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Moving urban Australia: can congestion charging unclog our roads?

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Foreword

Our road networks are vital conduits, facilitating productivity growth and empowering society to enjoy increasingly diverse and fulfilling lifestyles. But, with strong economic and population growth, cities are finding it increasingly difficult to ensure that road capacity keeps pace with traffic levels. As a result, road congestion is a major problem in many urban areas—one that is projected to get considerably worse.

Congestion charging is gaining favour internationally as an option for dealing directly with rising congestion costs. While there has been a number of successful congestion charging schemes around the world, it was the introduction of the London scheme in 2003 that focussed the world's attention on congestion charging as a traffic management option.

Transport is not alone in utilising advances in technology to enable direct time-of-use charging for community resources: water and electricity charges, for example, are increasingly reflecting fluctuations in supply and demand. However, with congestion charging for transport there is also the twin attraction of revenue generation and environmental gains.

This report reviews the case for congestion charging and provides a policy framework for assessing charging systems. At this time, congestion charging schemes are still in their infancy and evolving in concert with changing policy priorities and system technologies. While individual circumstances determine when and where congestion charging is in the interest of the wider community, some important general lessons can be drawn.

The authors are grateful to those who have assisted in the development of this report. In particular, David Starkie provided constructive comments, in his role as an independent reviewer of the draft report. Mark Harvey contributed Appendix A and Quentin Reynolds provided valuable insights. David Mitchell assisted in the final stages of preparation of the report. The authors, Lyn Martin and Peter Kain, also recognise the generous contributions of their colleagues.

The report has been prepared under the guidance of Phil Potterton.

Phil Potterton
Executive Director
Bureau of Infrastructure, Transport and Regional Economics
October 2008

At a glance

- High and increasing urban traffic congestion costs and the declining effectiveness of established congestion management strategies are a major concern internationally.
- Congestion charging is gaining favour as an enduring solution that directly targets congestion, has strong theoretical foundations, has worked well in key cities and provides an 'innovative source of finance'.
- A small number of schemes have been introduced following London's foray: many more are being considered.
- Congestion charging is often judged on its financial, political and/or technical success. However, it is its economic success that ensures that it will be in the community interest.
- Analysis shows that the economic success of London's scheme is highly sensitive to the choice of parameter values, particularly the 'value of time' used to estimate the value of travel time savings of road users.
- The policy relevance of congestion cost estimates depends critically on how it is measured.
- Choice of technology determines both the economics of a scheme and its political acceptability. Cordon charging is likely to prevail over the more costly area-charging (as adopted in London). Common use of the more versatile, global positioning systems may still be a decade away.
- Gaining community support can be difficult and costly, particularly if the use of the revenue generated from a scheme is not subject to standard public finance evaluation processes.
- High implementation costs can undermine congestion charging.
- Existing congestion charging schemes are confined to small areas within cities or links to those cities.
- The gains from a scheme depend on behavioural change for which Australian cities may not be well-placed, due to insufficient coverage of high quality public transport services.

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Executive summary

The high cost of traffic congestion is of increasing concern

The continuing rise in incomes and population in urban areas has led to a steady increase in motorisation. Where network capacity has failed to keep pace, congestion has become a major issue. Estimated costs of congestion are high and forecast to increase dramatically in many areas. Further, there is widespread concern that the potency of established methods for dealing with congestion has diminished. These dual pressures have fuelled interest in congestion charging.

Momentum is building for congestion charging schemes

Roads have been tolled for centuries. In recent times, particularly on bridged estuaries, higher tolls apply during peak periods. Also, for more than a decade, tolls on some US roads have varied with levels of congestion.

Charging for road links and estuarial crossings is technically easier than the cordon charging approach, adopted in cities such as Singapore and Stockholm, or the area-charging approach, adopted in London. With cordon charging, the charge relates to crossing a cordon; with area charging, variable charges are levied over a zone consisting of a network of roads within a cordon, rather than a single road.

Singapore pioneered cordon charging in 1975, with its paper-based scheme; it was upgraded for electronic tolling in 1998. However, it was London's high profile area congestion charging scheme, introduced to a zone in Central London in 2003, that has brought congestion charging to the forefront of international policy debate. British and US cities have been encouraged to consider charging schemes by significant grants from their national governments.

The twin influences of London's example and national government's financial 'carrots' have made congestion charging an integral part of established policy thinking.

Point-of-use road charges during periods of heavy congestion have been introduced to the central parts of other cities, such as Rome, Dubai, Milan and Valletta, and are under active consideration in many other cities.

Congestion charging can produce economic, engineering, financial and environmental benefits

Implementation of congestion charging schemes in key cities has added to international interest in the policy option. Theoretically, congestion charging can ensure that interests of individuals coincide with those of other road users, by making them more aware of the full cost of road use during congested periods. Because it can discourage low-value usage, congestion charging can improve traffic flow and throughput, ensuring more efficient utilisation of road space. In turn, this can reduce pressure for capacity expansion. 'Bonuses' of congestion charging include the revenue generated for public budgets and the environmental benefits—fuel use is reduced and so both ambient and global emissions decline.

Congestion charging is not a cure-all

Congestion charging targets 'recurring' congestion—the predictable excess of demand relative to available road space. An element of predictability is important as it allows road-users to make considered decisions about their alternative routes/modes, travel times and whether they travel at all. Often, severe congestion can be relieved when just a small proportion of travellers abandon travel at that time.

Congestion charging schemes do not directly address 'non-recurring' congestion, such as that due to accidents and bad weather. However, congestion due to irregular/unpredictable events will be worse when the underlying level of congestion is high. Hence, where congestion charging reduces the base level of congestion, non-recurring congestion should be less severe.

Financial, political or technical success does not guarantee economic success

To ensure that a scheme is in the interest of the wider community, it is important that it be assessed on its economic merits. The political, technical and fiscal success of a scheme are clearly relevant, but can often be in conflict with economic success. For instance, a scheme can be a fiscal success because it generates significant revenue and a political success because that revenue is used to appease the relevant electorate. However, it can be an economic failure, partly because the revenue generated by the scheme is not a gain to the community overall but rather a transfer between community members. And, the accompanying capital and operating costs of the scheme represents a real resource burden on the community.

Technically, there can be a great deal of uncertainty associated with scheme costs and benefits. While the costs of implementing a scheme are transparent and reasonably unambiguous, the costs in terms of the behavioural change brought about by the charges are not. Perhaps more importantly, the uncertainty around scheme *benefits* is even greater as they depend critically on the estimated time saved and the value attributed to that time. Objective measures of the value of time produce disparate and ambiguous results. Hence, sensitivity analysis—that is, determining how sensitive the economic outcome is to the underlying assumptions—is critical for sound governance.

Misallocation of the congestion charging revenue can undermine scheme benefits

There are many pitfalls for implementers of congestion charging schemes.

Even a scheme that can be justified at the evaluation stage as being in the community interest can be undermined if the revenue is regarded as a windfall gain and its allocation is not informed by considered judgements.

It is difficult to generalise about how the congestion charge revenues are best spent. A necessary (but not sufficient) condition for ensuring that a scheme benefits the community is that traffic is reduced relative to what would have otherwise occurred. This requires a behavioural change—something that is more likely to occur when the motorist has practical alternative routes, modes or travel times.

Erroneously, this link between scheme benefits and behavioural change is often used as a blanket justification for funding alternative travel choices, notably, for public transport. There is no intellectual rigour behind this—standard project evaluation processes should still be applied.

The policy relevance of congestion costs depend on how they are measured

'Top-down' congestion cost estimates can alert authorities to general trends in travel flows. However, the magnitude of these costs depends on the bench marks adopted. Many cost estimates use unrealistic 'free flow' speeds as a benchmark. However, as noted by the European Conference of Ministers for Transport (ECMT), free flow is an unaffordable goal for peak-hour traffic. Thus, congestion costs based on this measure have little, if any, policy relevance. A similarly unrealistic benchmark is where actual speed is compared to posted speed limits.

The ideal benchmark is actually speed against theoretically 'optimal speed', reflecting not only traffic levels and value of time but also the cost of implementing a congestion charging scheme necessary to achieve the optimal level of congestion.

Hence, while top-down estimates assist by focussing policy attention, they provide little in the way of policy guidance. Robust and reliable congestion measures require a 'bottom-up' approach. This approach has significant data and resource requirements as it involves aggregating the cost of congestion for each road link. Advances in modelling and computer technology may reduce some of the resource requirements: the data issues would then become paramount.

Gaining community support for a scheme can be difficult and costly

Gaining community support is as essential as it is difficult. Use of the congestion charge revenue is clearly a critical factor in influencing community attitudes, as is coordinating the scheme to coincide with improvements to travel alternatives. In most, but not all, cases studied, schemes gain favour after their introduction. However, even where congestion charging schemes would promote the interests of the wider community, the challenge of communicating such gains can be prodigious.

Rules for setting charges should be transparent

The rules determining congestion charge levels and structures should be transparent to reassure the community that charges have sound foundations and are not simply another motoring tax. For instance, rules can specify the level of congestion that triggers a rise in charges. This is the case with California's 91 Express Lanes, where an objectively measured and sustained increase in congestion activates a given rise in tolls. Similarly, the charge to enter Singapore's city centre and use some expressways is regularly revised using explicit criteria specified in terms of target traffic speeds.

In contrast, London's charge increased from £5 to £8, despite an initial commitment to maintain the £5 charge for the first 10 years of the scheme.

When setting the charges, there will always be a compromise between ease of understanding (facilitating community acceptance) and setting the charges to accurately reflect the congestion externality (the time and other costs that motorists impose on other road users). Those practical considerations include the ability to estimate an ever-changing monetary value of the average externality that reflects all road users; and setting a fee structure that would-be road users can readily comprehend and respond to. With technological developments, charging could be finely tuned to congestion levels, with road users needing to understand only the 'shape' of the charging structure and level in order to respond readily to the charging signals.

Congestion charging schemes should be designed at a local level

The management of an urban area is complex, involving coordination between many dimensions including land use, public transport, infrastructure investment and traffic management. If a single local authority had responsibility for all these aspects impacting on transport then policies could be tailored to reflect local characteristics and priorities. This would increase the likelihood of a successful outcome. For these reasons, there are significant gains from congestion charging being locally-based rather than nationally-coordinated.

If multiple layers of government are involved, the costs of coordination and of the extra administrative layer (to standardise the congestion charging as a traffic management tool) could undermine scheme success. To succeed, it is essential to customise charging frameworks to reflect local characteristics and priorities. There is no single 'right approach to congestion charging'; attempts at coordinating charging schemes across non-contiguous local authorities are likely to be counter-productive.

There is no 'one size fits all' in congestion charging schemes

Location characteristics determine the suitability of an area or facility for congestion charging. Internationally, there is great enthusiasm for transplanting the success from one urban location to another. However, whether an area or a facility is a good candidate for congestion charging is very location specific: traffic levels, flow patterns, alternatives to driving and reasons for travel all impact on the success of a scheme.

Urban configuration is a major determinant of success. A scheme suitable for a concentrated city centre with limited access points and where, say, over 80 per cent of the commuters use public transport may have no relevance for a city with different urban form and transport options. Thus, it is crucial that rigorous location-specific evaluation of congestion charging schemes (including sensitivity analysis) be undertaken. Australian policy makers therefore need to keep this in mind when observing overseas experiences.

High implementation costs can undermine congestion charging

Alternative, lower cost options for reducing congestion can appear lacklustre when compared to congestion charging. However, as London's scheme demonstrates, congestion charging can be resource hungry, absorbing a considerable share of the revenue raised. The Dutch authorities have explicitly recognised the risk of high implementation costs threatening the efficiency gains from a congestion charging scheme. To this end, they have set an upper limit of 5 per cent of revenue for the cost of a national scheme. On current experience of prevailing scheme costs, such a scheme could be a long way off.

Added features of congestion charging

Behavioural responses to congestion charging generate valuable data for road investment and other infrastructure improvements. Minimal behavioural change in the face of non-trivial charges would indicate a high willingness to pay for road access—information that can only be inferred in the absence of a charging regime. In other words, as a direct-charging system, congestion charging provides reliable information about network users' behaviour. The most important information conveyed is the value placed on travel at different times of day. This helps determine whether the most efficient option is to allow increased congestion, to increase charges or to expand capacity.

Congestion charging can also deal with policy concerns regarding induced travel following infrastructure improvements. Fears that the gains from capacity expansion will be 'undermined' by additional traffic would not be an issue with congestion charges since, in principle, individual road users would be confronted with the social cost of their travel. The level of usage would then be regarded as socially optimal, even if it were higher than that prior to capacity expansion.

Link between congestion charging and public private partnerships

In some countries, a strong link has developed between public-private partnerships and congestion charging. In particular, the private partner undertakes to provide road capacity for which a variable road toll is levied. Such partnerships may reflect a desire to capitalise on the expertise of the private sector and to shift risk to that party most able to manage it. It may also reflect political expediency—authorities may prefer not to be seen to impose higher charges during periods of high demand. However, overlaying congestion charging on public-private partnership (PPP) contracts adds considerable complexity. Such contracts need to be written to suit both parties but also to be in the long-term interest of the community.

One downside of PPPs is that they can constrain authorities' capacity to take a coordinated network approach to traffic management and so may undermine congestion-relieving strategies. Indeed, given the current exploratory nature of congestion charging and the uncertainty associated with the direction and speed of technological developments, caution is required before making long-term commitments that involve losing direct control of key parts of the road network.

The characteristics of Australian cities are generally not conducive to area or cordon charging

Australian policy makers have observed the experiences with facility charging in North America and with zonal charging (London's area charging and cordon charging in cities such as Singapore, Rome, Dubai and Valletta). The temptation will be to infer that such perceived or arguably real 'success' provides a policy backbone for its application in Australia. That is not the case. The lack of thorough analysis and unambiguous conclusions about these schemes should send warnings to policy makers.

Declining technology costs might make zonal charging a more practical policy option in future years. Innovative ideas—such as the Oregon Concept in the US—illustrate the need to monitor international developments. That said, the zonal schemes to date apply to a very limited area in the centre of the cities. Even the costly London scheme applies to under 3 per cent of the city area. There is no evidence that these schemes could be effectively applied to a larger area in Australian cities.

There are rapid developments with congestion charging, which policy makers should monitor. For instance, Manchester contemplated a very different approach to cordon charging, using a double (inner and outer city) cordon and 'tidal' charges (applying to inbound traffic during the morning peak and to outbound traffic during the afternoon peak).

This example illustrates one way in which scheme implementation is very location-specific, both within a city and between cities. Zonal charging schemes work best in city centres, where viable alternatives to private passenger vehicles are strongest. But in Australian cities, those public transport alternatives are relatively weaker, even in city centres. The nature of the city and urban form makes it extremely costly for alternative modes to play a significantly larger role. Without those viable alternatives, the key to successful congestion charging—behavioural change—would be lacking.

The technology and practicalities for facility charging—as applied in North America—are relatively better, though political realities will probably mean that such charges would only be applied to new or significantly upgraded roads.

In general, however, the merits of congestion schemes, whether applied as facility charging or zonal charging, are location-specific. Thus, policy makers should not draw inferences about the merits of applying congestion charging in a given city from the performance of a similar scheme in another city or road link. This policy instrument has a number of virtues that could assist in decongesting our networks but there are considerable hurdles that need to be overcome for its practical and successful application in Australia.

Chapter 1 Introduction

For all its vast expanse of country, Australia is highly urbanised with more than two thirds of the population living in and around a capital city and two fifths living in either Sydney or Melbourne.[1] Economic prosperity has also brought with it continuing increases in traffic—significantly outpacing increases in road capacity, and so increasing congestion.

The heart of our concern with congestion is that it degrades our mobility. We travel to enrich our lives, tapping into the benefits that come with social, entertainment, labour force and commerce linkages. Thus, as noted by the European Conference of Ministers for Transport (ECMT), 'what value (and benefits) mobility delivers lies in the activities that mobility enables' (ECMT 2007, p. 30).

Because congestion reduces our mobility, the quality of our lifestyles is devalued. It makes journey times longer and less reliable and leads to stressful stop-start vehicle operation; this imposes costs on driver and vehicle (wear and tear, increased fuel use and pollution) and on the environment. As Downs observed:

> One thing all global cities will have in common over the next several decades is rising traffic congestion. Moreover, that condition will have immense impacts on the quality of life, not only in those cities, but across the whole globe (Downs 2002).

Alarm over current and projected levels of congestion is widespread and policymakers are searching for solutions. For instance, in September 2005, the then Victorian Treasurer, John Brumby, announced the introduction of a 'congestion levy', an annual charge for off-street long-stay parking spaces within Melbourne's central business district (CBD). He stated that:

> Traffic congestion is a 21st Century challenge … Governments around the world are grappling with how to maintain a city's accessibility, while reducing traffic congestion and related environmental impacts (Brumby 2005).

