purpose through non-transport means (such as substituting the use of telecommunications for work or shopping trips).

Alternative transport modes Often people are unaware of the public transport service available (Merseyside Travelwise, undated; Sloman, 2004). Therefore, providing generic and/or tailored public transport information can consequently raise awareness. For example, Birmingham City Council provides information boards to organisations and sends out regular mailings of public transport timetables and information to them (Cairns et al., 2004).

Car-sharing is another common measure adopted in a travel plan. It can be used for both regular commute and occasional travel (Sloman, 2004). Normally, participants register into the car-sharing database and travel matches will be identified automatically or manually. Car-sharers can benefit from closer parking spaces to the building, discounted parking fees, or guaranteed taxi ride home

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1 Travel plan is also known as 'Commute Trip Reduction', 'Employee Trip Reduction', 'Employee Commute Option', 'Transportation Management Plan', 'Employer-Based TDM Programme' and 'Site-Based Mobility Management'.

2 Similar terms to travel planning include Travel Demand Management and Mobility Management.

scheme. For example, the Halifax, now part of HBOS plc, has encouraged car-sharing at its offices in Leeds and Halifax with a matching service and designated parking bays for registered car share groups. Consequently, more than 15 percent of member employees at Lovell Park in Leeds and Copley in Halifax now actively car share (Transport, 2000; 2006).

Cycling and walking initiatives are also important tools employed in a travel plan. Organisations normally invest on small scale infrastructure/facility improvements at their worksite such as cycling lanes, pedestrian routes, lockers, shower facilities and cycle racks. In Merseyside and York, there has been a great deal of awareness-raising work relating to the health benefits of walking (Cairns et al., 2004).

Incentives/disincentives Travel plans can include both incentives and disincentives to make a travel plan more attractive or more effective.

Public transport pass subsidies are a useful incentive element of a travel plan. For example in Buckinghamshire, UK the County Council has negotiated a 34 percent discount with a local railway operator, and 50 percent discount with a local bus operator (Cairns et al., 2004).

Parking management comprises a range of methods covering charges for use of the car park, allocation of car park permit, parking cash out, benefits for people who do not use the car park or give up their parking permit, and preferential parking for car-sharers. An example of parking management comes from the UK Highways Agency at its Manchester office. The Highways Agency reduced the size of the car park and promised that disabled people and car-sharers would be guaranteed a parking space. This has made life easier for all staff as the car park does not fill up until 9:30am instead of the previous time of 7:00am (Sloman, 2004).

Non-transport means This refers to non-transport means in reducing the need to travel.

By implementing teleworking or working-at-home, and providing on-site service facilities such as cash machines, shops can reduce the need to travel. Whilst flexible working time will help member employees travel at off-peak time which may consequently reduce transport congestion. For example, after moving into a new head office, Focus Consultants in Nottingham developed a travel plan which provides facilities for home and teleworking, and supports alternative travel options in order to reduce increasing car reliance (EST, 2005).

Table 12.1 summarises a range of measures which can be adopted as part of a travel plan.

Summary

In essence, a travel plan can incorporate a set of different measures namely alternative transport modes, incentives/disincentives, and non-transport means. These measures are designed to provide both 'carrots' and 'sticks' in order to promote alternative travel choices to reduce single occupancy car use. Typically, most travel plans introduced so far have consisted mostly of carrots rather than sticks and hence have not yet usually encountered significant implementation problems. On the other hand, this has meant that their effectiveness has been correspondingly limited. Lastly, from a Government and local authority perspective travel plans are attractive because they are implemented by other organisations which to some extent shields them from the controversy normally generated from introducing TDM measures.

Table 12.1 Tools of travel planning

Categories	Tools
Alternative transport modes	
Public transport	• Providing generic and tailored public transport information • Access to rail planner • Liaise with local operator for new or better services and cheaper prices • Pay for new services
Cycling	• Pool bikes • Providing better facilities, for example, changing/shower/parking • Encouraging cycling, for example, training for cycling, free bike maintenance • Bike loan scheme
Walking	• Providing better facilities, for example, lighting/walkways/crossings at site • Encouraging walking, for example, walking map
Car-sharing	• Priority parking spaces for car sharers • Guaranteed ride home scheme • Staff travel survey to identify potential sharers
Incentives/disincentives	
Incentives	• Incentives for walkers for example, vouchers for sports shops • Discount purchases of cycles and equipment • Providing subsidies on public transport
Disincentives	• Reducing parking supply • Car fleet management • Company car initiatives (phased out/altered)
Non-transport means	
Technology/operation	• Flexible working hours • Telecommuting/teleworking/teleconferencing
Culture	• Creating a car-free culture, for example, campaign/car-free day

Source: Compiled from Rye 2001, Sloman 2004.

Benefits of Travel Plans

A successful Travel Plan can bring a number of benefits to organisations, member employees and the wider community (Highways Agency, 1999; Pollution Probe, 2001; Shinkwin et al., 2001).

Benefits to organisations A travel plan can help organisations improve accessibility. Organisations can mitigate site traffic congestion and provide more travel choices in accessing the workplace. This will consequently lead to improved customer service and an enhanced public profile.