In February 2006, the Council of Australian Governments (COAG) identified congestion as a major issue and agreed to pursue policies to:

> … reduce current and projected urban transport congestion, within current jurisdictional responsibilities, informed by a review into the main causes, trends, impacts and options for managing congestion focusing on national freight corridors (COAG 2006).

The impetus for policy initiatives to tackle congestion arises from personal experiences with congestion and from the quantification of 'congestion costs'.

The commonly accepted costs that are quantified include time delays to road users, incremental fuel costs arising from congestion, and loss of reliable travel and freight movement. The aggregation of these costs is always a very large monetary value, creating pressure for policy solutions. For instance, the cost of traffic congestion in

1. In 2001, 87 per cent of the population was classified as living in urban areas (ABS 2001).

Australian capital cities has been estimated to be $9.4 billion in 2005, rising to $20.4 billion by 2020 (BTRE 2007, p. xv).

In the United States (US), congestion costs are estimated at over US$78 billion a year, with the average peak-hour traveller experiencing a tripling of the annual delay costs over the past two decades. At a time when policy focus is on energy security and efficiency, there is further policy concern with congestion in the US due to wasted fuel: the increased congestion is estimated to consume an extra 2.3 billion gallons (8.7 billion litres) of fuel as engines idle in traffic jams or operate at sub-optimal speeds (Mallett 2007, p. CRS-46).

The European Commission's view is that:

> … congestion is the scourge of European cities … the costs of traffic congestion are enormous. In the European Union (EU), the total costs of road congestion have been estimated at around 120 billion or some 2% of gross domestic product (GDP) (European Commission 2001).

Rising vehicle numbers, which is a reflection of population growth, and vehicle usage are two key factors in rising congestion. That is, the growth in vehicle numbers and usage is the underlying cause of escalating congestion costs. For instance, in the Netherlands, current congestion costs have been estimated at $1.4 billion per annum (LogicaCMG 2003). Vehicle numbers have gone from 30 000 daily in 1970 to 70 000 in 2000 and increased by another 10 000 since then (World Highways 2006b).

The first systematic analysis of urban congestion in Canada estimated congestion costs in the range of $C2.3 billion to $C3.7 billion per year (in 2002 dollars).

As with other studies, in other countries, time lost is the main congestion cost, in this case being more than 90 per cent of the cost (Transport Canada 2006, p. i).

In Japan, the estimated cost of congestion in Tokyo's city centre is almost ¥5 trillion or around US$50 billion (Sato and Hino 2005, p. 608). Developing countries are facing similar issues. Reports from Beijing indicate that, despite a 30 per cent increase in capacity, rapidly growing car use is projected to result in heavy congestion with average speeds in the city centre around 20 kilometres per hour by the end of this decade (World Highways 2006a).

Traffic authorities are skilled at dealing with urban congestion and have a number of policy options. However, there is widespread concern amongst these authorities and policy makers that the potency of these policy options has diminished and that more radical measures are called for. Thus, because prevailing measures appear to be struggling to contain the upwards trend in congestion (principally through road capacity expansion), policy makers have looked for other options. In particular, attention has focused on the potential for congestion charging to either substitute for or to supplement the standard approaches.

The primary attractions of congestion charging for reducing congestion are its well-established theoretical economic foundations and the revenue stream that it produces.[2] It is perceived by non-economists that an economist will always advocate this approach. This is not the case.

2. The theoretical framework is presented in Appendix A.

There is a view that economists will always advocate congestion charging. This is not the case.

The other impetus driving widespread consideration of congestion charging is that advances in technology have made direct charging more feasible and reduced the burden on road users of the actual payment process. Major technical and political developments have moved congestion charging from an interesting academic issue, operational only in limited and unique conditions, to a policy option that is currently being seriously considered by dozens of cities and urban areas around the world.

The political sea-change that has led many cities to at least consider congestion charging is due, in particular, to London's introduction of a congestion charging scheme. Typical of this view are the following:

> The most practical and promising approach to reduce congestion that is gaining interest is charging fees on road users, i.e. congestion pricing (World Highways 2006a).

> From a users' viewpoint, congestion pricing would provide an opportunity for them to avoid the high costs of recurrent delays and unreliable travel conditions which they currently pay for with their time—by paying with money instead of time—for faster, more reliable and more predictable travel (ECMT 2007, p. 212).

The concept of setting differential prices according to the level of demand is not unique to roads. Other areas of transport, such as airlines, public transport and car rentals, routinely charge more during periods of high demand, whether over the day, week or the year. Similarly, parking spaces generally cost more during business hours. Higher charges are also used as a rationing device in the energy market and in the service sector, such as for holiday accommodation, restaurants and theatre tickets.

1.1 Defining 'congestion'

The success or otherwise of strategies such as congestion charging depend critically on how congestion is defined. There are a variety of definitions of congestion ranging from the inability to travel at the posted speed to the more abstract economic burden resulting from the 'congestion externality'.

The definition adopted is important as it will strongly influence both the estimate of congestion costs and the ranking of policy options to deal with congestion (see Appendix B). If congestion is defined as not being able to travel at the posted speed, then a reduction in the posted speed could make congestion disappear *even though there has been no actual change in traffic flows or travel time*.

Alternatively, when the focus is on total congestion costs estimated by multiplying average delay due to congestion by the number of road users, then the congestion costs will increase as population grows and the number of road users grows *even if the average delay facing each road user is unchanged*. With this definition, the only way to avoid an increase in congestion costs would be to reduce the average delay facing each road user.

Because of the sheer enormity of congestion cost estimates, it is important to understand how these numbers are derived. Without such insights, the congestion cost estimates have little meaning or policy relevance. One danger is that the congestion cost estimates will be drawn on to provide an indication of expenditure that could be justified to reduce congestion. For instance:

> Under various simplifying assumptions, it has been calculated that the maximum justifiable expenditure in 2005 to address the worsening road transport social costs could lie anywhere between $800 million and $11 billion in present value terms, depending on the social costs to be avoided (CIE 2005, p. vii).

Similarly, Betalen voor Mobiliteit (2006), suggested that, given an estimated cost of congestion of €1.4 billion per annum, then spending up to €140 million per annum could be justified if it reduced congestion by 10 per cent.

Thus, if congestion cost estimates are to have a significant impact on policy then it is critical to understand how the costs are derived. In this context, evaluations of congestion charging schemes depend critically on understanding what the 'congestion costs' mean. As we discuss later (in relation to the assessment of the success of the London scheme), the ex-ante and ex-post evaluations of congestion charging schemes depend critically on how congestion costs are measured.

For two of the main components of congestion costs, increased travel time and reduced reliability, there is no unequivocal value. Willingness to pay for travel time savings is normally used as a guide to the value that road users place on their time. However, measuring this is also fraught. As one analyst observed:

> Of course in any real travel population, values placed on and willingness to pay (WTP) for travel time savings differ widely from individual to individual and depending on circumstances of any particular trip (Mallinckrodt 1999, p. 1).

In practice, values are assigned to time and, in some instances, to improved reliability. The uncertainty inherent in these values become embedded in the congestion costs estimates. Hence, these estimates must be approached with caution.

The sensitivity of the outcome of a project evaluation to the parameters used can be accommodated by adopting sensitivity analysis as part of the scheme appraisals. For example, if there is dispute or uncertainty over the value of road-users time then it is important to know whether the viability of the project would be impacted by say, a small reduction or increase in the value attributed to time.

1.2 Report outline

This report reviews the international experience with congestion charging to distil the policy implications for Australia. This involves identifying the key issues and then analysing them within a consistent public welfare framework.

While many experiences will not be directly transferable, overseas experience invariably provides important lessons. For instance, why the London scheme, covering less than 3 per cent of Greater London (Figure 1.1), should have such an impact on the international debate when Singapore's scheme has been operating successfully for decades? The London scheme, along with the development of many smaller schemes including those of Stockholm, Rome, Dubai and Valletta, has significantly lifted the profile of congestion charging for roads. Numerous urban areas and roads are currently being considered as candidates for congestion charging. This report explores the underlying themes of both current and prospective systems.

While the principles of congestion charging remain unchanged, the scheme developments outlined in this report should be viewed as a 'snapshot in time'.

Chapter 2 reviews the prevailing strategies used to manage urban road networks and road use. Chapter 3 provides an overview of the rationale for congestion charges and some of the major implementation issues. Chapter 4 discusses the issues associated with community acceptance of congestion charging, and road user charges more generally. Chapter 5 presents the principles involved in determining the level and structure of congestion charges to meet the various, often conflicting, scheme objectives. Lastly, Chapter 6 draws all of the learnings from the foregoing material together into some policy lessons for (Australian) authorities evaluating congestion charging.

The report includes three appendices. Appendices A and B cover the economics of congestion charging and practical issues associated with measurement of the travel time savings arising from congestion charging. Appendix C provides a brief outline of various technologies either currently in use or applicable for congestion charging.

Figure 1.1 Location of congestion charging zone within Greater London

Note: Greater London area consists of London boroughs; congestion charging area (including the Western Extension) is shown in red colouring, river Thames in black.

Chapter 2 Prevailing strategies to manage congestion

Summary

- Options for reducing congestion fall into one of two categories: those aimed at increasing supply (enhancing road capacity) and those aimed at reducing demand (changing behaviour).
- Strategic expansion of road space is the critical determinant of traffic flows but this option faces mounting financial and political obstacles in urban areas.
- Technological developments in intelligent transport systems potentially provide cost-effective ways of reducing congestion.
- For a given level of traffic, reducing the demand for road space could be achieved if sufficient solo drivers abandoned their vehicles for car-pooling or high-capacity public transport.
- Measures to encourage higher vehicle occupancy can involve taxing single-occupant vehicles or rewarding high-occupancy vehicles (such as provision of high-occupancy vehicle lanes and public transport subsidies).
- In general, however, such strategies aimed at reducing demand for road space have had limited impact and are of doubtful cost effectiveness.
- Since it is becoming increasingly difficult to expand capacity and because of the limited cost-effective gains from indirect measures to reduce demand, policy makers should remain open-minded about a direct congestion-charging strategy.

For as long as there has been road congestion, there have been ways for dealing with that congestion. These strategies can be loosely grouped into two categories: those aimed at increasing supply and those aimed at reducing demand (or, to put it another way, those that target the infrastructure and those that target the users). This chapter reviews the primary strategies.

2.1 Increasing supply of road space

There are two basic ways of enhancing road space:

- physical expansion of capacity
- better utilisation of the available road space.

Physical expansion of road space

Crowded roads often trigger the expansion of road capacity, through the construction of new roads, the addition of lanes or through utilising the hard shoulder during peak-periods, as on some roads in England. Logically, if kilometres travelled increases faster than the space available, congestion is likely to increase. Congestion in the US has increased more where network expansion falls significantly behind growth in the demand for road space.

However, the number of lane kilometres added does not tell the whole story. Poorly selected expansion of road capacity may do little to relieve congestion. In contrast, the astute expansion of the network can make a major contribution to traffic flow. An internal or external bypass of a city can significantly relieve congestion. In Australia, the expansion of the urban motorways in Sydney and Melbourne has provided significantly faster travel options. In particular, the 2006 opening of Westlink M7, a 40-kilometre motorway through western Sydney provided a new route that avoided up to 48 sets of traffic lights and reduced travel time on the north–south trip by up to 40 minutes.[3] Illustrated in Figure 2.1, the M7 provided the 'missing link' in Sydney's orbital road network.

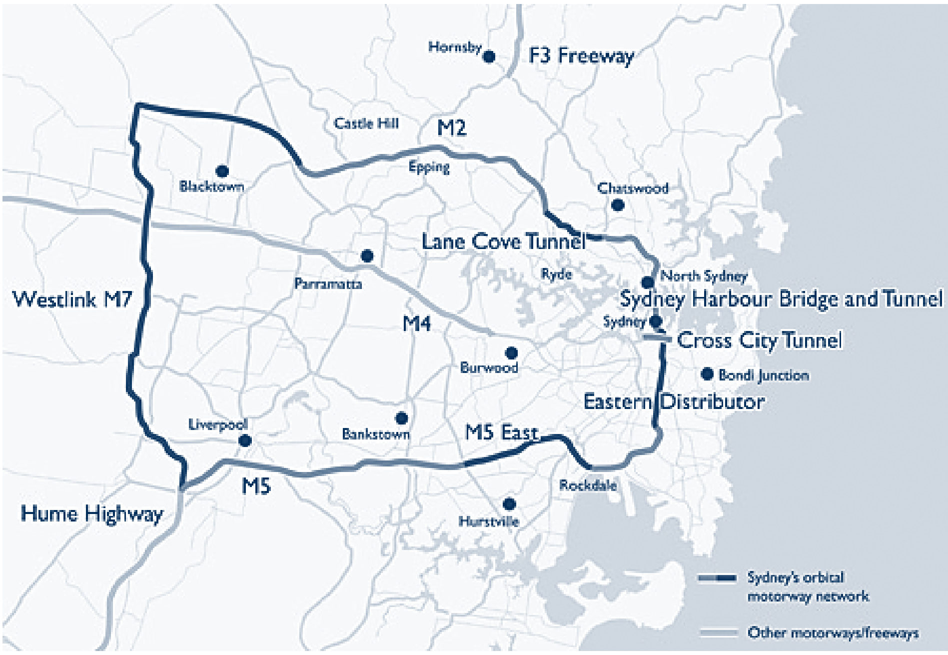
Such strategic expansions in network capacity can make a major difference to congestion. Thus, *despite traffic volume growth of around 45 per cent* over the past 15 years, the average peak hour speeds on the seven major routes to and from the Sydney CBD have hardly changed (NSW RTA 2006, p. 27).

Significant gains in traffic flow have also been achieved with Melbourne's 22-kilometre CityLink motorway (see Figure 2.2), connecting three major urban freeways that previously terminated at the edge of the highly congested CBD.

The story is echoed around the world. Britain's first major toll road in modern times, the M6 Toll, was built to relieve congestion on the M6.[4] Previously, the busiest section of the nearby M6 Motorway was carrying up to 180 000 vehicles per day—more than double its design capacity. The M6 Toll is reported to have reduced congestion

3. The M7 is also known as the Western Orbital.
4. The M6 Toll was previously known as the Birmingham Northern Relief Road.

on the route, halving travel time during peak periods between Birmingham and



Manchester.[5]

Figure 2.1 Sydney's orbital network

Source: NSW RTA (undated).

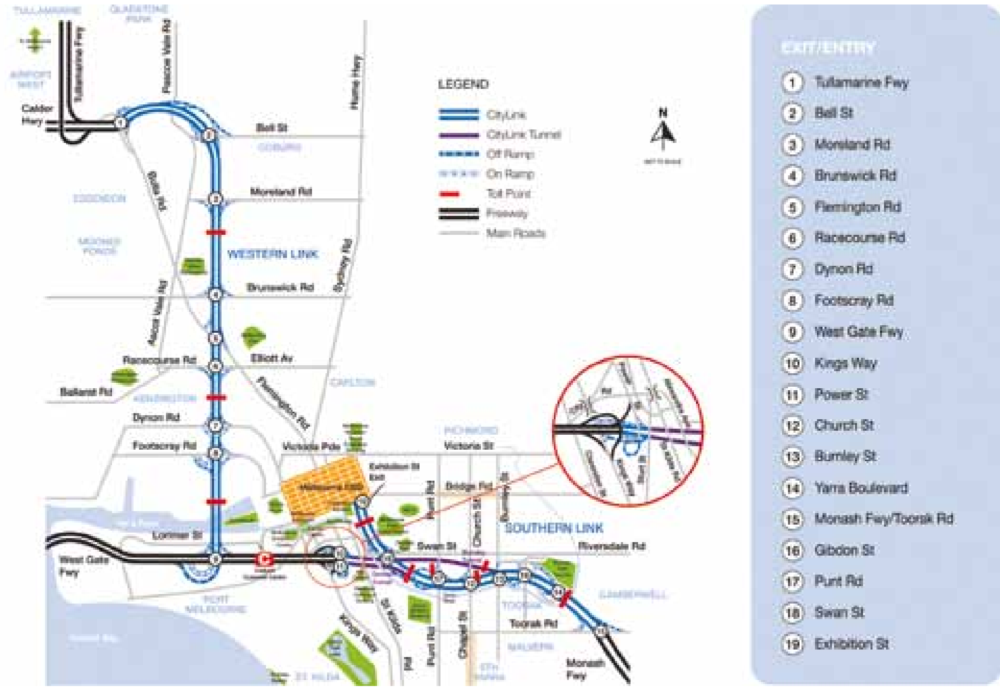
Similarly, Israel's aggressive road-building program is reported to have brought about a marked decline in congestion (World Highways 2006c).

The strategic expansion of road space is the critical determinant of traffic flow. Schrank and Lomax (2005), in a study comparing urban areas across the US, found that congestion grew faster when network expansion fell significantly behind growth in the demand. As noted by the researchers, 'areas that have added roads have seen congestion levels grow more slowly than other cities' (Schrank and Lomax 2005, p. 82). This is illustrated by Figure 2.3. The 53 areas where demand grew more than 30 per cent faster than supply exhibited the greatest rise in the researchers' congestion index.