A travel plan can help organisations increase productivity. The improved accessibility will consequently increase productivity as member employees will spend less time looking for parking spaces for example. In addition, absenteeism and illness can be reduced.

A travel plan can also help organisations save money. A reduction in car parking requirements or office space requirements can enable the release of land or buildings for more productive uses. A reduction in off-site car parking needs can also represent a substantial reduction in overheads.

Finally, a travel plan can help organisations with the recruitment and retention of employees. Easing the journey to work for member employees will enhance an organisation's reputation. Travel plan measures can be integrated into an employment package for new staff recruitment. While reduced travel stress levels ensure more content staff, reducing turnover and the associated costs of recruiting and re-training new people.

Benefits to member employees Through the adoption of a travel plan, member employees can benefit from improved travel choices to and from their workplaces. In addition, flexible working hours and teleworking can be tailored to meet a range of individual staff circumstances and requirements, offering staff greater flexibility in their working day, while still meeting organisation performance targets.

The costs of commuting can be considerable. Alternative travel options such as car-sharing, cycling, walking, as well as incentives such as discounted transit passes can significantly reduce the travel costs of member employees.

A travel plan can make a journey to work easier, cheaper, quicker and safer for member employees through improved public transport, car-sharing and/or other non-motorised travel modes. As a result, stress can be relieved whilst walking and cycling also bring other health benefits.

Developing a travel plan involves communication, consultation and facilitation of flexibility and choice. Both the communication processes and the facilitation of choices can enhance the overall working environment within an organisation.

Benefits to government and the wider community Enoch and Rye (2006) states that 'the attractions of travel plans to Governments and local authorities are that they are reasonably quick to introduce, relatively cheap and importantly are usually politically acceptable. In short, they are an "easy win". This is in marked contrast to most other transport improvement schemes which often require high levels of investment over a long period of time and can carry a high political risk – especially in the short term as conditions frequently deteriorate while improvements are being carried out'.

Travel plans can help improve air quality with less noise, dirt and fumes, as well as reduce the impact of other national and global environmental problems such as photochemical smog and global warming (Highways Agency, 1999). In addition, the environmental benefits of a travel plan can contribute to a 'good neighbour' policy towards other organisations or residents in the area. Such a plan can also form an integral part of an organisation's environmental management programme including formal standards such as the Environmental Management and Audit Scheme (EMAS) and ISO14001 (Shinkwin et al., 2001).

EEBPP (2001) and Litman (2007a) summarise the benefits of travel plans to organisations, member employees and the wider community. These are:

- Organisations can gain increased productivity from a healthier workforce, cost savings and reduced demand for car parking, with less congestion, better corporate image, and improved worksite accessibility for member employees, visitors and deliveries;
- Employees can have greater travel choice, enjoy improved health, be less stressed, have an improved quality of life, and save money and time;
- The surrounding community will enjoy the reduced traffic congestion and crash risks, shorter journey times, and better public transport services and will appreciate less parking by non-residents in residential areas.

Impacts of Travel Plans

The aggregate impact of workplace travel plans depends on the average effectiveness of individual travel plans, and the number of workplaces adopting a travel plan (that is, the level of travel plan take-up) (Jones and Sloman, 2003). The effectiveness of individual travel plans is highly dependent on what measures are chosen, how widely they are applied and adopted, how and by whom the measures are implemented, and how they are assessed according to worksite or area's characteristics, operational characteristics, commuters' demographic and travel characteristics (Berman and Radow, 1997; COMSIS, 1993; COMSIS, 2002; Litman, 2007a). As a result, the evaluation of individual travel plans is always complicated as is often the case in behavioural change programmes (Taylor and Ampt, 2003).

The 'reduction in car use' is the most common indicator when evaluating travel plan effectiveness in the British, Dutch and American literature (Cairns et al., 2002; Cairns et al., 2004; Napier University TRI et al., 2001; Organizational Coaching and Schreffler, 1996; SDG, 2001). This indicator however, has its limitations in that it 'gives no indication of the organisation's original starting point or the level of car use achieved in relation to other organisations in similar circumstances'. Therefore, other factors are also used (Ferguson, 1990; Organizational Coaching and Schreffler, 1996; Ligtermoet, 1998; Pollution Probe, 2001; SDG, 2001; Cairns et al., 2002). These include:

- 'Change in modal share' (difference in travel behaviour);
- 'Number of car parking spaces given up' or 'Car/employee ratio'; (to determine level of car dependence),
- 'Reduction of vehicle kilometres' (strong link to congestion and environmental impacts);
- 'Average vehicle ridership' (level of car occupancy);

- 'Cost per employee' and 'cost per trip reduced' (measure level of cost effectiveness).

The next section will review existing literature with respect to the impact of travel plans in terms of both average effectiveness of individual travel plans including cost effectiveness and the level of travel plan take-up. The impacts on overall commuting travel are also described.

Effectiveness of individual travel plans Research for the UK Department for Transport (DfT) (Cairns et al., 2004) reveals that 'fully fledged travel plans (with parking management) typically reduce car driving by an average of 15–20 percent at individual sites'. A number of other studies revealed similar results (Cairns et al., 2002; Ligtermoet, 1998; Organizational Coaching and Schreffler, 1996; Shoup, 1997; Touwen, 1999; TCRP, 1994).

More specifically, Cairns et al. (2002) looks at a number of public and private sector organisations in the UK and finds that 'on average, the travel plans had resulted in at least 14 fewer cars arriving per 100 staff, representing a reduction of at least 18 percent in the proportion of commuter journeys being made as a car driver'. In terms of alternative travel modes, 'on average, the organisations had nearly doubled the proportion of staff commuting by bus, train, cycling and walking. There had also been considerable success with encouraging car-sharing'.

A US study (TCRP, 1994) looks at travel plans developed by 49 employers and found that 'the average vehicle trip reduction was 15.3 percent'. This study also finds that travel plans providing only information did not bring any trip reduction results; those providing commute alternatives (such as van pools) had an average 8.5 percent reduction; those providing financial incentives (such as transit subsidies) achieved 16.4 percent reduction; and travel plans providing both financial incentives and services (such as van pool/car-sharing matching) realised an average 24.5 percent reduction.

A Dutch study (Ligtermoet, 1998) reviews other studies in the Netherlands together with results from 40 organisations and concludes that 'travel plans with "basic" measures (such as car-sharing schemes) could achieve a reduction of 6–8 percent in vehicle kilometres; while those with "luxury" measures (such as works buses, public transport subsidies, and parking management) would achieve reductions in the range of 15–20 percent'. Another Dutch study (Touwen, 1999) gives a similar result.

In addition, the impacts of workplace travel plans may increase over time for several reasons (Jones and Sloman, 2003):

- More measures: the longer a travel plan goes on, the more incentives can be put in place;
- Turnover of member employees: new employees are less likely to have fixed ideas about how to get to work, and may be more receptive to options such as car-share matching or cheap public transport;
- Ideas take root: as employees see 'early adopter' colleagues trying new ways of getting to work the idea that they could try these too will gradually take root.

Both British and North American literature reports on the cost effectiveness of travel plans (costs of running a travel plan) and this tends to find that costs vary hugely according to the measures adopted in a travel plan.

Cairns et al. (2002) finds that gross annual running costs on individual travel plans vary from GBP£2 per full-time-equivalent employee through to GBP£431 per full-time-equivalent employee. The median average annual running cost is GBP£47 per full-time-equivalent employee which is notably cheaper than the USD$400–USD$2,500 (GBP£192–GBP£1,198) range quoted in Litman (2007b) as the annual cost of running a parking space.

Other studies of cost effectiveness of travel plans could be summarised as follows:

Organizational Coaching and Schreffler (1996) reports that,

> the cost per employee per year of a travel plan ranged from USD$8 to USD$105 (GBP£4 to GBP£50), but in most studies the cost was closer to USD$30 (GBP£14) a year. The cost per vehicle trip reduced ranged from a low of USD$0.70 (GBP£0.34) to a high of USD$100 (GBP£48). However, the most typical cost was closer to USD$1.00 (GBP£0.48) per daily vehicle trip reduced and some programmes had net savings through programme revenues such as parking income.

Pollution Probe (2001) looks at 18 organisations in the US and seven organisations in Canada and finds that in North America, 'the cost of travel plan to employers varies from USD$0.71 (GBP£0.34) per employee to USD$735[3] (GBP£352) per capita annually'.

Level of travel plan take-up The UK Department of Environment, Transport and the Regions (DETR) indicated in its 1998 White Paper that it aimed to secure 'widespread voluntary take-up of travel plans'. A decade on, and the evidence remains patchy. This is because while the average effectiveness of individual travel plans has been fairly well monitored (see earlier), the level of travel plan take-up has not. This section will look at a limited number of key studies conducted on this issue. The proportion of organisations that have travel plans in place is the key indicator when evaluating the level of travel plan take-up.

From a series of UK surveys with 413 local authorities and 38 other organisations,[4] Bradshaw et al. (1998) reports that 'only about 3 percent of the local authorities had implemented a travel plan for their own employees on a permanent basis and a further 4 percent had implemented one on a pilot or trial basis. Forty percent of local authorities had started the process, 30 percent had considered the idea of a travel plan but not yet taken any action and the remaining 25 percent had not considered a travel plan at all'.

3 Calvert Group (with only 170 employees and an extensive subsidy programme) spends USD$735 per capita (Pollution Probe 2001).

4 Including both public sector organisations mainly hospitals and private sector organisations.

Interestingly in the late 1990s, local authorities were slightly more involved in encouraging other organisations to develop travel plans than developing them for their own employees. However,

> overall only about 6 percent of authorities had encouraged travel plans at other organisations on a permanent basis, a further 6 percent had encouraged pilot or trial travel plans at other organisations and 23 percent had started the process by contacting employers. Almost 40 percent of authorities had considered encouraging other organisations to adopt travel plans but had not taken any action and 28 percent had not even considered it (Bradshaw et al., 1998).

Rye (2002) reports that in 2000 '4 percent of a random sample of large (more than 100 employees) private UK employers had travel plans'.