The results are intuitive: other things being equal, the further capacity falls behind growth in road use, the greater the congestion. A 2006 report on Washington State, focussing on the Puget Sound region, found that the fundamental reason congestion was growing was the demand/capacity imbalance; vehicle miles travelled increased 91 per cent between 1980 and 2002 while roadway lane-miles grew by only 8 per cent (Poole and Soucie 2006).

5. There are discounts available for travel between 11 pm and 6 am ranging from 25 per cent for most cars to 12.5 per cent for trucks—see M6 Toll. It is not clear the extent to which these discounts have encouraged less peak-hour traffic and hence contributed to shorter travel times.

Figure 2.2 Melbourne's CityLink



Source: CityLink (undated).

Limits to expansion

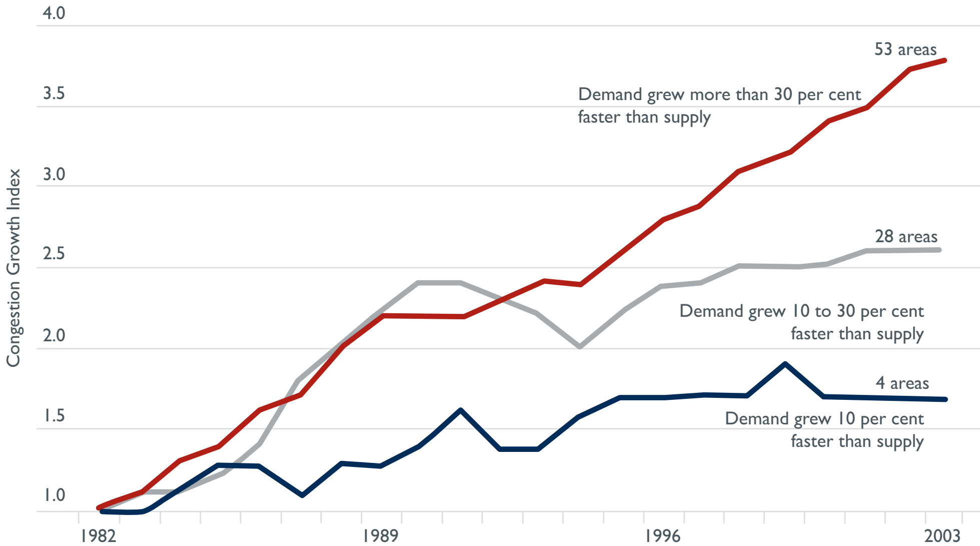
So, in principle, the solution to road congestion is to expand capacity. However, capacity expansion is not always an option. The Dutch Minister of Transport noted in 2005 that 'not all ambitions for the roadways can be achieved with investment alone' (UNECE 2004). The Economist put it more bluntly: 'there is no space, no money and no appetite for endless road-building' (The Economist 1997, p. 15).

The lack of space, money and political/community appetite are all related. These factors present major impediments to network expansion in many congested areas. The narrow streets of historic towns and cities do not lend them selves to lane-widening or completely new routes. The land needed for expansion is scarce and (therefore) expensive. The environmental ramifications are often unacceptable.

Singapore's urban form is an extreme illustration of the concern about land take. In that city, the roads have absorbed 12 per cent of the land, compared with 15 per cent for housing (Yap 2005, p. 2). In that context, it is perhaps not surprising that the city was one of the first to apply congestion charging.

Even at a national level, some argue that the land take of roads is unacceptable. Whitelegg estimates that the land take per kilometre of road is almost hectares. Further, offering the M6 Toll as an example, Whitelegg observes that 'new roads have large land requirements which must often be accommodated in tightly defined 'green' corridors' (Whitelegg 1994, p. 5).

Figure 2.3 US road capacity growth and mobility level



Source: Schrank and Lomax (2005, p. 55).

As land take increases, so does the cost of expanding capacity. For Singapore, an island with a land area of 700 square kilometres, it has been estimated that the cost of dealing with traffic growth by expanding the road network (instead of implementing their pioneering congestion charging scheme) would have cost around $S1.5 billion (Menon (2003, p. 124), quoting a World Bank study from 1984).

In theory, capacity expansion is justified when the marginal cost of congestion exceeds the marginal cost of expansion (see page 58). There will always be network expansion options that do not absorb land. These include deep tunnelling, 'cut and cover' tunnelling and double stacking of roads. However, these options come at a significant financial cost and, often, unpalatable environmental costs.

Nonetheless, despite apparently crippling levels of road congestion, it is not unusual for the financial cost of expansion to far outweigh the congestion costs, particularly in built-up areas. We note that the more built-up the area, the greater will be the community resistance and, thus, the lower the political acceptability.

A good illustration of this is the 1960s London Ringways plan advanced by the Greater London Council: the plan involved building a series of motorways in and around London to accommodate the expected growth in traffic. Public opposition was widespread, but particularly so for the route south of the Thames, Ringway 2, otherwise known as the South Circular. The local newspaper reported that '2,189 homes will be demolished and schools, churches, playing fields, sports grounds, swimming baths, public halls, allotments will be taken or affected to some degree' (C. Marshall undated). As noted on an unofficial British roads website: '… only way was to pick a line and follow it—to mirror railway lines and to buy up golf courses, and for the rest of the route, to draw a line and bulldoze every building that stood in the way' (CBRD undated).

Not surprisingly, the development of Ringway 2 incorporating the expansion of the South Circular did not proceed:

> … it is difficult to see any prospect of major investment to substantially alter the South Circular because of the cost, the wider environmental issues, the sheer unacceptability of the extensive compulsory purchase and demolition of house involved, the severance caused by a wide dual carriageway and the fact that the wider road would probably fill up with traffic within a relatively short period of time (Lewisham Council 2003).

Thus, there are escalating geographical, financial and environmental impediments that make it increasingly unpalatable for governments to exercise political fiat to bring about the network expansion that could temper the growth in congestion.

Overcoming capacity limits through public–private partnerships

For many years, privately-provided tolled roads and bridges have been a part (albeit, a small part) of road networks around the world. Public-private partnerships (PPPs) have been an extension of that private involvement, with the public sector contracting with the private sector to provide a facility that it, hitherto, might have undertaken. In this context, PPP contracts have been used as a mechanism to increase private funding and expertise into infrastructure provision. These PPPs rely on formal agreements between the entities, to allocate risk/responsibility and to protect the interests of the respective parties. This section considers this specific form of innovative finance and provision.

PPPs are attractive to budget-constrained authorities. But they introduce rigidities that inhibit congestion charging schemes.

The term 'innovative finance' for infrastructure often refers specifically to government partnering with the private sector to expand capacity. In the case of the Dulles Greenway toll road (discussed further at page 61), the private partnership option was adopted because it appeared to be the only option: the Commonwealth of Virginia elected not to construct the road and that 'if a private toll road was not to be built, there would be no road at all' (Commonwealth of Virginia 2007, p. 3).

A further illustration of such an agreement is the Oregon Innovative Partnerships Program, which:

> … was created to develop transportation projects for solicitation of private sector proposals for partnership and to respond to proposals initiated by private firms and units of government.

There is no doubt that the PPP option has appeal to authorities. Funding individual projects generally imposes no strain on the budget and the authority is absolved from the responsibility for introducing higher charges during the heavily-trafficked peak period.

However, PPPs introduce rigidities into tollway charging generally, and (in the context of this report) specifically in the gamut of congestion control management systems. In reviewing the Dulles Greenway operator's claim for raising tolls and introducing congestion charges, the State regulator acknowledged the inevitability of higher charges with the PPP:

> the case presents the private part of that partnership, and the piper must be paid (Commonwealth of Virginia 2007, p. 4).

The regulator regretted the need to increase tolls, but observed that bringing in a private partner introduces an important policy trade-off/rigidity when this financing approach is adopted:

> Almost 20 years ago, the Commonwealth made a series of policy decisions that leave us little choice to make the decision we make [to raise tolls] in this case. Those decisions led to a regulated private company constructing and operating the Dulles Greenway (Commonwealth of Virginia 2007, p. 2).

As that regulator noted, the attraction of PPPs is that they allow budget-constrained governments to bring forward infrastructure delivery. This is normally couched in terms of 'taking advantage of a greater range of financing options for network enhancement' and 'unleashing private sector investment resources'.

The opportunities for, and interest in, adopting PPP funding of infrastructure is growing. For instance, a change in legislation in the US has encouraged the wider adoption of PPPs. In April 2006, Georgia's Department of Transportation announced that it was considering a public–private proposal for four high-occupancy toll (HOT) lanes on the Georgia State Route 400, locally referred to as the 'Georgia 400'. Under the proposal put forward by the private Crossroads 400 Group, the US$1.4 billion project would involve a charge that varied with the level of congestion, ensuring free-flow traffic operating at the speed limit. The proposal calls for 51 per cent of funding from toll revenue and the balance from public money:

PPPs introduce rigidities in tollway charging generally, and congestion management in particular

> Message boards would announce the toll in advance. High-occupancy vehicles (two or more occupants) would travel toll free. Cars would be equipped with transponders, and scanners along the route would automatically track and bill usage to a credit card. The new lanes could cut 40 minutes off a mile stretch of roadway (Barry 2006).

PPPs are being considered elsewhere in the US to reduce congestion. In Georgia congested roads such as Interstate75/Interstate 575, Georgia 316, a highway in Atlanta, and another near Dallas/Fort Worth International Airport, have all been considered by private road builders as opportunities for implementing congestion charging to fund infrastructure expansion (Frankston 2005). In each case, the alternative free route would remain available.

Over the past few years, PPPs have become a mainstream instrument for expanding road capacity in the US. In 2006, the (then) US Secretary of Transportation, Norman Mineta, announced a national congestion relief initiative—'The National Strategy to Reduce Congestion on America's Transportation Network'—with congestion charging as a key element (Mineta 2006). The focus of the program was on 'Urban Partnership Agreements' in the major metropolitan areas.

An integral part of this approach is to encourage states to 'find ways to open up their transportation infrastructure to private investment opportunities'. Encouraged by the combined impact of strained State budgets and the threat that petrol taxes are untenable as long-term sources of funding, Mineta observed that this also suits the market since 'major financial institutions and their clients are expressing increasing willingness to invest billions of dollars in roads and airports' (Mineta 2006).

Mineta's successor, Mary Peters, has upped the ante considerably on use of PPPs, suggesting that using such partnerships are necessary and not an option:

> Attracting private sector participation and deploying market-based solutions to our transportation problems is not simply a laudable objective; it's a necessity. And it requires us in the Federal Highway Administration to adjust the way we approach our Federal-aid mission (Yakowenko 2007, Slide 4).

However, there are important trade-offs in policy application and private sector financial returns in private sector provision, whether that provision occurs through more traditional private toll roads or whether it be the 'innovative' PPP projects. As we noted with the Dulles Greenway example, there is a major issue of applying PPP financing while also supplying a public amenity with politically-acceptable tolls. Flat tolls are one political and regulatory challenge; a much greater challenge arises when managing road usage with targeted instruments such as congestion charging. A specific complication (or sensitivity) is the variable charge, which is naturally set highest during periods of peak demand.

The challenge of optimising the network is increased when PPP provision is adopted, as it alienates part of the network and reduces flexibility of network management.

In this context, the PPP seeks to protect public and private interests. While it may seem straightforward to create a contract between public and private sectors that allowed for variable charges, there are a number of difficulties:

- With the cost and performance characteristics of the technology changing so rapidly, it is extremely difficult to draw up a contract that anticipates the range of likely outcomes and ensures that benefits of technological developments can be shared with the community. Few, if any, road authorities are in a position to confidently anticipate the developments in technology over the period for which the road segment is held in private hands. While renegotiation of contracts is always an option, this is invariably costly and not necessarily successful. In fact, renegotiation of contracts is widely regarded as a sign of failure of the original negotiation.

- The benefits from congestion charging depend critically on the impact of the charges on the remainder of the network. If such charges encourage 'rat running', or diverting to uncharged and often lower standard roads, then the community may be worse off. Optimising network use is quite challenging in itself when ownership is concentrated. However, the magnitude of the challenge increases significantly when part of the network has been alienated and is beyond the direct control of the road authorities. While contracts will usually be written with a view to ensuring coordination of the network, it is inevitable that all changes in circumstances cannot be fully anticipated.

A policy issue, therefore, is that the use of PPPs for parts of the road network may constrain public authorities in adopting an optimal mix of road traffic management options (including congestion charging).

A case in point is 91 Express Lanes. Orange County had found itself powerless to prevent the deterioration of the alternative (free) SR-91 Freeway, adjacent to the private 91 Express Lanes.

Through removing the facility from private ownership, Orange and Riverside County public officials are now able to adopt a network approach to the road facilities, coordinating improvements for both the toll road and the Freeway. Riverside County's sales tax has been increased to pay for improvements in SR92 Freeway.

Non-compete clauses have also been a feature of the road PPPs in Sydney and Melbourne. These can severely constrain road authorities attempting to take an integrated approach to management of the road network.

An important downside of PPPs is that they constrain authorities in taking a coordinated network-wide approach to traffic management.

2.2 Better utilisation of the available space

The performance of a road is not only a function of its physical capacity but also of how that capacity is utilised. For instance, the NSW RTA reports that reductions in travel time have been achieved in the urban Sydney area through intersection upgrades and improved access to major roads on corridors and at specific locations (NSW RTA 2006, p. 28).

The appropriate application of technology can also be a major factor in the more efficient utilisation of existing capacity, thereby (effectively) expanding network capacity.[6] Intelligent transport systems (ITS) is the umbrella term applied to that technology. It can be used in both recurrent (excess demand based) congestion and in non-recurrent (caused notably by road accidents) congestion.

Application of new technology

The most significant factor in ensuring efficient utilisation of the network has been the continuing development and application of new technology, particularly intelligent transport systems (ITS). These systems cover a broad range but can generally be defined as follows:

> … the integrated application of computer, sensor, electronics and communications technologies along with transport management strategies to provide an integrated, safer, more efficient and more sustainable surface transport system (An Roinn Iompair 2006, p. 3)

This generally refers to the technology developed to monitor traffic and network performance, to facilitate strategic responses by road managers and to enable real-time communication with impacted parties. For instance, the Sydney Coordinated Adaptive Traffic System (SCATS) is estimated to reduce 'stops' by 40 per cent and travel time by 20 per cent, resulting in an associated 12 per cent reduction in fuel usage.[7]

6. While technology can be utilised to manage demand, such as through the imposition of charges, the focus in this section is on technology to effectively expand capacity.
7. For more details, see Tyco Integrated Systems (undated).

However, many of the technologies—such as traffic signal coordination and ramp metering—could be regarded as 'mature' in that their capacity benefits have already been heavily exploited. Hence, some argue that they offer only limited potential for further reductions in congestion. The contrary view is that there is still significant scope for broadening their application across the network. For instance:

> the network-wide deployment of fully-managed motorways (which actively manage demand across the system) and the associated operational strategies, including optimisation of arterial road signalised intersections represent a significant opportunity to improve efficiency and manage congestion (pers. com. D. Walsh, Queensland Department of Main Roads).

Current technology use aside, there remain many emerging technologies where applications have been limited to date and others in the pipeline that have the potential to reduce congestion.

Network-wide systems, using Global Positioning System (GPS) and/or roadside-detection technology, can also provide a critical tool in managing congestion. The technology allows accurate vehicle location and dynamic route guidance, such as adopted in China. The Beijing Transportation Information Centre has introduced an innovative system to monitor traffic flows using GPS chips in 10 000 taxis throughout the city. Real-time information is available to road-users to assist their route planning (see Box 2.1).

Box 2.1 China deploying GPS to reduce congestion

Since the introduction of a combination of a GPS technology and mapping system for Beijing in April 2006, drivers can track congestion on each road using colour coding: red for severe congestion, yellow for moderate and green for uncongested. The system then allows them to input their point of origin and destination, generating a route according to the pre-selected criteria (fastest, shortest or least toll). Distance and travel time is estimated and monitored with alternative routes being made available when traffic conditions change.

The web site received 300 000 hits *per day* during its first week of use and the Beijing Transportation Information Centre is looking to adapt the technology to mobile phones (see Staley 2007).

However, the two main drawbacks of such systems are:

- the prohibitive expense that impedes widespread network user uptake; and
- in some system designs, the delays in communicating the information to motorists.