In 2001, the DETR commissioned a larger scale study which covered 388 local authorities, 1,000 businesses employing over 100 employees, 60 hospitals and 40 higher education establishments. SDG (2001) states that '24 percent of local authorities have a travel plan in place of some sort. Forty five percent said they were currently developing a travel plan. Meanwhile 22 percent have considered a travel plan but have taken no action and only 8 percent have not considered a travel plan at all'. This result illustrates a significant increase of travel plan take-up by organisations at public sector, local authorities in particular, compared with the 1998 figures.

Table 12.2 Level of travel plan take-up (1998–2006)

<table>
<tr><th rowspan="3">Travel plans take-up</th><th colspan="3">1997/1998</th><th colspan="3">2001[d]</th><th colspan="2">2006[f]</th></tr>
<tr><th colspan="2">Local authority[a]</th><th rowspan="2">Private business[c]</th><th colspan="2">Local authority</th><th rowspan="2">Private business[e]</th><th rowspan="2">Local auth.</th><th rowspan="2">Private business[e]</th></tr>
<tr><th>Own</th><th>Others[b]</th><th>Own</th><th>Others</th></tr>
<tr><td>Had travel plans on a permanent basis</td><td>3%</td><td>6%</td><td>4%</td><td rowspan="2">24%</td><td rowspan="2">47%</td><td rowspan="2">7%</td><td rowspan="2">62%</td><td rowspan="2">11%</td></tr>
<tr><td>Had travel plans on a pilot or trial basis</td><td>4%</td><td>6%</td><td>–</td></tr>
<tr><td>Had started the process</td><td>40%</td><td>23%</td><td>–</td><td>45%</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Had considered but no action</td><td>30%</td><td>40%</td><td>–</td><td>22%</td><td>–</td><td>4%</td><td>–</td><td>–</td></tr>
<tr><td>Not considered</td><td>25%</td><td>28%</td><td>–</td><td>8%</td><td>10%</td><td>–</td><td>–</td><td>–</td></tr>
</table>

Notes: [a] Based on Bradshaw et al. (1998): study included authorities in Wales and England; [b] Local authorities had encouraged or started the process by contacting other organisations; [c] Based on Bradshaw and Lane (1997) and Rye and MacLeod (1998): large organisations (more than 100 employees); [d] Based on SDG (2001); [e] Large organisations (more than 100 employees); [f] Based on the estimation of Cairns et al. (2004).

Source: Compiled from; Bradshaw and Lane, 1997; Bradshaw et al., 1998; Cairns et al., 2004; Rye and MacLeod, 1998; SDG, 2001.

By contrast, results from the private sector organisations gave no optimistic signs of widespread travel plan take-up. 'Only 7 percent of businesses had a travel plan and a further 4 percent were thinking about developing a travel plan [in 2001]' (SDG, 2001). Compared with the 1997/1998 results, there was only a 3 percent increase of travel plan adoption among private sector organisations. Similarly in the Netherlands, organisations which have been most actively adopting travel plans are those in the public sector, such as local and regional government, universities, hospitals, and organisations which are expanding and/or relocating. Private sector organisations without site-specific transport problems are less likely to be active (Rye, 1999).

The latest study for the UK Government (DfT and GORS, 2007) reports that a review based on Local Transport Plans found that workplace travel plans are mentioned in every example, but that only a minimal reference was found in a third of these. Meanwhile Cairns et al. (2004) estimates that by 2006 only 11 percent of private organisations with 100 or more employees will adopt a travel plan. Table 12.2 summarises level of travel plan take-up since 1998 to 2006.

Finally, Coleman (2000) indicates that the Small and Medium-sized Enterprises (SMEs) (of less than 100 employees) are relatively neglected when developing travel plans, with only '19 percent of small businesses being aware of travel plans'.

Impacts of travel plans on overall levels of commuter traffic Clearly, then, travel plans work effectively at individual sites. However, the low level of travel plan take-up (especially by private business) has meant that the aggregated impacts of travel plans on overall levels of commuter traffic at a national level has not been significant. DETR's research (Cairns et al., 2004) estimates that travel plans implementation may have only reduced overall levels of car commuting by 0.4–3.3 percent. Similarly, Rye (2002) estimates that travel plans removed up to 1.143 billion km per year, which equates to only 0.74 percent of the total vehicle km travelled to work by car overall.

Summary

In section 2, the definition, types, measures of a travel plan, and their benefits to organisations, member employees, the Government and the wider community have been described. The impacts of travel plans including average effectiveness of individual travel plans, level of travel plan take-up, and overall effectiveness on commuter traffic have also been reviewed.

Aiming at promoting sustainable travel choices and reducing on car use, travel plans consist of a package of different measures including both 'carrots' and 'sticks'. Travel plans are attractive to Government as they are easy to introduce, relatively cheap to implement and politically acceptable. They can also bring benefits to organisations, member employees and the wider community.

The impacts of travel plans have been evaluated from two aspects, the average effectiveness of individual travel plans, and the level of travel plan take-up. At individual sites, travel plans can work effectively and in average, they can achieve a 15–20 percent car trip reduction with a good mix of measures. Despite the fact that travel plan take-up has grown rapidly in the public sector, its implementation among private businesses is still at a low level. This has consequently affected the overall impact of travel plans on commuting travels.