Trials using data generated by mobile phone networks in conjunction with electronic mapping systems indicate that such a system has the potential to produce faster, more accurate and comprehensive traffic information at a lower cost. Furthermore, the privacy concerns associated with the 'big brother' style tracking devices are overcome as the signals collected from the mobile phone networks are anonymous. The technology was trialled in the Netherlands early in this century.[8] (For more details

8. Further detail is available at LogicaCMG (2003).

see Appendix C.) While recurrent peak-hour congestion provides much of the focus for policy makers, non-recurring—that is, congestion caused by irregular incidents—can account for a significant share of congestion costs. Hence, an important element of improving network utilisation is incident management.[9]

Incident management

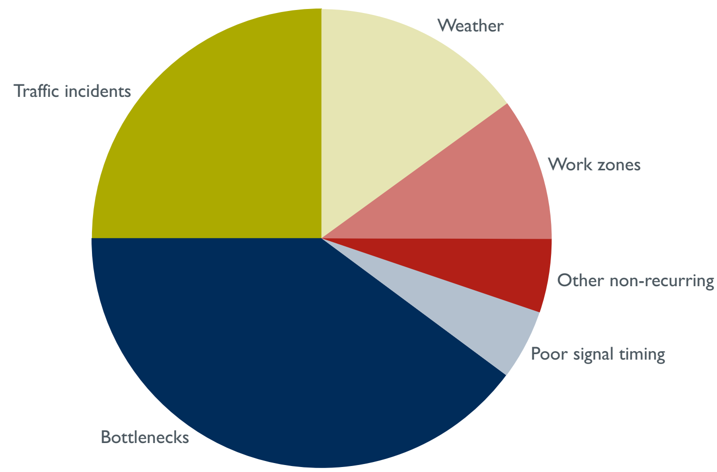
Non-recurring congestion caused by traffic incidents is a major source of congestion and one that is not addressed by new construction. This non-recurring congestion is estimated by one US road authority to account for approximately half of the congestion problem (Maryland DOT 2005, p. vii).

In the US, traffic incidents account for an estimated 25 per cent of congestion costs.

Incidents can cause congestion to increase in an unpredictable way. Being unpredictable, this can impose a greater cost per minute of delay on road users than the equivalent recurring congestion. As summed up by the (then) Secretary of Washington State Department of Transportation, 'the traffic congestion you experience as intolerable is often caused by 'incidents', not by inherent demand/capacity imbalance' (Macdonald 2006, p. 12).

While clearly the share of congestion cost caused by traffic incidents would vary between different networks and parts of the networks, in the US it has been estimated that traffic incidents account for 25 per cent of congestion costs, as illustrated by Figure 2.4. 'New construction does not address non-recurring congestion, which is approximately half of the congestion problem.

Figure 2.4 Sources of US highway congestion



Source: Derived from Cambridge Systematics Inc. (with Texas Transportation Institute) (2004, p. ES-6).

9. 'Incident' has been defined as 'any event that degrades safety and slows traffic, including disabled vehicles, crashes, maintenance activities, adverse weather conditions, special events, and debris on the roadway' (Federal Highway Administration 2002, p .6).

While this figure may seem high, we should note that incidents disrupt the steady flow of traffic, reducing road capacity. There is a multiplier effect in that the funnelling of traffic through an incident bottleneck magnifies the impact on congestion well in excess of the initial blockage. For instance, research has shown that an incident blocking one lane out of three lanes reduces the capacity of that facility not by one-third but, rather, by one-half.[10]

There is also a flow-on effect from any peak-hour incident in that it creates an important 'congestion tail'. The US Department of Transportation estimated that, 'in general, each minute of lane blockage creates 4 minutes of congestion after the incident is cleared' (DOT (US) undated).

If a lane is blocked when traffic flow is at or near the capacity of a facility the queue of traffic that accumulates behind the incident will not dissipate after the incident is removed until the traffic flow into the queue decreases—in other words until the peak period ends (DOT (US) undated).

Clearly, the more severe the congestion the greater will be the impact of an incident. The important issue is whether we can influence the impact of an incident on traffic flows. Efficient incident management—which seeks to reduce the impact of an incident—can be a powerful tool in congestion-reduction.

Efficient incident management can be a powerful tool in reducing congestion.

There are many incident-management strategies available and the combination adopted would depend on local circumstances. However, the common threads appear to be quick vehicle removal and improved communication between all parties. These fundamentals are illustrated by the US Department of Transportation's *Congestion Initiative: Focus on Incident Management*:

- encouraging individual states to adopt rapid driver removal ('Move It') laws[11]
- integrating inter-agency communications
- providing 24-hour provision of full-function service patrols to deal quickly with breakdowns on major roads.

Thus, efficient incident management, including the cost effective application of ITS, may play an important role in improving the capacity of a network.[12] Finally, we should note that congestion arising from irregular incidents will not be resolved by congestion charging systems.

Congestion charging will not resolve congestion arising from irregular incidents.

10. For further analysis of this relationship, see ECMT (2007, Table 8.1, p. 185).
11. The 'Move It' laws require individuals in non-injury crashes to move crashed vehicles out of roadways, if they can do so safely. Non-injury crashes accounted for about two-thirds of all crashes on US roadways in 2002.
12. As we discuss elsewhere in this report, the benefits of any congestion-relieving scheme must exceed the costs of applying the remedial action.

2.3 Reducing the demand for road space

Many policy measures aim to reduce congestion by discouraging the use of roads. For some policy measures, such as motoring vehicle taxes and charges, this discouragement is simply an unintended consequence of raising revenue or recovering costs. For other policy measures, such as 'anti-sprawl' policies, the discouragement is a key objective. For the purpose of this report, it will simply be noted that travel, in itself, is not a 'public bad' and so it is not inherently in society's interest that travel should be discouraged.[13] Steadily declining costs of travel have provided the community with unprecedented freedom to live, work and to pursue leisure activities in dispersed geographical areas. The days of 'living over the shop', walking to the only school available and marrying someone in the same valley are well and truly gone.

The issue facing policy makers is to ensure that travel is in the community interest. To do this efficiently requires clear and accurate price signals about the costs associated with the travel choices and with the substitutes for travel.

This section focuses on the separate set of policies that have the specific aim of reducing the demand for road use *during congested periods*. In general, these involve encouraging travel at different times, alternative routes, and/or other modes.[14] The general theme of these measures are designed to reduce single-occupant vehicle use and, preferably, to move as many commuters as possible to public transport.

Increasing vehicle occupancy

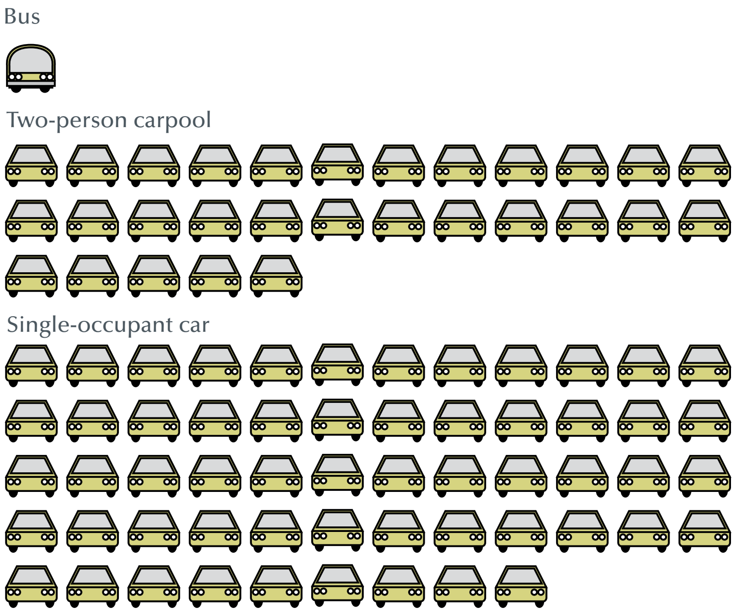
Congestion is about too many cars in too little road space. It is reasoned that if you could shift commuters from single-occupant vehicles to car pools, van pools or buses, the number of vehicles on the road would diminish, reducing congestion in the process. This logic is well illustrated by Figure 2.5, where 57 people can be carried either by one bus, 29 two-person cars or 57 single-occupant vehicles.

There are many ways to encourage high-vehicle occupancy: some will be by design and others will be an incidental side-product of other policies. Under the latter category, any government measure that increases the cost of motor vehicle use will encourage vehicle sharing. All developed countries impose one or more of the following fixed and variable taxes/charges on vehicle use: registration charges, stamp duty and some form of fuel tax. These taxes and charges normally have a dual role of recovering the cost of road provision and raising general revenue.

A by-product of these taxes and charges is an increase in the cost of vehicle ownership and use. This, in itself, encourages the shared use of vehicles, just as do higher fuel prices and road tolls. However, whether it is because of familiarity or their indirect nature, these taxes are not widely regarded by policy makers as an 'instrument of first choice' to change commuting patterns. The more popular approach is to reward directly high vehicle occupancy through high-occupancy vehicle (HOV) lanes.

13. We do note that suites of policies aimed at responding to 'Climate Change' often target reduced travel and other forms of consumption. We acknowledge, therefore, that these policies may imply that travel and other consumption might be considered to be 'public bads'.
14. While measures to encourage the uptake of 'telecommuting' do not neatly fit into these categories, it is probably as effective as subsidising movie theatre tickets during peak-hour traffic—neither will be pursued in this chapter.

Figure 2.5 Number of vehicles needed to carry 57 people



Source: Adapted from Canadian Ministry of Transportation (undated).

High-occupancy vehicle lanes

While Australian cities have some lanes reserved exclusively for high-occupancy vehicles—HOV lanes—they are widespread through the US.

The logic underlying HOV lanes is straightforward: if solo drivers are encouraged to car-pool to gain access to faster HOV lanes, this would remove cars from the road and congestion would decline. The (then) Secretary of Washington State Department of Transportation praised HOV lanes:

> HOV lanes in the right places are highly efficient, enhance the speed and reliability of multi-passenger vehicles and ease congestion in adjacent general purpose lanes (Macdonald 2006, Slide 8).

In the US, HOV lanes are commonly available to any vehicle carrying more than one person, including car-pools, van-pools, buses and taxis.[15] The lure of the lanes is a faster trip with a more reliable travel time, since fewer vehicles qualify to use the lane.

However, the unforeseen consequences of HOV lanes have caused a rethink of their role as a congestion reduction tool. There are two main issues: their apparent lack of effectiveness in generating a shift to high-occupancy vehicles and hence their impact on congestion levels in the other lanes.

15. Note that the use of the term 'high occupancy' is not to be taken literally since, it many cases, it means two or more occupants.

HOV lanes may not increase vehicle occupancy

HOV lanes owe much of their existence to the fact that they seem like a good idea, rather than analytical support for the hypothesis that they will bring about a significant change in commuter behaviour. There are two important steps in creating a case for HOV lanes. Firstly, a causal relationship needs to be established verifying that the HOV lanes will be used by former solo drivers, rather than simply grouping existing high-occupancy vehicles into HOV lanes.

Secondly, even if vehicles are now travelling with more occupants than previously to access the HOV lanes, the source of new occupant(s) is important. If the extra occupant(s) previously caught the bus or train, then the outcome is perverse in terms of the objective of HOV lanes. Public transport patronage has declined and the number of single-occupant vehicles in the general-purpose lanes is unchanged. Put another way, unless the additional occupants had abandoned their own cars, the results could be perverse for congestion reduction.

In general, HOV lanes have failed to get commuters to abandon their cars.

In general, HOV lanes have failed to achieve their objective of encouraging commuters to abandon their vehicles and join a car-pool. Research indicates that car-pools work more for families than for work colleagues. As one US analyst observed:

- while HOV lane-miles increased fivefold between 1990 and 2000 in the US, the fraction of commuters who car-pool declined from 13.4 per cent to 12.2 per cent;[16]
- between 33 per cent and 75 per cent of car-pool members (depending on the city) are members of the same family—hence are unlikely to have been influenced in their commuting behaviour by the introduction of HOV lanes; and
- vehicle occupancy is not only lowest for work trips but also lowest during commute hours (Poole and Soucie 2006).

Where HOV lanes prove to be ineffective in significantly changing commuter behaviour, then it is likely that they will add to total congestion, rather than relieve it.

HOV lanes may increase congestion

Macdonald (2006, slide 8) credited HOV lanes with providing a faster trip both for multi-occupant vehicles and for those in the adjacent general purpose lanes. This logic is commonly used to validate HOV lanes and to some extent is true—when the HOV lane is created from the construction of an additional lane.[17] This may come about through converting the median strip, the hard shoulder or building an entirely new lane. Unfortunately, the conclusion generally overlooks the fact that *if* the additional lane was not a HOV lane but, rather, a general-purpose lane, then the reduction in congestion could be even greater. The issue arises because of the common phenomena in the US of 'under-utilised' HOV lanes running alongside

16. It is a moot point whether the decline would have been greater without the increase in HOV lane miles.
17. If no new lanes were built, it would be highly unlikely for general-purpose lane traffic to move faster. It would require a significant decline in vehicles on the road, meaning a significant shift to higher vehicle occupancy. If the HOV lane reduced congestion on the road, this would reduce the incentive for road-users to coordinate their travel plans for multiple occupancy.

congested general-purpose lanes. That is, many drivers do not, or cannot, respond to the lure of a less congested lane in return for higher vehicle occupancy.

The outcome is that the existence of HOV lanes increases congestion. Research by the Transportation Research Centre at the University of California, based on 5 years of data produced by 26 000 sensors buried under the pavements of Californian freeways, left little doubt regarding the impact of HOV lanes (Varaiya 2005). The Centre found that the combination of under-utilised HOV lanes and congested general-purpose lanes meant that HOV lanes inevitably increased the *overall* level of congestion.

This pattern of under-utilised HOV lanes and congested general-purpose lanes is repeated across the US. The 'solution' to the under-utilisation has been to provide access to HOV lanes to toll-paying single-occupant ('driver only') vehicles, creating HOT lanes. HOV vehicles normally either travel free or at a discount in HOT lanes. By allowing toll-paying single-occupant vehicles to use the lanes, utilisation of the lane is generally improved.[18]

HOT lanes

The US Department of Transportation define HOT lanes as:

> … limited-access, normally barrier-separated highway lanes that provide free or reduced cost access to qualifying HOVs, and also provide access to other paying vehicles not meeting passenger occupancy requirements (DOT (US) 2003, p. 2).

By using price and occupancy restrictions to manage the number of vehicles travelling on them, HOT lanes maintain volumes consistent with uncongested levels of service even during peak travel periods.

Most HOT lanes are created within existing general-purpose highway facilities and offer potential users the choice of using general-purpose lanes or paying for premium conditions on the HOT lanes.

HOT lanes utilise sophisticated electronic toll collection and traffic information systems that also make variable, real-time toll pricing of non-HOV vehicles possible. Information on price levels and travel conditions is normally communicated to motorists via variable message signs, providing potential users with the facts they need in order to decide whether or not to utilise the HOT lanes or the parallel general-purpose lanes that may be congested during peak periods.

HOT lanes may be created through new capacity construction or conversion of existing lanes. Conversion of existing HOV lanes to HOT operation is the most common approach.

In 2008, US Transportation Secretary, Mary Peters, announced that Los Angeles would be eligible for more than US$213 million in federal Congestion Reduction Grants to convert 85 miles of local HOV highway lanes into HOT lanes by the end of 2010 (Peters 2008).

Converting a HOV lane to a HOT lane improves utilisation of the HOV lane and reduces pressure on the rest of the network. However, it is an empirical question of

18. While still providing a subsidy to HOV vehicles.

Box 2.2 San Diego's Interstate 15 Express Lanes

In October 1988, three reversible HOV lanes, for exclusive use during peak periods by car-pools (2+), van-pools, buses and motorcycles, were opened down the median strip of Interstate 15, one of the fastest growing freeways in San Diego.[a] In 1998, the lanes became available for driver-only vehicles, in return for a toll payment. This was one of the first HOT lanes in the US. Tolls vary with the level of congestion on the HOV lanes, with changes possible every six minutes to maintain traffic-flow targets on HOT lanes. Variable message signs located in advance of the entry points post the current charges, which generally vary between US$0.50 and US$4 but can be as high as US$8 if demand is high.

On average, approximately 75 per cent of the weekday traffic using the priced HOV lanes goes for free (vehicles with two or more occupants qualify as HOV).[b]

a. While California's 91 Express Lanes are often cited as the first example of a HOT lane in the US, it does not provide an example of a conversion from a HOV lane to a HOT lane, as it was built as the latter.

b. For more details on San Diego's Interstate 15 Express Lanes see Business, Transportation and Housing Agency, California (2002).

whether this outcome is an improvement over all general-purpose lanes. The answer will be location-specific.

In conclusion, in the researched applications of the system to date, network congestion increases because the HOV lanes are under-utilised. Studies also show that much of the observed usage of HOV lanes is by groupings of existing HOVs onto that lane rather than an actual behavioural change (which is needed if congestion is to be ameliorated).

Increasing public transport usage

The other major policy strategy aimed at reducing demand for road capacity involves promoting public transport as an alternative mode. Improvements in public transport are often coupled with congestion charging. Subsidising public transport is commonly justified on the grounds that it reduces congestion.