Given that organisations should be the key implementers of travel plans if successful implementation is to be achieved (Coleman, 2000; Meyer, 1999), there is a need to better understand how the organisation views the whole area of staff travel and travel plans in order to find out why the level of travel plan take-up is poor, especially within the private sector.

Before detailing the barriers to a wider take-up of travel plans by private businesses, it is essential to understand why organisations implement travel plans, that is, the motivations behind them.

Motivations Behind Travel Plans

Understanding organisational motivations behind travel plans is especially important because organisations are largely responsible for implementing the travel plans (Pultz, 1990). Outlined here are some of the key findings that focused on what have motivated organisations to implement travel plans.

Broadly speaking, organisations adopt travel plans either voluntarily or because they are legally required to.

Voluntary take-up Ferguson (2000) notes that initially travel plans were developed voluntarily in response to specific circumstances.

- *Oil crisis*: Initially, travel plans were introduced in response to the energy crisis in the 1970s (see later).
- *Employee recruitment and retention*: Many organisations have realised that 'recruitment, retention, and morale problems have been linked to commuting problems' (Pultz, 1990), and so travel plans are sometimes adopted to address these issues.
- *Transport problems*: Another key driver is to mitigate perceived transport problems such as parking shortages or congestion (Cairns et al., 2002; Cleland and Cooper, 2003; Potter et al., 2004; Rye, 1999).
- *Site relocation or expansion*: Relocation or expansion of the existing facilities also encourage organisations to consider travel plans, whether to save money (for example, parking provision is expensive) or to minimise member employee disruption and turnover (Pultz, 1990).
- *Construction works*: Some organisations have implemented travel plans to mitigate problems caused by large scale construction or maintenance work near their worksites.
- *Leading by example*: Organisations in the public sector in particular, have adopted travel plans in order to lead by example. This is partly to encourage private sector organisations to follow suit (Coleman, 2000).
- *Altruistic reasons*: Lastly, many organisations adopt travel plans for altruistic reasons, either to fulfil environmental or corporate social responsibility goals or else to improve their image locally (by reducing transport impacts such as overspill parking and congestion), or nationally (Cairns et al., 2002; Pollution Probe, 2001; Pultz, 1990).

For widespread impact, travel plans need to be adopted more by private businesses (Coleman, 2000). However, Potter et al. (1999) finds that UK organisation attitudes are not entirely positive towards travel plans although more organisations are willing to implement low-cost elements such as the provision of facilities for cyclists. Studies (see Bradshaw, 1997; Coleman, 2000; Rye and MacLeod, 1998) also reveal that organisations prefer voluntary measures but do not feel that they can work alone because they believe that local and particularly national Government have a great deal of responsibility for dealing with transport problems and it is very difficult or impossible for them to influence member employees' travel mode choice.

Consequently, Governments have begun imposing mandatory requirements in order to achieve a wider level of travel plan implementation.

Mandatory Requirements

Legislation/regulation has proved to be a major external motivation in implementing travel plans (Cairns et al., 2002; Pollution Probe, 2001; Rye, 1999). In the US and Italy for example, regulations have tended to be focused on a particular type or size of existing organisation, whereas in the UK the regulations have been applied through the planning system (that is, on *proposed* organisations).

However, Pultz (1990) finds that these are not popular, and that organisations think that 'travel plans should be voluntary because organisations can not actually force employees to change their commute behaviour'. They also think that 'travel plans will require money and impose a burdensome reporting requirement without any guarantee that they will actually change commute behaviour and relieve traffic'. What is more, 'some employers think that it is Government's job to control traffic and that it should not pass its responsibilities off onto the private sector. They think that Government should shoulder some of the burden by providing other inducements for changing commute behaviour, such as a convenient transit service and HOV lanes for car-sharers'.

Different Motivations for Public and Private Sector

It is interesting to see that the motivations in developing travel plans have evolved over time and they are very different in public sector organisations and private sector organisations. Table 12.3 summarises two surveys of the main reasons given to implement travel plans by the public and private sector respectively.

Table 12.3 shows that organisations in the public sector including Government Departments, local authorities and the National Health Service have a strong moral obligation to 'lead by example' and to fulfil environmental responsibility when developing travel plans. By contrast, the private sector sees little need to lead by example, or to introduce travel plans for altruistic reasons. They implement travel plans only when they have transport problems, have other internal reasons or are required to do so in comply with a legal requirement. Having said this, more recent evidence seems to indicate that this mood is changing and that the Corporate Social Responsibility and Environmental Audit agendas are now becoming far more influential in persuading organisations to at least consider travel plans (Enoch and Ison, 2007).

Table 12.3 Most common reasons to implement travel plans

	1998	2001
Public sector organisations	• Congestion • Sustainability • Air quality improvements/ targets	• Lead by example • Improve environmental image • Government encouragement
Private sector organisations	• To solve parking problems • Environmental reasons • To reduce congestion around worksites	• Environmental reasons • Parking pressures • Saving money/time/fuel • Secure planning permission

Source: Compiled from Bradshaw et al., 1998; SDG, 2001.