The logic of promoting public transport usage is straightforward: if some motorists shift to public transport there will be fewer cars on the road and hence less congestion. Public transport use in preference to private motor vehicles is also advocated as having added health benefits: reduced emissions as congestion declines; and because public transport users tend to walk more than car users.

However, in many cities, public transport has declined to become only a small proportion of trips. Furthermore, it has proved difficult to achieve a significant mode shift from car to public transport as public transport usually provides a poor substitute to car for door-to-door trips. Indeed, as the ECMT has noted, this task becomes increasingly difficult—even with significant road congestion—as other aspects of private transport quality improve:

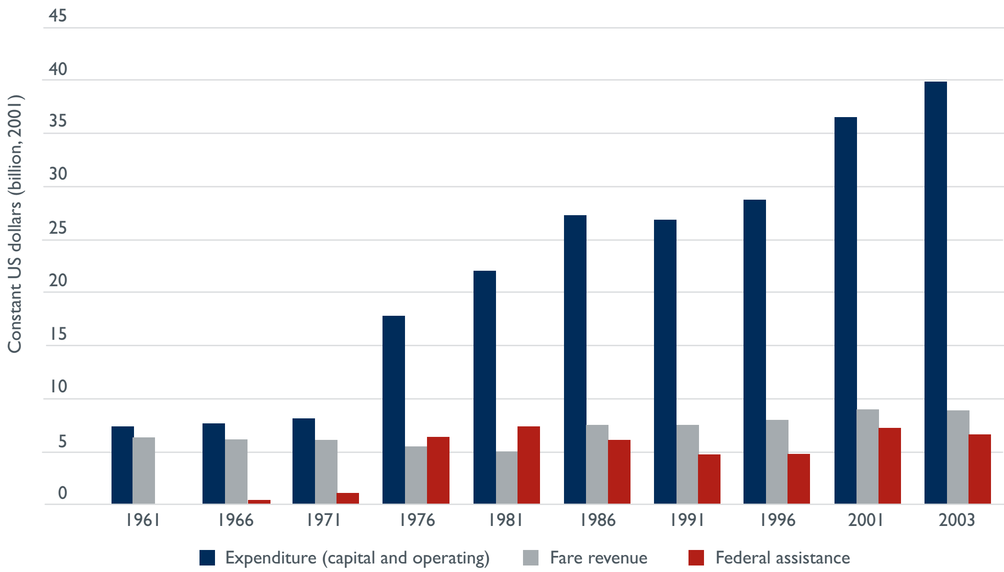
> On-board entertainment systems, advances in vehicular comfort, mobile communications and computing have all contributed to making the drive alone experience something that many look forward to, rather than dread. If transport authorities ignore this factor, they may find themselves puzzled at the remarkable resilience of demand for car-travel even in consistently congested conditions (ECMT 2007, p. 36).

Governments' strategy for assisting public transport to be an attractive alternative to the motor car has had limited impact in ridership—and it has come at a very high price. The significant increase in public transport funding in the US in the latter part of the twentieth century (as illustrated in Figure 2.6) has not been matched by a concomitant increase in patronage.

Public transport usage has increased in London following the introduction of the London Congestion Charge. However, it is debatable how much of the increase is due to the charge. Three other important factors account for at least some of the increased patronage: strong economic growth over a sustained period, growth in both domestic and international tourism and major enhancements to the bus service, albeit financed by the revenue from the congestion charge. Indeed, the increased expenditure on public transport associated with the charge has resulted in the total subsidy growing faster than patronage levels, leading to an increase in the average subsidy.

Impediments to car drivers switching to public transport tend to be similar around the world. Public transport offers different service characteristics to private motor vehicles. The convenience and perceived personal safety of car driving is usually preferred to using public transport. Further, as incomes rise, individuals increase their private motoring at the expense of public transport usage. However, public transport can become more attractive with the application of technological advances: real-time timetable information available at transit stations, payment through multipurpose stored-value cards and Internet and mobile phone access to location-specific timetables. The difficulty facing public transport operators is that, in parallel with these improvements, private-vehicle travel also becomes more attractive as communication technology enables travel time to be both a more comfortable and more productive experience.

Figure 2.6 Annual public transport expenditures, fare revenue and Federal assistance, 1961–2003



Source: Adapted from Transportation Research Board (2006, p. 36).

Personalised promotion of alternatives to solo driving

There are a number of established information-based programs aimed at promoting alternatives to solo driving during peak hours. Arguably, the most intensive form of such advertising involves personal interviews aimed principally at encouraging a shift to public transport. Travel Blending, Indimark and TravelSmart each represent different interpretations of 'personalised travel planning'.[19] In essence, the approach involves assisting selected participants to monitor and review their travel behaviour. The interviewer then counsels the participant on their travel behaviour, suggesting other travel patterns that involve less car use. The overall aim of the counselling is to encourage the participant to travel less and to make greater use of 'sustainable travel modes', thereby reducing their unaccompanied vehicle use.

Scheme advocates report significant reductions in motor vehicle use. However, doubts have been cast on the methodology adopted: in particular, that sample sizes are too small to draw firm conclusions (Stopher and Greaves 2004). Transfund (NZ) echoed this concern:

> Given the underlying variability of travel behaviour, relatively large sample sizes are needed to estimate modest changes in travel behaviour with reasonable confidence (Transfund New Zealand 2004, p. 53).

Essentially, this means that analysis of personalised travel programs have not been statistically reliable (Transfund New Zealand 2004, p. 59). In the absence of long-term comprehensive programmes the technique is unproven. Further, Transfund concluded that due to a self-selection bias in the survey, the sample results cannot be extrapolated to the wider community (Transfund New Zealand 2004, p. 57).

19. For background see TravelSmart Australia (undated).

Morton and Mees (2005) have also argued that because these programs are usually evaluated through self-reporting surveys rather than direct observation of travel behaviour, they are particularly vulnerable to participant-related artefacts:

> … they are also more vulnerable to 'good subject' effects when the experimental target is a group that self-selects as wanting to change their behaviour (Morton and Mees 2005, p. 5).

The efficacy of personalised travel information systems, compared to conventional advertising, therefore remains unclear. Irrespective of the level of effectiveness of such approaches in altering travel patterns, it is clear that it is a costly strategy; the systems require a high level of human input—both the priced interviewer time and the unpriced interviewee time that is sacrificed.

The efficacy of personalised travel planning remains unproven.

This is probably why the approach has yet to be applied beyond small samples and pilot programs. Thus, such systems aimed at road space demand reduction are unproven in their efficacy and cost effectiveness.

2.4 Other strategies

There are a variety of other indirect measures that may impact on congestion, including those focused on parking (increased parking fees, reduced availability of spaces and eliminating salary-packaging of parking) and others that target vehicle ownership (such as rides-share organisations and car clubs).

Ideally, parking spaces would be priced at their opportunity cost: however, this is rarely the case. Manipulating parking costs to reduce congestion requires some analysis. For instance, reducing the number of available parking spaces may discourage workers driving into a city, but will do little to discourage through traffic and is likely to encourage it as other traffic declines. (See BTRE (2002, pp. 34–42) for a discussion of parking policy strategies.)

As a rule, these options have specific aims other than the management of congestion. If they were to be promoted as part of a congestion-management package, each would require individual assessment.

One perceived drawback of all the prevailing strategies to reduce congestion is the phenomena of induced travel. It is commonly argued that if such strategies were successful, then induced travel would undermine the success. This is considered next.

2.5 Induced travel

A major barrier to expanding capacity to reduce congestion is the resulting impact on travel patterns. There is a widely held view that capacity expansion is 'self-defeating', in that it encourages more travel which eventually results in the road becoming congested again. This road-user response is commonly referred to as 'induced traffic', the 'induced travel' effect or 'generated traffic'. To the extent that expanding capacity is perceived as 'self-defeating', then for better or worse, this can push policy towards congestion-charging strategies, whether or not they are appropriate.

This section examines the issue of induced travel and its relevance for road policy. Concern with this traffic is such that policy makers sometimes seek to arrest the apparent generation. Thus, we assess the linked concept of policies of 'locking in the benefits' of capacity expansion. Here, policy makers employ strategies to suppress traffic in order to prevent recurrence of congestion from people using expanded road facilities.

Theoretical underpinnings

In transport literature, the term 'induced travel' is usually given negative connotations.[20] This association is unfortunate: travel is normally a derived demand—a consumption that is undertaken in order to enjoy pleasurable and beneficial activities. Affordable mobility is a central part of lifestyles. Separation of the home and work environment ensure that we are no longer obliged to 'live above the shop'. Children can attend more distant schools that best suit their learning styles and interests. A wide array of goods is available to purchase, sourced from around the world at competitive prices. Friendship groups are wider, liberating individuals from marrying 'within the valley'. Practical and affordable mobility is also a vital part of labour market flexibility; such flexibility delivers higher economic productivity and lower inflation.

Travel is a normal economic good, being the conduit for society to engage in productive activities and pleasurable diversions.

Travel is thus a normal economic 'good', in being a desirable (direct and derived) activity, so that more will be demanded when the price falls. The price of travel—the 'generalised cost of travel', to use the economic term—includes both monetary costs (costs of owning and operating a car, tolls and other out-of-pocket expenses) and the time costs involved with travel.

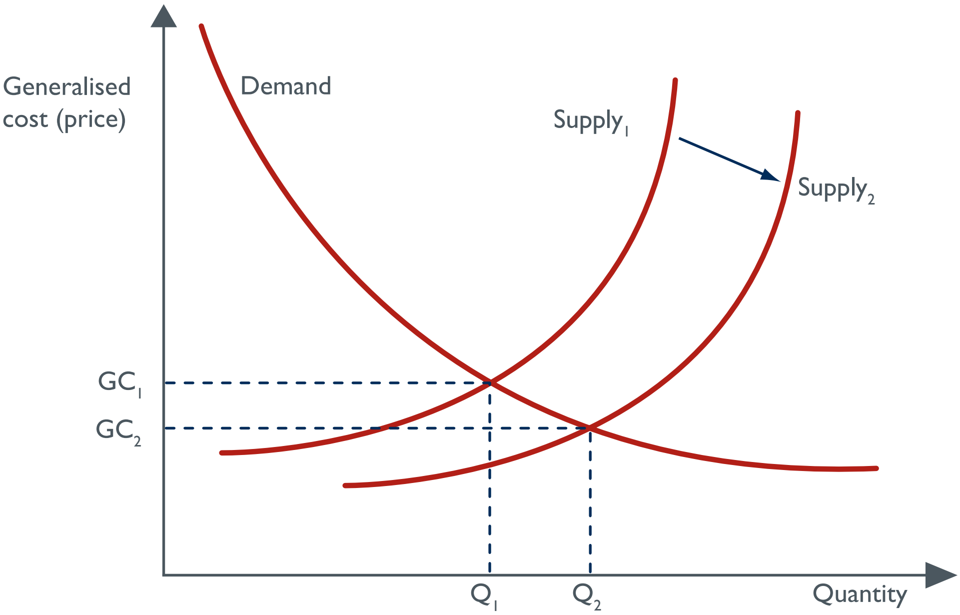
When capacity is expanded congestion is reduced and the time cost of travel declines, leading to a decline in the generalised cost of travel. In response, demand for travel will increase, as is illustrated by Figure 2.7. The vertical axis represents the generalised cost of travel—an amalgam of the component costs, including time. An increase in capacity due to infrastructure expansion is represented by the outward shift of the supply curve (Supply_1 to Supply_2).

In conjunction with a downward-sloping demand curve[21], this translates into a 'price' fall from GC_1 to GC_2.

As a normal good, a fall in price will lead to an increase in demand—in this case, a shift in quantity of road travel 'consumed' from Q_1 to Q_2.[22]

20. Indeed, greenhouse concerns mean that road travel and other forms of consumption are increasingly regarded as undesirable.
21. If the demand curve was 'flat', rather than downward sloping, there would be no change in price but the quantity consumed would still increase. Such a demand curve is 'perfectly elastic'. For background, see, for example, en.wikipedia.org/wiki/demand_elasticity.
22. Note that a 'virtual capacity increase' achieved by shifting, say, some road users onto rail, would be represented by a contraction in demand. The demand curve would shift left and the result would be the same—the price would fall.

Figure 2.7 Capacity expansion impact on travel cost



Opposition to the expansion of roads needs to be understood in this context. When the impact is to reduce the price of using the road (because there is now less time-consuming congestion) this can lead to the transfer of travellers from 'environmentally-friendly' public transport, to road. For example, much of the decline in patronage on Sydney's CityRail East Hills line in 2003 was attributed to the opening of the M5 East motorway tunnel link.[23]

Hence, critics of capacity expansion argue that the benefits are quickly eroded because the reduced congestion attracts more road users. The inevitable conclusion is that 'we can't build our way out of congestion'. The Sierra Club, a long-established American environmental organisation, articulated the argument:

> The jury is in! Recent studies show that building or widening highways induces more traffic, called induced travel. Shortly after the lanes or road is opened traffic will increase to 10 to 50% of the new roadway capacity as public transit or car-pool riders switch to driving, or motorists decide to take more or longer trips or switch routes. This is short-term induced travel. In the longer term (three years or more), as the new roadway capacity stimulates more sprawl and motorists move farther from work and shopping, the total induced travel rises to 50 to 100% of the roadway's new capacity (Sierra Club undated).

Similarly, in the context of the M6 Toll in England comes this comment:

> This new road carries false hopes of a congestion-free future. But the road is unlikely to reduce congestion on the M6 other than in the very short term. Any immediate advantage is likely to be quickly swamped by new traffic (Hounsham 2003).

We now consider how significant this travel inducement is and then examine the possible policy implications. Such implications include policy measures that seek to prevent induced travel—often referred to as 'locking in the benefits'.

23. See, for instance, Kerr (2003).

How significant is the induced travel effect?

A decline in congestion and the consequent reduction in travel will invariably attract more traffic. Exactly how much more traffic depends on a number of factors, including time savings involved. In general, the magnitude of the induced travel effect will depend on:

- the behavioural response to the capacity expansion; and
- how broadly induced travel is interpreted.

The following section reviews the relative importance of the factors that determine the magnitude of the induced travel effect.

Behavioural response to the capacity expansion

The response of users to a reduction in congestion due to capacity expansion will vary between locations and, for the same location, at different times. People can make immediate and simple adjustments to travel patterns, such as leaving for work a little later in the morning, while in the longer term they can change their work or home location.

Because the level of induced travel is so much a function of location, it is not surprising that there is wide variance in the short- and long-term responses to capacity expansion. Estimates of the traffic growth due to network expansion vary widely and in the following table range between 10 per cent (in the short term) to up to 100 per cent (in the long-term), as illustrated in the following summary compiled by the Sierra Club (Table 2.1).

Table 2.1 Share of new capacity filled with induced travel

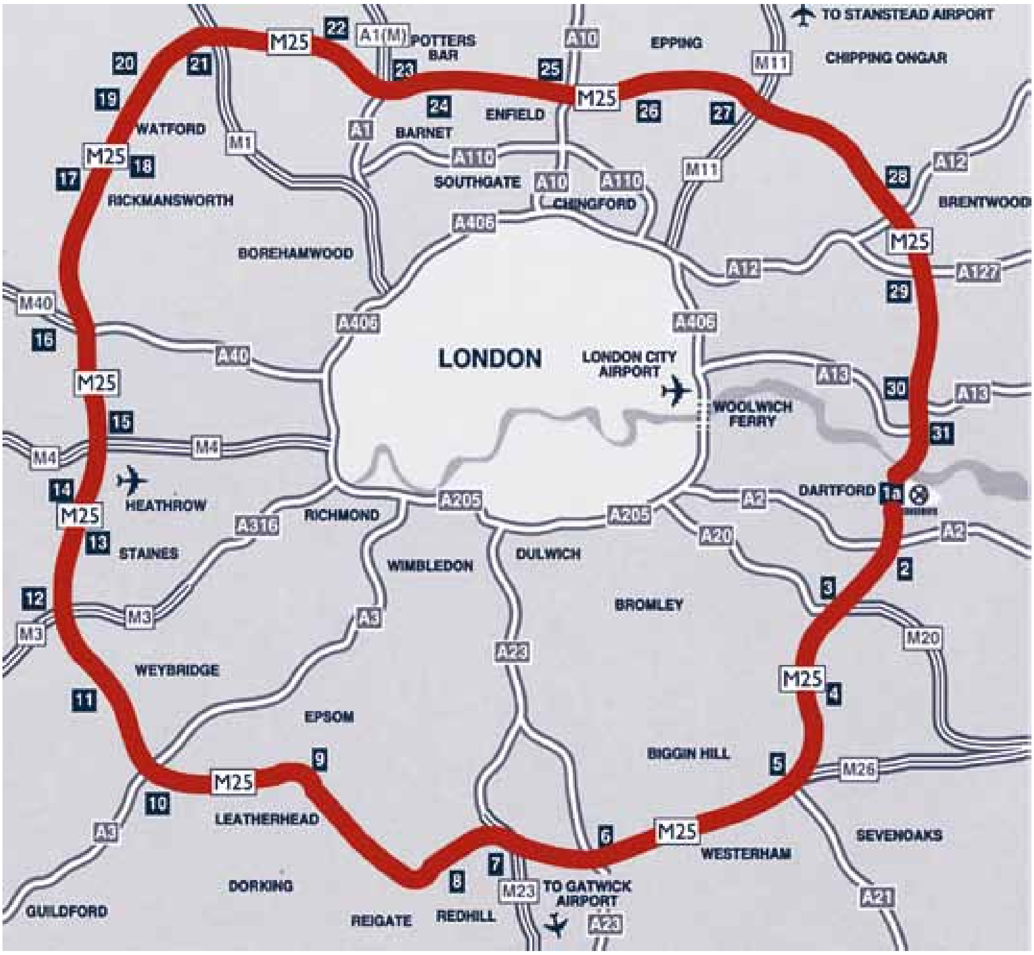
	Short-term	*Long-term (3 years)*
	(per cent)	
SACTRA		50–100
Goodwin	28	57
Johnson and Ceerla		60–90
Hansen and Huang		90
Fulton, et al	10–40	50–80
Marshall		76–85
Noland	20–50	70–100

Source: Sierra Club (undated).

Economics has a term for the responsiveness of the level of consumption of a good or service to a change in price: the elasticity of demand. The more elastic the demand for road use, the greater the increase in use following a fall in price. In this case, the ‘price’ is the generalised cost of travel.

Essentially, demand is regarded as elastic if a small reduction in the generalised cost results in a large increase in demand. Such a high degree of responsiveness is suggested by the studies where traffic congestion ‘recovers’ to its previous level within 3 years of capacity expansion. For instance, dramatic traffic growth followed the completion of the M25, the 188 kilometre orbital motorway that encircles London (see Figure 2.8). Within one year of opening, traffic levels had reached the levels forecast for the 15th year after opening:

Figure 2.8 London's M25



Source: http://www.stephens-wholesale.co.uk/DirectionMapM25.htm.

> Traffic on the M25 has shown wide differences between forecast and actual traffic flows. For 21 out of 26 sections of the M25 actual flows already exceed 79,000 vehicles per day, the upper end of the design reference flow for the 15th year after opening (National Audit Office (UK) 1988, p. 4).

Before the expansion, there was considerable congestion on roads in the Greater London area. The opening of the M25 would have dramatically reduced the generalised travel costs—even after traffic growth on the motorway substantially reduced those cost savings.

The M25 is probably an extreme case. In other cases, such as the I15 interstate roadway in Utah (US) it took 10 years for traffic congestion to reach its pre-construction levels (Surface Transportation Policy Project 1998).[24]

24. Often overlooked in the discussion of the induced traffic effect is the fact that if traffic failed to increase after the expansion of capacity, the value of the project could be questioned.

Project and location-specific features determine road users' response to capacity expansion. Nonetheless, the degree of induced travel is determined by the definition of induced travel.

So, how broadly should induced travel be interpreted?

There are a number of interpretations of 'induced travel'. When used in a critical sense as a shortcoming of the 'build more roads' approach, induced travel generally refers to all the traffic growth that follows capacity expansion.

However, this interpretation is too simplistic and fails to recognise that there are a number of other sources of traffic growth unrelated to capacity expansion. These can be divided into:

- those that also reduce generalised travel costs; and
- other, external aggregate factors (income, economic activity, population, leisure time and other lifestyle changes).

These are examined in more detail below.

While infrastructure expansion generally leads to lower generalised travel costs, other factors have also been putting downward pressure on inflation-adjusted travel costs. Even taking account of oil price spikes, vehicle purchasing and operating costs have consistently trended downward. At the same time, vehicle quality and comfort (which, in principle—but not in practice—is also part of generalised cost) have improved considerably. Reliable data series that incorporate quality changes are difficult to find, but Axhausen (2005) compiled the following chart (Figure 2.9) from two time series (different time periods, different countries) to illustrate the 'true price change' of motor vehicles, after quality improvements are taken into account.

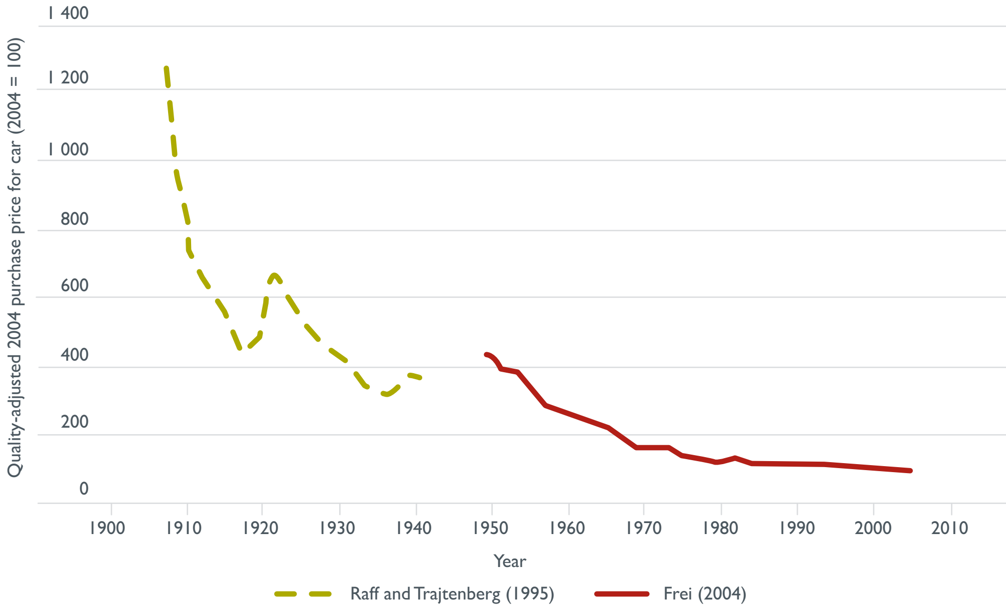
The quality-adjusted price of cars has fallen dramatically throughout the last century, against a background of rising incomes. What is evident from the chart is that the most dramatic falls in the quality-adjusted purchase price for vehicles was during the first 30 years of introduction of the motor vehicle, with blips for the two world wars. The rate of decline has slowed considerably over the last few decades, but there is still a downward trend in prices.

Improved vehicle quality has also meant declining maintenance costs—which, in turn, contributes to the long-term trend in the reduction in the generalised cost of travel.

In addition to falling generalised travel costs, there are wider social and economic factors that have also contributed to an increase in road use. Strong economic activity generates increased commercial and commuting traffic. Continued economic growth has brought rising incomes and more leisure time both of which lead to an increase in the demand for travel.[25] Between 1985–86 and 2005–06, Australian per capita final consumption on transport closely tracked real household consumption expenditure, which more than doubled (in real terms) in the 45 years to 2006.[26]

25. The very presence of this apparent linkage has given rise to policy initiatives aimed at breaking the link ('decoupling', to use the jargon) between economic growth and car usage.
26. At 2004–05 prices, refer to ABS (2007).

Figure 2.9 Quality adjusted 2004 purchase prices for private cars 1906–2004: US and Switzerland



Source: Adapted from Axhausen (2005, p. 5).

Figure 2.10 illustrates the situation in Britain, where real incomes almost doubled over the period 1980–2005, stimulating rising car ownership against a background of declining real motoring costs. These declining motoring costs and socioeconomic factors (economic growth, rising incomes and increased leisure time) need to be excluded from calculations of induced travel.

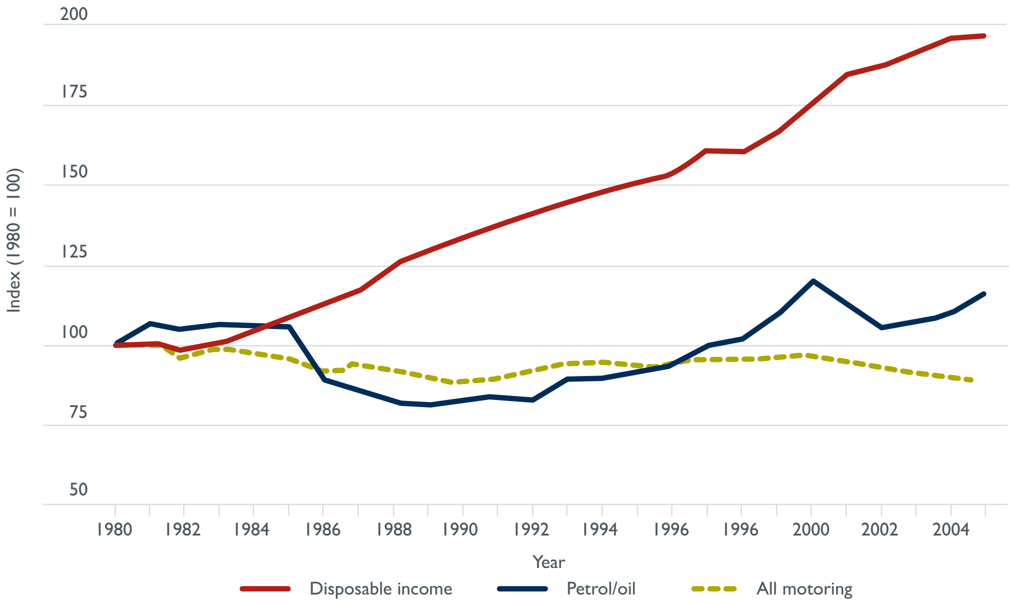
Diverted traffic also needs to be excluded from the calculation. There are two aspects of the diverted traffic: it does not increase overall network travel and it brings congestion-reduction benefits on the 'old road'.

Some traffic will divert to the newly uncongested road from other roads. For instance, the M25 orbital motorway in London added capacity to an existing road system that was highly congested; these roads became relatively uncongested when traffic diverted to the new motorway. Traffic will also divert to the new road capacity from other modes (such as buses) or other times. This diverted traffic cannot be included as 'induced travel' since it will generally not contribute to an increase in total network travel. As pointed out by DeCorla-Souza (2001, p. 5), an increase in total travel is a necessary, but not sufficient, condition for induced travel to have occurred.

As well as traffic being diverted, it is likely that some activities will be diverted when the generalised costs of travel are lower. For example, the opening of the M25 motorway has facilitated the siting of two major out-of-town shopping centres (at Thurrock, Essex and Blue Water, Kent) adjacent to the motorway. These developments will have diverted economic activity from traditional retailing centres but will only generate extra travel if the cost of travel has fallen or the returns to travel have risen.[27]

27. It is not possible to be conclusive here about how much, if any, net travel inducement arises in these situations:. travel and shopping patterns may have changed, with people travelling further to these shops but also travelling less frequently.

Figure 2.10 Changes in the real cost of transport and in income: United Kingdom, 1980 to 2005



Source: Adapted from DfT (UK) (2007, p. 24).

We should note the importance of the reconfiguration of travel patterns across the wider network. For instance, congestion-reduction benefits could be important on the parts of the network from which traffic is diverted, providing the traffic growth on the new road.

> **The apparent importance of induced traffic declines after allowing for population growth, rising incomes, falling motoring costs and diverted traffic.**

One other source of traffic growth that also needs to be excluded from the calculation of induced travel is that due to demographic factors, in particular, population growth.

Once travel growth due to population growth, rising incomes, declining motoring costs and diverted traffic are excluded, the apparent importance of induced traffic declines. Thus, it is not surprising that Goodwin concluded that, when rigorously defined, the induced traffic effect is not generally a major issue (Goodwin 1996). DeCorla-Souza also observed that 'person trip rates used in travel forecasting models have not been found to change measurably as a result of changes in transportation system capacity' (DeCorla-Souza 2001, p. 10).

Induced travel in context

To reiterate, travel, per se, is not a societal problem. On the contrary, declining travel costs expand lifestyle choices. Travel is fundamental to labour force mobility, which in turn is imperative to economic growth and low rates of inflation. Thus, even where induced travel may *appear* to be a major issue, Litman stresses that it should not be a reason for not expanding capacity:

> This is not to suggest that increasing road capacity provides no benefits … It means that road capacity expansion benefits consist more of increased peak period mobility and less of reduced traffic congestion. Accurate transport planning and project appraisal must consider these three impacts (Litman 2001, p .2).

Travel, per se, is not a societal problem. It facilitates lifestyle choices and labour mobility, underpinning economic growth and low inflation.

The critical issue for policy makers concerned with the prospect of induced travel is to identify correctly the travel increase that specifically arises from expanded capacity. The task is then to determine whether net societal benefits, after accounting for the external costs of induced travel, could be justified by the costs. It has been put succinctly that:

> … even when the magnitude of induced travel is high, capacity expansion could be warranted, depending on the public and social costs to be incurred in implementing the capacity expansion (DeCorla-Souza and Cohen 1998).

If the policy maker perceives travel to be a societal problem, rather than as a societal good, it may lead to policies that restrict travel, capacity expansion and/or embrace congestion charging.

The problem that arises with the misperception of the value of travel to society is that it sends the wrong policy signals. In particular, the misperception may incorrectly lead the policy maker to embrace congestion charging as the only solution to increasing travel and, specifically, to capacity expansion that induces travel. Thus, one policy response to induced demand is to use it as a justification for not expanding capacity—and, indeed, as noted above, this can then lead policy directly to embrace congestion charging as a brake on personal movement. In the extreme, policies have been adopted to prevent the net expansion of road capacity in city areas.[28]

The other main, and related, policy response is to 'lock in the benefits' of expansion by discouraging use of the road. This approach is illustrated by the following observation from Department for Transport (UK) in context of the possible widening of the M6:

> The work on widening will examine the technological and physical practicalities of locking in the benefits of that additional capacity. This will involve considering a number of measures, which could be used individually or in combination, such as: access management; segregated lanes for priority traffic; speed controls; and pricing on the new capacity (Department for Transport (UK) 2005, p. 9).

While the sentiment expressed in the term 'locking in the benefits' has some appeal, as a policy objective it provides little, if any guidance. The measures normally advocated for 'locking in the benefits' are those that would have been evaluated in the first instance

28. In Australia in the early 1970s, this option was taken seriously enough to prompt a report by the CBR (1973).

to reduce the original congestion—along with road expansion. There is no reason to assume that their worth is transformed because of the expansion in road capacity.

The main danger with the application of actions designed to 'lock in the benefits' is that it tends to replace sound analysis. Indeed, the twinning of 'locking in the benefits' with capacity expansion can ironically have the very effect of neutralising (removing) the very benefits that the expansion is intended to deliver. In other words, allowing such a phrase to drive policy options runs a serious risk of 'locking out the benefits'.

Policies that seek to deter travel are inevitably inconsistent with policies intended to enhance travel.

Induced travel in brief

Suffice to say, what is of policy relevance is the more general issue that travel as such is not an 'economic bad' but what is of relevance is accommodating the travel growth (and not the origins of its growth) that matters.

The spectre of induced travel is often advanced by critics of road expansion plans. The basic thrust of their objections is that any expansion is futile because the traffic levels expand to fill the available capacity. For some policy makers, the growth in travel—whether due to vehicle ownership or induced through capacity expansion—leads to apparent despair and the view that expansion is futile. This is illustrated by this observation from Singapore: '... road building can never keep pace with the annual growth in vehicle population. In other words, supply will always outstrip demand' (Yap 2005, p. 2).

In the extreme, then, this would imply that we should never expand road capacity. This, in itself, can then lend weight to congestion charging policy, even though such an approach to optimising congestion levels may not be in society's interests.

When rigorously defined, induced travel is both less significant than popularly believed and not, in itself, a reason for a blanket ban on capacity expansion.

2.6 Conclusions

Supply and demand policies to manage congestion typically face substantial financial, environmental and political obstacles. The strategies will often be unpopular and/or costly to implement (road construction); effective in delivering congestion reductions but facing declining returns in the longer term (ITS and incident management); or limited in effectiveness (demand-changing strategies).

The case for congestion charging must be evaluated on a case-by-case basis, reflecting local conditions.

The appropriate strategy will depend on local conditions—the nature of the congestion and the cost of, and returns to, the conventional policy options. Thus, it is important to keep an open mind on the option of targeting congestion directly, through congestion charges.

Chapter 3 Congestion charging as an alternative strategy

Summary

- Congestion charging has the potential to generate revenue and environmental benefits as well as improve travel times and increase traffic throughput.
- The main measures of success for a congestion charging system are: political, technical, financial and economic. Success in one area does not guarantee success in other areas. To be in the overall interests of the community, a congestion charge needs to be an economic success.
- Congestion charging schemes are generally costly to establish and operate. For a scheme to be an economic success, this cost needs to be less than the benefits that arise from the change in driver behaviour in response to the charge. A comparison with the revenue raised is not relevant.
- The three common aims of congestion charging schemes are:

  – to internalise each user's time delay externality

  – to use the charge as a demand 'management' tool

  – to fund infrastructure provision.