Summary

Section 3 explained motivations behind travel plans. In general, organisations are either implementing travel plans voluntarily in order to fulfil their own goals, or required to do so under laws or regulations. The following section looks at the barriers to the widespread travel plan take-up, and reviews the role of the UK Government in stimulating travel plan development.

Barriers to Wider Travel Plan Take-up and Possible Solutions

The UK Government encourages both public organisations and private bodies to implement travel plans. This assumes however, that these organisations are keen to introduce them. Section 3 revealed that the basis of travel plans may be undermined in that the whole process is predicated on other organisations being motivated to participate in helping to solve something that is not legally or institutionally 'their problem'. Thus, unless these organisations have some pressing motivation, for example, they have access issues, a shortage of parking, need more space, want to save money, or enhance corporation image, they are unlikely to participate. In particular, eight key barriers are identified (Rye, 2002; Bradshaw et al., 1998; Coleman, 2000; SDG, 2001; COMSIS, 2002; Litman, 2007a), namely:

- Companies' self interest and internal organisational barriers;
- Personal taxation and commuting;
- Lack of examples due to novelty of the concept;
- Lack of staff resource;
- Lack of financial resource;
- Lack of small and medium-sized enterprise involvement;
- Lack of public transport operator involvement; and
- Lack of regulatory requirements for travel plans.

This section will give details on each barrier to wider take up as well as tactics employed by the Government. It will then provide some suggested solutions that have been adopted.

Companies' Self Interest and Internal Organisational Barriers

As a general rule, unless there are specific operational problems most organisations will not devote resources or change existing organisational practices in developing travel plan. According to SDG (2001), 'of those private businesses who had not yet developed a travel plans, the most common reason given was that all/most staff live locally. The second most common response was that they had not heard of travel plans. This was followed by 'no interest in travel plans or not seen as a priority'.

Personal Taxation and Commuting

Historically in the UK, any organisational contributions to member employees' commuting costs have been subject to personal taxation. This has had an impact on the type of measures that are implemented in travel plans (Potter et al., 2006).

Lack of Examples due to Novelty of the Concept

When the travel plan concept was officially adopted in the UK Government's 1998 White Paper – *A New Deal for Transport: Better for Everyone* (DETR, 1998) – there were very few examples of them having worked successfully, particularly in the UK meaning that relatively few organisations had good examples to emulate (Rye, 2002).

Lack of Staff Resource

Bradshaw et al. (1998) and SDG (2001) report that 'lack of staff resource' is the most common reason preventing organisations from adopting travel plans. Put simply, suitably trained travel planners remain a rare commodity meaning that organisations are often unable to properly implement a plan.

Lack of Financial Resource

Another common reason for not developing a travel plan is the 'lack of financial resources' (Bradshaw et al., 1998; SDG, 2001; Haddock and Hyner, 2000).

Lack of Small and Medium-sized Enterprise Involvement

At the start of 2005, SMEs (0–250 employees) together accounted for 99.9 percent of UK businesses, employing 58.7 percent of the workforce (approximately 13 million people) in the UK (DTI, 2005; SBS, 2006). Collectively, SMEs have significant transport impacts, but so far little progress has been made in involving them in travel plan development, which NCBS (2006) ascribes to being because:

- The majority of SMEs are simply not aware of the advice, training and funding they can access;
- Those that are aware of the support available do not always think their organisation will be big enough for any help;
- Some SMEs said they were concerned about appearing disorganised and unprofessional to other organisations if they opened themselves up for closer scrutiny.

Lack of Public Transport Operator Involvement

Outside of London, most public transport in the UK is operated in a privatised for profit environment. Yet 'the very areas most in need of travel plans are often not attractive places for [public transport] operators to serve' (Rye, 2002; Rye et al., 2002). As a result, modern public transport operators are reluctant to take commercial risks and get involved in developing travel plans mainly because of the highly peaked demand and the hostile layout of bus service infrastructure (SDG, 2001). By contrast, businesses see the need for co-operation from operators if their travel plans are to be effective.

Lack of Regulatory Requirements for Travel Plans

Enoch and Potter (2003) reviews a range of solutions that have been applied to the problems discussed. Specifically, the review suggests that national and local governments can apply 'information and exhortation' methods (for example, lead by example at their own sites and compile good practice guides); fiscal subsidies (for example, capital grants for equipment, bursary posts or expert advice); and tax incentives (that is, ensure as far as possible that the tax system discourages car use and encourages the use of alternatives). Finally, it suggests that a further mechanism would be to legally require organisations to adopt travel plans in order to force organisations to act (and overcome the final 'barrier') – that is, the lack of regularity requirements for organisations to set up and manage travel plans.