3.1 Introduction

The previous chapter outlined the prevailing strategies for managing congestion. Such strategies include building additional road space, improving utilisation of road capacity and seeking to reduce demand for road space.

Ultimately, however, such strategies are insufficiently effective at containing congestion—too many vehicles seek to use the limited road space. The result is that road space is rationed by queueing—another name for congestion. This queueing is not costless, as the ECMT has observed:

> Congestion delays imposed by means of queueing impose costs indiscriminately on all road users. With a queueing regime, users who have a high need to use the road space suffer the same consequences as those who do not … [Queueing-based systems] effectively meter access to the road space according to 'willingness to wait …' (ECMT 2007, p. 212).

Thus, in many parts of the world, transport strategies have failed to contain congestion and road users have been left with no alternative but to queue.

The declining effectiveness of conventional methods for dealing with recurring traffic congestion has been a key factor in the emerging policy interest in congestion charging schemes. While the terminology adopted differs between countries—in the US the term 'value pricing' is used, and in the UK road-user charges and road pricing generally mean congestion charging—such schemes potentially allow road users to choose a charge/queueing combination.

We identify three broad types of charging systems that can be applied to road use:

- *facility charging*—applied to vehicles moving along a specified roadway
- *cordon charging*—applied to vehicles crossing boundaries into or out of a given area (but not for movement within that area). Many forms apply, including the concentric cordons proposed for Manchester (UK)
- *area charging*—applied to the use of a vehicle with a specified area—a network of roads (as in London).

These classifications are illustrated in Figure 3.1. The important aspect of the systems is not where the charge is enforced (the toll gates or camera systems) but the circumstances where a charge is accrued—moving along a road, moving within a network of roads or moving across a point on the road, respectively.

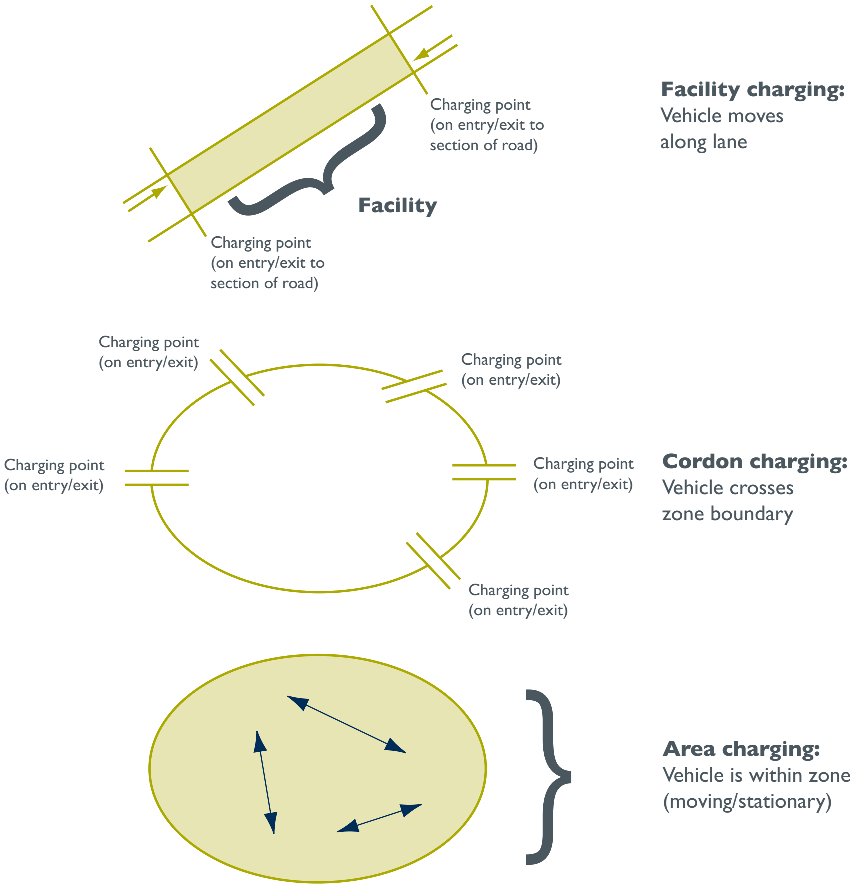
Even within these broad classifications, congestion charging schemes assume many forms. Whether a particular scheme is regarded as a success depends, in part, on the objectives specified for the scheme. A more general measure of success is whether a scheme is in the community interest in that it generates benefits in excess of the costs imposed on the community. Both aspects will be reviewed.

The declining effectiveness of conventional methods for dealing with congestion has fostered interest in congestion charging.

This chapter examines the strengths and weakness of congestion charging as an alternative strategy for reducing recurring congestion. It should be noted that congestion charging is aimed at curbing congestion that arises from high traffic volumes: the system has no direct impact on reducing incident-based congestion.[29]

29. There are more direct tools for dealing with non-recurrent congestion arising from traffic accidents, events and weather-related disruptions.

Figure 3.1 Broad classification of congestion charging systems



3.2 The attraction of congestion charging

Congestion charging is often presented as the 'magic bullet' that solves the problems that have hitherto beset road network providers and road users alike. As observed by an influential community group in Washington State:

> Higher pricing during high-use hours, lower pricing at less-congested times, has support across the political spectrum, in large part because it works so well to adjust supply and demand, and is paid by those actually using the roads (Meacham and Marshall 2008).

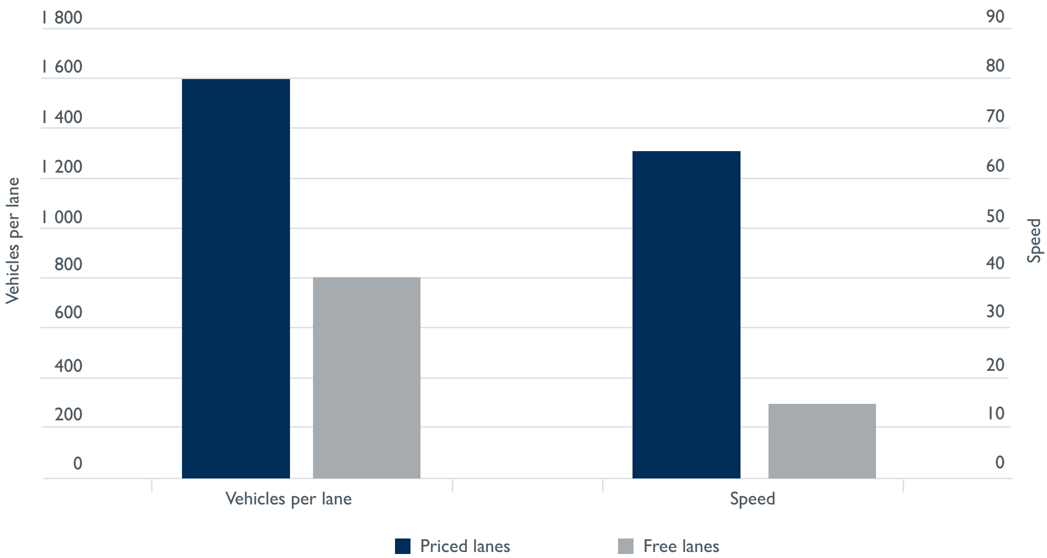
Congestion charging potentially delivers three major benefits to road users:

- smoother flow of traffic increasing the amount of traffic that can flow on the network.
- the overall traffic speed can be increased, notably at the peak times when traffic would otherwise be facing stop-start movements.

- more reliable travel times; this would be a crucial benefit because, as the ECMT has noted, 'there is considerable evidence that travel time reliability is an even more important factor [than travel time and speed] in the user experience' (ECMT 2007, p. 37).

The first two benefits (higher throughput and faster travel times) are well illustrated by the case of the 91 Express Lanes in California—the lanes to which congestion charging applies—when compared to the parallel free lanes.[30] As illustrated in Figure 3.2, the average speed in the charged lanes is 65 miles per hour compared to 15 miles per hour in the free lanes, and throughput on the charged lanes is double that of the free lanes.

Figure 3.2 Impact of introducing congestion charges on peak-period throughput and speeds (91 Express Lanes, California)



Source: Adapted from Paniati (2006).

The increased throughput at peak times is an important feature of congestion charging. What is not shown by the chart, since it is not so readily measured, is the benefit of the associated improvement in reliability, following the introduction of congestion charges.

While it is clear that congestion charging can get traffic moving, it still needs to be determined whether it is in the long-term interest of the community and whether congestion charging is unequivocally superior to prevailing strategies of dealing with congestion.

Congestion charging can actually increase traffic throughput and speeds.

30. 91 Express Lanes consists of four tolled lanes constructed within a 16 kilometre section of toll-free Californian State Route 91 corridor. These four tolled lanes (two for each direction) utilise the centre median strip.

3.3 Criteria used to determine 'success'

The success of a congestion charging scheme depends on the benchmark criteria used. In the first instance, a scheme will be judged against its specified objectives. Where this is to reduce congestion, the scheme will logically be regarded as a success when it achieves this. Where there are several, potentially conflicting, objectives the assessment is more complex.

The premise underlying this chapter is that there are many measures of success and not all will be consistent with the long-term community interest. For instance, a sure way of reducing congestion would be to close the road. This is unlikely to improve community welfare. In the following pages we examine the standard measures of success, including ultimately 'economic success'.[31]

Assessing whether a congestion charging scheme is successful depends on the benchmark criteria used.

More generally, schemes may be judged on the basis of one or more of the following measures:

- technical success
- political success
- financial success
- economic success.

We note that the treatment of equity and 'fairness' are generally subsumed under the more general 'political success' category. See Chapter 4 for a detailed discussion of equity issues.

3.4 Technical success

Technical success can be as simple as whether the equipment works with sufficient accuracy and reliability. This may have nothing at all to do with the more complex question of whether the most suitable technology was chosen for the job. This point is illustrated by the contrast between the London congestion charge and the German lorry charge. The former was an 'off the shelf', well established technology while the latter employed cutting-edge GPS/Global Navigation Satellite System (GNSS)—in conjunction with more established dedicated short range communication (DSRC) systems.

The London system was ready on schedule, is reliable, although 'clunky', and, by no measure, 'low cost'. The German system suffered a number of costly delays but it is now regarded as a success. The point is that in the widespread discussion of both systems, the focus has been on the technical success and there has been little debate

31. Economic success can be regarded as the proxy for the community interest in that it ensures the greatest return to the community, potentially providing for the maximum improvement in community welfare.

over the appropriateness of the technology.[32] Plans are underway to replace the automatic number plate recognition (ANPR) system with one based on transponders.

The question of appropriateness of the technology was central to the debate surrounding proposed a congestion charging scheme for New York City. A number of the companies that responded to Mayor Bloomberg's invitation for expressions of interest to design, build, operate and maintain (DBOM) such a scheme addressed the issue of suitable technology. The expression of interest from IBM Global Business Services noted that there are several technologies that could be used for the scheme.

> These include E-ZPass transponders, cameras, GPS-based devices and VII based devices in the future. While each of these methods has its respective advantages and disadvantages, we feel that the most appropriate and cost effective detection method presently for NYC is a combination of transponders and cameras (IBM Global Business Services 2008, pp. 8–9).

3.5 Political success

The political success of a scheme would depend on many factors, one of which is whether there is a reduction in congestion. As illustrated by the London scheme, the litmus test of political success is likely to be as simple as whether or not the introduction of a scheme brings down the government responsible.[33] (Chapter 4 covers, in more depth, the issues relevant to any assessment of the political success of congestion charging schemes).

3.6 Financial success

Financial success reflects an accounting perspective: whether the scheme generates net revenue after allowing for establishment and operating costs. Financial success may also incorporate the wider impact on businesses.

From these three measures, it is understandable that the London Congestion Charge is widely renowned as a success. Since the scheme was introduced in February 2003, the technology has been operating reliably, congestion has declined with little apparent damage to businesses in the area, and revenue has been generated. Thus, the scheme's place in history seems established:

> … congestion charging in Central London is the most radical transport policy to have been proposed in the last 20 years and it represents a watershed in policy action (Banister 2003, p. 259).

In general, there is reasonable clarity between the different measures of success, with the exception of the distinction between financial and economic success.

32. Transport for London has commissioned a series of technology trials with a view to reducing operating costs and providing more flexibility for paying the charge. For more details see TfL (2005a).
33. The May 2008 mayoral defeat of Ken Livingstone is not generally attributed to the London scheme.

3.7 Economic success

Economic success is a much broader and more complex question than the other measures of success. While economics provides the 'theoretical backbone' for congestion charging, in practice, schemes are rarely evaluated on the basis of their economic success. For instance, critics and advocates of New York City congestion charging focus on the technical, political and financial aspects of the various schemes mooted.

Financial, technical and/or political success does not indicate economic success. A congestion charging scheme may be a financial success through generating net revenue, but this is a transfer between motorists and the relevant agency. It cannot be regarded as a gain to the community. In contrast, the cost of operating the scheme is a resource cost. Put bluntly, the resources used to implement the scheme are a drain on the community, while the revenue generated is simply a transfer within the community producing no gain.

For a congestion charging scheme to be an economic success it is necessary for the efficiency gains to exceed the cost of running the scheme.[34] The efficiency gains depend on the changed behaviour patterns (reduction in road use during peak periods) as a result of the charge. However, it can be difficult to achieve an efficient reduction—that achieved when the congestion externality is internalised. If traffic is discouraged beyond that point (as briefly occurred in the history of the Singapore scheme) then there could be an efficiency loss rather than gain. Setting charges to generate an efficiency gain is more difficult when only a flat charge applies. This is a challenge for all such schemes: it would be a coincidence if the charge that the road user pays in the London scheme bears any resemblance to the external congestion cost of their trip.

To be an economic success, the efficiency gains of a scheme (changed road user behaviour) must exceed scheme set-up and operation costs.

In the Netherlands the risk of the capital and operating costs of a congestion charging scheme eroding the gains to the community has been tackled explicitly. The cost of implementing a national system of congestion charging is high and uncertain: €2.2–€4.1 billion with operational costs estimated to be €500–€1100 million per annum (Betalen voor Mobiliteit 2006, slide 5). A notional target has been set of ensuring the operational costs are no more than 5 per cent of revenue. This figure has been acknowledged as 'ambitious'. The extent of the ambition becomes more apparent when compared to reputedly one of the more efficient schemes, the Singapore system, where operating costs account for 20 per cent of revenue (Menon 2003).

In 2007, the Dutch Government announced plans to introduce nationwide distance-based charges that also vary with congestion levels, starting with lorries in 2011–12 and culminating in a complete system roll-out around 2016.

34. The efficiency gains from the scheme will be a net figure, reflecting the sum of the desirable and undesirable behavioural changes. Examples of undesirable changes would include an increase in congestion outside the charging zone or diversion of traffic onto other, less-suitable roads.

However, in line with their previous commitment, the introduction of the scheme will depend on costs not exceeding 5 per cent of revenues.[35] While such a decision rule reflects an appreciation of the danger of a scheme being uneconomic, the 5 per cent figure is without economic foundation.

Where there is sufficient revenue to cover operating costs, there may be little to no interest in determining the economic impact of the scheme. This is not surprising—fiscal success is much more readily understood than economic success. Further, there can be many stated aims of congestion charging schemes, against which they are logically evaluated. However, regardless of the stated aims, a scheme should ultimately be evaluated in terms of its impact on community welfare—that is, whether it represents an efficient use of the community's resources.

The implications of the nature of the aims on the evaluation of a scheme are considered in the next section.

3.8 Nature of the aims

Diversity

The distinguishing feature of congestion charging around the world is the variety of aims drawn on for its support. Table 3.1 outlines the range of objectives associated with different congestion charging schemes.

The stated rationale tends to reflect the discipline and background of those espousing the aims.

Three principal aims are:

- to internalise each user's time delay externality
- to use the charge as a demand management tool
- to fund infrastructure provision.

Economists focus on 'ensuring that road users face the marginal social cost of their activity'. Essentially, if motorists impose costs on others (such as time delay costs) for which they are not charged, they will 'overuse' the road and generally not operate in the interests of the wider community.[36]

On the other hand, traffic engineers and environmentalists focus more on 'demand management' as the underlying rationale for congestion charging. That is, congestion charging is seen as a way of more closely aligning road use with what the engineers and environmentalists judge to be an appropriate use of road space—for the engineers, one that allows maximum throughput.

35. Another safeguard of the Dutch scheme will be that the payments will be different and not additional to current motoring costs. This they label the 'honesty principle'.
36. Conversely, if motorists are over-charged they will under-utilise the road and, again, not be acting in the community interest.

The ‘demand management’ aim seeks to encourage road users to either shift the time or the mode of their travel or to forgo the trip. This terminology they may share with economists. However, economists focus on changing the incentives facing road users so that they better align with those facing the community. The outcome is the observable result of changing the incentives. In contrast, the ‘demand management’ advocates tend to focus on achieving a specified outcome, with congestion charging being one of many options with which to pursue that outcome.