FoE (1995) summarises the thinking behind this barrier by suggesting that the voluntary approach is fundamentally ineffective because 'the potential motivations for compliance are neither strong enough nor sufficiently widespread'. Moreover, 'the voluntary approach has been shown to fail to stimulate innovation and to tend to lock firms into existing, often short-term, solutions', while lacking 'public credibility'. Interestingly though, while mandatory programmes appear more effective than voluntary ones at getting all employers or developers in an area to participate in the programme, Pultz (1990) reports that 'contrary to the common perception, mandatory programmes are not necessarily more effective than voluntary programmes [at limiting transport impacts]'. Also revealing, is that with the significant exception of Washington State (where TDM measures form an integral component of how transport improvements are delivered) (Enoch and Potter, 2003), the US as the pioneer of this approach has shifted away from mandatory requirements to some more flexible means which give incentives to organisations. Therefore, although mandatory requirements can play a role in encouraging travel plans, particularly where they form part of an integrated suite of TDM measures, it would seem that in general it has so far been more effective to encourage organisations to play an active role in leading travel plans implementation rather than requiring them to do so.

Summary

This section has reviewed a number of barriers identified by the existing literature. These include companies' self interests, personal taxation issues, lack of examples, staff resource, financial resource, lack of SMEs and public transport operators involvement, and lack of regulatory requirements. So far, evidence in the UK demonstrates that only slow progress has been made but that things are slowly improving (Enoch and Ison, 2007), while elsewhere there are relatively few cases of effective travel plans in operation.

Where Next for Travel Plans?

Despite these barriers, travel plans have somehow survived and over the last few years have begun to make an increasing impression on the formulation of transport policy and practice and on the travel behaviour of some people in the UK. This final section aims to look from mainly a UK perspective at how travel plans have evolved thus far, and then tries to predict how travel plan policy will develop in the future.

The Story of the Travel Plan

Travel plans were originally developed (simultaneously and independently) as a response to the oil crises of 1973 and 1979 by electronics company 3M in St Paul, Minnesota and Conoco in Houston, Texas in the US (Martz, 2006). The travel plan concept spread first to the Netherlands and eventually arrived in the UK in the mid-1990s, where Boots and Nottinghamshire County Council in Nottingham and Derriford Hospital in Plymouth became some of the first UK organisations to develop plans. Thus, initially, travel plans were focused on large organisations at single sites and on commuting and business trips.

Since this time, travel plans in the UK can be said to have developed in three core directions – by segment, scope and scale. The following paragraphs briefly describe how this relatively niche mode of operation has subsequently expanded.

Segment From a segmental perspective, workplaces were the first area to develop travel plans, largely as a response to commercial pressures (as noted earlier). Then there was a gap of a few years – the creation of the School Travel Advisory Group (STAG) by Government occurred in December 1998 – before the idea of travel plans for schools was put forward (this time by local authorities) as a way of combating traffic levels during the 'school run' and improving children's health. After this, the segments where travel plans have been applied has begun to grow more quickly, and hence leisure facilities (both for day to day visitors and for one off events) (Transport, 2000; 2001), shopping centres and most recently residential areas (DfT, 2005a) are now also served, while the idea of Quality Freight Partnerships – that focus on goods delivery and distribution issues rather than on just people – are also gaining currency with pilot schemes operational in Winchester (Hampshire) and Bristol.

Scope A second major trend, has been in the scope of travel plans. In particular, while the first plans were applied by the organisation themselves to mitigate existing problems, by the late 1990s a number of local planning authorities were beginning to make the link between travel plans and planning consent. Therefore, by 2001 a survey for the UK Department of Transport Local Government and the Regions found that 156 local authorities out of 388 surveyed required the developers of some proposed developments to set up a travel plan as a condition for being awarded planning permission (DTLR, 2001). However, until the changing of planning guidance in 2005 with the issuing of Planning Circular 5/05 (ODPM, 2005), such rules and regulations tended to be made on a case-by-case basis with no guarantee that an effective plan would be in place following the results of the negotiation phase. With the new guidance though, local authorities are now encouraged to develop standardised, transparent, and area-based approaches to planning decisions although so far there is little evidence as to whether this is happening or not. One exception to this is in London, where Transport for London (TfL), the capital's transport authority is currently in the process of drawing up guidance for London Boroughs that aims to ensure that some form of travel plan will need to be provided for every planning application in the capital. Once again however, there is resistance from staff in several of the London Boroughs affected who say they do not have sufficient resources to implement this guidance.

There is also evidence that the scope of travel plans is also been extended to more existing organisations. For example, all NHS facilities and all Government Department offices have been required to adopt a travel plan for a number of years, while a limited number of commercial organisations are applying similar regulations based on internal drivers typically driven by cost saving and/or by corporate responsibility agendas.

Scale Meanwhile a third trend that has started to emerge since the beginning of 2005 in the UK (but twenty years ago in the US) is the development of so-called local travel plan groups or networks. Such groups have come about for a number of reasons, but fundamentally these are that:

- Groups are collectively able to achieve more than single agencies or employers when dealing with common concerns (thanks to pooled resources delivering higher investment, dedicated staff, and greater political influence) and yet allows the member companies/organisations to focus more on their core competencies.
- Groups have the ability to move Transport Demand Measures (TDM) from a site-specific application to more flexible and effective area-wide application.
- Groups can improve the level of communication between the sectors and allow the level of flexibility necessary to ensure that transport objectives are met in ways that maximise the benefits for businesses, residents and commuters.

Enoch, Zhang and Morris (2005) provides an overview of the various types of groups in place as of mid-2005 and develops a basic framework to classify their structures and functions. What is particularly interesting is that some of these groups are becoming increasingly formal, while some also include not only business organisations, but residential areas and shopping facilities too – for example, at the Dyce Transportation Management Organisation in Aberdeen.

At this point it is also important to note that a slightly different form of travel planning is also now being applied at the individual level. Variously known as 'Travel Blending', 'Personalised Journey Planning', 'Travel Smart' and 'Individualised Marketing', this technique involves trained personnel visiting householders or employees and discussing the travel choices available to them in a bid to persuade them to try alternatives to the car. First developed by Werner Brog at SocialData in Germany, the technique has since been tried at several locations including Perth, Western Australia; London and Edinburgh with some significant results (see DfT, 2005b for a review of these schemes).

In addition to the trends directly affecting travel plans and the transport agenda, it is also clear that such a shift towards this neighbourhood-based model of service delivery is not just confined to the transport sector – for instance policing and health care have been moving to such a devolved model for a number of years. Until now though, transport has usually been an absent voice even in such policies as the Sustainable Communities programme, run by the Department for Communities and Local Government.

Structural Finally, there is a fourth dimension which is rather less visible and far less linear in its development (and therefore does not appear in the following figure as a dimension). This concerns the degree to which the travel plan is integrated within the structure of an organisation. Therefore, travel plans tended to be first developed within Transport, Facilities or Estates departments and so consequently did not tend to be taken seriously within the organisation a whole. Indeed, it is only with the support of Personnel, Corporate Social Responsibility, Environment and (especially) Finance departments that travel plans are likely to reach their true potential.

Possible Future Directions for Travel Plans

Based on the above observations, it is therefore possible to plot how these steps have occurred (see Figure 12.1). Moreover, these stepping stones actually seem to lead towards a possible future policy destination, whereby travel plans continue to develop until:

- They cover all segments.
- They apply to all proposed and existing organisations (the logical extension from covering all proposed developments as they will in London from 2007 and from them being mandatory for all NHS and Government Department buildings).
- They apply to increasingly comprehensive local networks or groups that apply across all segments on a neighbourhood basis.

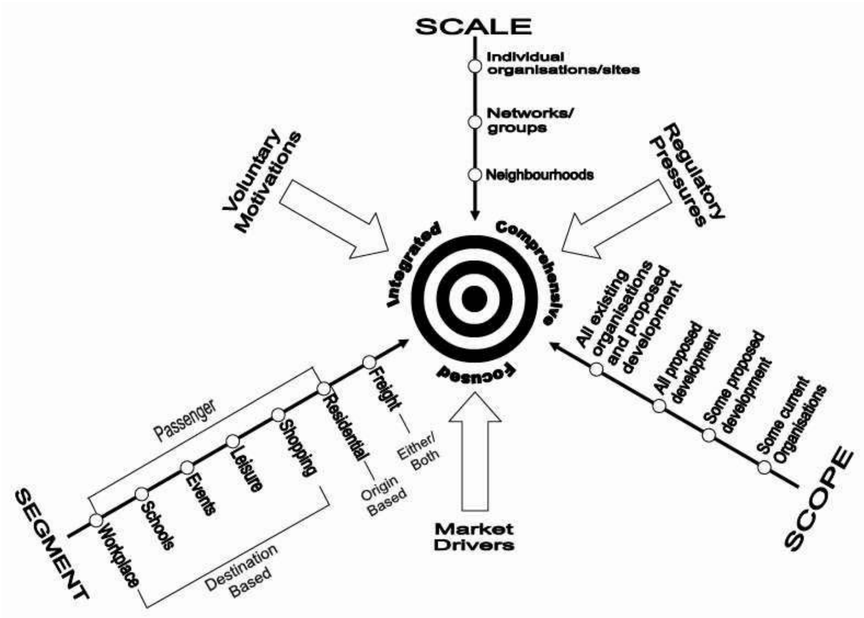

Figure 12.1 Mapping the development of travel plans in the UK

In other words, travel plans could potentially switch from being a very niche tool not just to being a mainstream mechanism of transportation demand management, but to being the primary means of delivering transport policy within a local area or neighbourhood. However, this will only happen if the UK Government dramatically changes its approach to travel plans and sees them as this delivery mechanism, rather than as the marginal tool as currently.

Future Policy Implications

In terms of future implications for policy, such an adjustment to this neighbourhood development approach may finally allow Government to deliver its sustainable transport policy agenda in a more joined-up and integrated way – rather than in the age-old mode by mode approach.

For instance, in London the Local Implementation Plans (LiPs) (equivalent to Local Transport Plans outside the capital) are currently made up of sections considering walking, cycling, parking and so on, and travel plans independently of each other. Instead, LiPs could seek to consider local transport issues as a whole on a neighbourhood by neighbourhood basis (involving local stakeholders perhaps from some kind of local transport network), look at the authority-wide strategic decisions, and then consider the interactions before finalising the details.

In this way, perhaps travel plans may finally realise their true potential as the default delivery system of transport demand measures at the neighbourhood level.

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