Economists advocate congestion charges that internalise the congestion costs that each motorist imposes on others, ensuring roads are not over-used.

Put another way, the approach of the engineers and environmentalists generally involves a preconceived notion of an appropriate level of motoring activity—generally lower than that occurring in congested situations. In contrast, economists are more concerned to ensure that the motorists face the price signals that incorporate the costs they impose on others, whether or not this brings about a behavioural change.

The distinction is illustrated by a common (and understandable) complaint by environmentalists that ‘even if you increase the price, people still want to drive’. The economist’s response is that as long as road users pay the social cost of their activity, then how much they drive is not an issue since the outcome reflects an efficient level of road use. In economists’ reckoning, paying the ‘marginal social cost of road use’ (to use the economic term) ensures that individuals act in the community interest.[37]

The infrastructure financier, with serendipitous support from both economists and environmentalists, will regard congestion charging as a promising scheme for funding or recouping the cost of the infrastructure.[38]

In addition to the primary role of internalising the congestion externality, economists value two other features of congestion charging: as a potentially efficient revenue source while providing a litmus test for any expansion of the infrastructure. Economists are probably alone in regarding congestion charging in this light:

> Those associated with the environmental movement tend to see pricing as purely a demand-side mechanism. In contrast, mainstream economists like to stress the validity of priced roads as providing a test for investment in new road capacity just as profitability and return on capital justify capacity investments in other areas of the economy (Samuel 2003).

The CfIT (UK) similarly concluded that ‘there are a variety of different objectives behind the introduction of road pricing in a given area’. The Commission noted that the London scheme was promoted purely on the grounds of congestion reduction while the Rome scheme was justified on environmental considerations (CfIT (UK) 2006). An important point to note, then, is that schemes that seek to reduce congestion can aspire to different ‘downstream’ objectives—in Rome the reduction in local pollution was important.

37. Critics have likened this to ‘buying indulgences from the Pope’ and in this context it is easier to understand the environmentalists’ objections.
38. The environmentalist’s support for the financing objective is based on the congestion charge being additional to current road-use charges and not an alternative way of paying for road use, as proposed by the discussions on the national schemes in Britain and the Netherlands.

Table 3.1 Selected congestion charging schemes

Location	*Year*	*Stated aims*	*Time system*	*Modulation*	*Technology*	*Response*	*Concessions/ exemptions*
Facility charges							
91 Express Lanes, Orange County, CA	1995	Finance 91 Express Lanes and reduce congestion elsewhere	Posted speeds—applies at all hours	Many small gradations ranging from US$1.20 –US$10 (Eastbound 3pm Friday)	Tag & beacon plus ANPR	New lanes	3+ car pool, motorcycles, disabled and zero-emission generally exempt
Interstate 15, San Diego, CA	1999	Improve HOV lane utilisation; part fund PT; and test efficacy of congestion charging	Applies 05:45–11:00 southbound; 12:00–19:00 northbound	Toll adjusted in US$0.25 increments to maintain target level of service. Tolls generally US$0.50 –US$4.00 (US$8.00 maximum).	Tag & beacon plus ANPR	New lanes	2+ carpools exempt
Hudson and East River crossings (NY/ NJ)	2001	Reduce congestion	Cars: 06:00 –09:00 and 16:00 –19:00 (weekdays); 12:00 –20:00 weekends. Lorries: 00:00 –06:00 weekdays	Differential car/truck charge: Cars off-peak US$4; Trucks $US5/axle; Cars peak US$5; lorries US$6/axle; Cars overnight, free; lorries $3.50/axle	Tag & beacon plus ANPR		Registered car pool users and low emission vehicles receive discount
407ETR Toronto	1997	Finance 407ETR and provide a lower-congestion alternative route	Charge applies at all hours; 7% discount for off-peak	Distance-based charges that vary by vehicle class	Tag & beacon plus ANPR	New facility	Diplomatic, emergency & defence vehicles
Santiago de Chile	2004	Reduce air pollution and fund additional transport investment	Variable (6, 12, 18 US cents/km)—applies at all hours	Distance modulation; Congestion modulation based on speed reduction	Tag & beacon plus ANPR		
Dubai	2007 (Jul.)	Reduce congestion and raise revenue for roads	Dh4 per entry with maximum charge of Dh24 per day. Toll (Salik) applies at all hours	None	Tag & beacon plus ANPR	25 per cent reduction	Buses emergency vehicles and military vehicles
Area charges							
London	2003; (extended in 2007)	Reduce congestion and fund transport investment	Fixed 07:00 –18:00 Mon.–Fri.	£8 for non-exempt vehicles[a]	ANPR	30 per cent reduction inside the zone	Many categories exempt or heavily discounted

(continued)

Table 3.1 Selected congestion charging schemes (continued)

Location	*Year*	*Stated aims*	*Time system*	*Modulation*	*Technology*	*Response*	*Concessions/ exemptions*
Cordon charges							
Oslo	1990	Raise revenue for road investment	Fixed-charge applies at all hours	20NKr veh.<3.5t; 40NKr veh.>3.5t	Tag & beacon plus ANPR		
Stockholm	2006 (Jan.–Jul., trial); 2007 (Aug.)	Reduce congestion and emissions and fund public transport	Variable (three toll levels), two-way, 06:30 –18:29 (Regular weekdays except July)		Tag & beacon plus ANPR	20 per cent fall in traffic on commencement	Many exemptions
Bergen	1986	Fund road transport investment	Fixed 06:00–22:00 weekdays	15NKr veh. <3.5t; 30NKr veh.>3.5t	Tag & beacon plus ANPR	6–7 per cent fall in traffic	Buses
Trondheim	1991–2005	Fund road transport investment	Variable: 06:00–18:00 (regular weekdays)	15NKr veh.<3.5t			
Singapore	1975 (area licence); 1998 (electronic)	Reduce congestion and encourage PT	Variable, 07:30–19:00 (central area) and 07:30–09:30 (expressways/rings).	S$1 increments	Tag & beacon plus ANPR	13 per cent fall in traffic	
Durham	2002 (Oct.)	Reduce traffic in heritage and pedestrianised area	Fixed 10:00–16:00 Mon.–Sat.		Rising bollard	85 per cent fall in traffic	Buses, residents, emergency, disabled, security and postal
Rome	1998 (day zone); 2005 (night zone)	Reduce traffic in heritage area and increase PT use	Fixed: 06:30–18:00 Mon–Fri 14:00 –18:00 Sat; Annual permit or €20/day. Also night zone		Gates with sensors control access	10 per cent fall in traffic	Residents; others with permits
Valletta (Malta)	2007 (May)	Reduce congestion and improve the environment	Variable– based on time within zone 08:00–18:00 Mon–Fri; 08:00–13:00 Sat		ANPR		Extensive exemption list
Milan	2008 (Jan.)	Reduce congestion, emissions and raise revenue	Business hours	Up to €10 according to emission class			Electric and hybrid cars

a. CO_2 adjustment to the charges to be phased in from February 2008.

Source: BITRE compilation.

Jack Short, Secretary General, ECMT, summarised the diverse objectives of road-user charging schemes and the implications for scheme design:

> They can be introduced to reduce congestion, to reduce environmental harm, to finance infrastructure, to increase efficiency in the use of infrastructure, to increase fairness in who pays or to meet combinations of these objectives. Meeting these different aims can lead to differences in the kinds of scheme that are introduced, to the categories of vehicles it applies to, and the levels charged (Short 2004, p. 4).

Mutating aims

Furthermore, objectives tend to mutate over time. According to the Commission for Integrated Transport, 'objectives are not necessarily stable; a scheme that started with one intention may evolve into a different emphasis over time' (CfIT (UK) 2006). The objectives of the London scheme appear to have shifted with the 2008 phased introduction of penalty fees for high emission vehicles.[39]

There is a strong possibility of scheme failure where congestion charges are structured to pursue multiple objectives.

Similarly in Norway, schemes introduced to raise funds for road improvements have had their flat charges adjusted to reflect higher levels of congestion at different times of the day, and revenues are gradually being diverted to fund public transport.

Multiple, but not necessarily compatible, aims

A golden rule in public policy formulation is 'one objective, one instrument'. Congestion charging can run into problems where multiple objectives are assigned to the one instrument. Where the objectives are closely related (such as reduce traffic levels and reduce emissions) this is not an issue. However, when the objectives are in conflict problems arise. The extensive list of exemptions under the London Scheme (in pursuit of the political objective) seriously undermine the congestion-reduction objective. It was for this very reason that most exemptions were eliminated from the Singapore scheme in 1989.

This point is illustrated by the current proposal to exempt cars with tailpipe emissions of 120 grams CO_2 per kilometre and below (Band A and Band B cars) from the London congestion charge. While this is aimed at reducing emissions in the zone, it appears that it will also increase congestion. A study of the likely impact of the proposal, commissioned by Transport for London, concluded:

> Over time, the increasing numbers of cars eligible for the low CO_2 discount could start to impact more significantly on the level of congestion (Greater London Authority 2007, p. 21).

This outcome would simply mean that the number of cars attracted by the exemption would exceed the number discouraged by the higher charges. Perversely, the increased traffic could undermine the environmental objective. As one motoring

39. With the recent change of Mayor, these fees may be reviewed.

organisation pointed out, 'more congestion would result in cars moving more slowly, increasing the amount of emissions' (Wright 2008).

> **When schemes mutate over time, with the addition of supplementary objectives, conflicting objectives are more likely.**

The success of congestion charging schemes in meeting their stated aims requires precision in purpose and a clearly articulated system for adjusting both the operating rules and charges. Thus, aims need to be clear. This is the case whether congestion charges are introduced to achieve social engineering objectives, to efficiently fund infrastructure investment (as in the Norwegian schemes), to recover infrastructure costs (as with SR91 in California), to raise revenue for funding public transport or simply to reduce congestion.

3.9 Case study: is the London scheme successful?

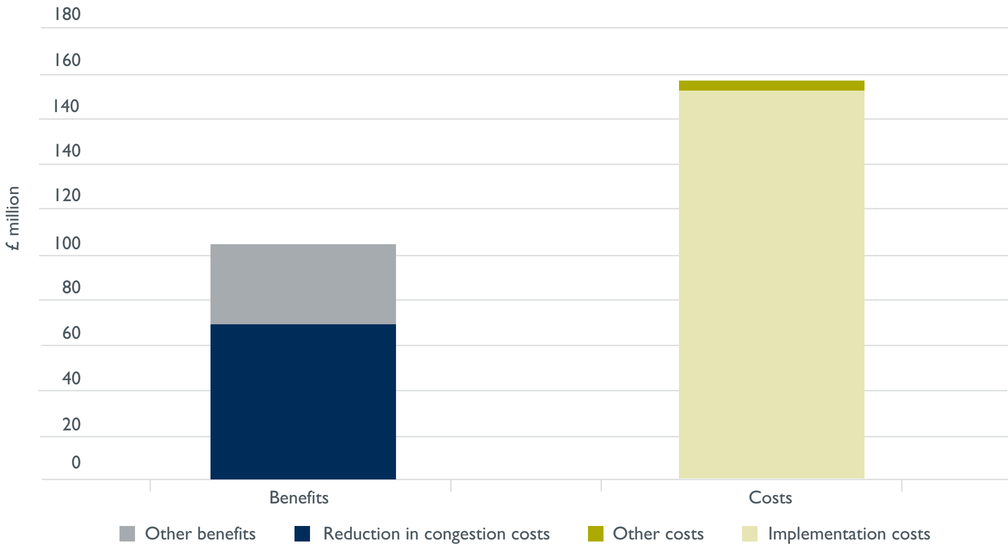
Thus far we have considered the goals of congestion charging schemes and the criteria for assessing the merits of schemes. The London Congestion Charging Scheme illustrates the impact of using different criteria for success.

London's area-charging scheme is widely heralded as a success and consequently created a great deal of interest in other major cities struggling to deal with congestion, such as New York. It is generally regarded as a *political* success since the Mayor was re-elected, a *financial* success because it generates net revenue for funding public transport and a *technical* success due to its reliability. However the question of its economic success has been the subject of debate.

The economic definition of a successful scheme is one where the benefits exceed the costs. Transport for London estimate benefit–cost ratios of around 2.0 and 2.5 with £5 and £8 charges (TfL 2007, p. 137).

However, different assumptions have produced conflicting results. In their tentative economic appraisal, Prud'homme and Bocarejo concluded that the London scheme is an economic failure with the benefits being between 40 and 60 per cent of the costs, as illustrated in Figure 3.3. In their words, the scheme 'could be described as a mini or micro Concord' (Prud'homme and Bocarejo 2005).

Figure 3.3 One perspective of the costs and benefits of the London Congestion Charging scheme



Source: Adapted from Prud'homme and Bocarejo (2005, Table 2, p. 286).

TfL (2007) identified the main reasons for the conflicting conclusions. Prud'homme and Bocarejo acknowledge that their estimates are based on:

- changes in the charged zone only, since they did not know whether congestion in the rest of London increased or decreased[40]
- the ROCOL (Road Charging Options for London, Government Office for London, 2000) values of time, which Prud'homme and Bocarejo describe as 'generous'
- ignoring 'a likely gain in transportation reliability experienced by both car and bus users, which is hard to measure and harder to value' (Evans 2007, p. 1).

Since time saved is a significant source of the benefits from congestion charging, a higher value of time would generate a more favourable economic outcome.[41]

Prud'homme and Bocarejo's study also raises two important aspects of congestion charging that are pivotal in the overall merits of a scheme:

- the cost of establishing and operating the scheme; and
- the underlying level of congestion on the road network.

40. Mackie (2005, p. 287) reports that under Transport for London's calculations, around two–thirds of the time benefits accrue to those outside the charging zone.
41. The absence of an unambiguous value of time is explored on pages 128 and 131.

Figure 3.4 Congestion charging zone in London

Note: This picture shows a zone boundary, at Portland Place. The motorist is alerted to the boundary by metal signs and a 'C' sign painted on the road surface.

Source: Photograph courtesy of Peter Kain.

In essence, the likelihood that a scheme will be an economic success will be low when the scheme's establishment and operating costs are high and when the prevailing level of congestion is low. These aspects are now considered in the context of London.

The operating costs of the London scheme are substantial—reflecting a combination of high capital costs and the labour intensive nature of the technology adopted. The 693 fixed cameras cost more than £100 million. Additional mobile cameras and enforcement measures to detect stationary vehicles in the zone add to the costs. We should note that London's *area*-charging scheme (where movement within the zone is charged as well as movement into the zone) is likely to cost more than a technically simpler *cordon*-charging scheme. Figure 3.4 shows a typical congestion charge zone boundary in London and Figure 3.5 shows area-charging enforcement equipment needed to detect intra zone movements.

Prud'homme and Bocarejo concluded that, in the case of the London congestion charge, the high costs of the scheme overwhelm the economic gain.

The prospects for the economic case for the London scheme improving are limited, particularly with the expansion of the congestion charging zone—the Western Extension. With the Western Extension, many motorists who previously paid the full congestion charge now have access to the 90 per cent residents' discount. The lower charge for this group reduces the pressure for behavioural change and, hence, the benefits from the scheme.

Figure 3.5 Intra-zone enforcement equipment in London

Source: Photograph courtesy Peter Kain.

Given the high capital costs of such a scheme, the conclusion that the costs were around twice the benefits would not be surprising if Prud'homme and Bocarejo had included the total cost of setting up the scheme upfront. However, this is not the case: the investment was accorded correct treatment. Prud'homme and Bocarejo estimated an investment component of the yearly cost (allowing 5 per cent for the opportunity cost of capital, plus 10 per cent for the depreciation), to which they added the operation component.

If we accept the methodology of Prud'homme and Bocarejo, the conclusion is that the London Congestion Charge scheme, despite being a political success, is an economic failure. Different methodologies produce different results and other analysts, such as Mackie (2005) and Raux (2007, p. 221), do not come to the same conclusion.

One analysis of the London scheme leads us to conclude that it is an economic failure.

We can make a few observations about the London scheme that suggest caution in embracing it as an unqualified success. First, the different evaluations are contentious, indicating that the net value of a scheme depends highly on the assumptions adopted. Secondly, irrespective of the calculations, we can observe that the set-up and operational costs of the scheme are high in absolute terms and relative to the benefits generated. Finally, the congestion charge structure itself is essentially flat; unlike (particularly) some toll road congestion charges, the charge is either levied (weekday daytimes) or not (evenings and weekends). That is, the charges are very coarse—they are unresponsive to varying levels of congestion.

The purpose of this discussion is not to support either the calculations of Transport for London or those of its major critics. Rather, it is to make clear that it is possible to assess the economic merits of a congestion charging scheme and this is an essential tool for policy and planning. Key elements in the assessment are the capital and operating costs. A policy consequence of these conflicting verdicts on the London scheme is that it is imperative to apply sensitivity analysis when assessing a scheme.

3.10 Transferability of overseas experiences

The keystone for successful congestion charging schemes is that they bring about some change in road user behaviour—essentially a reduction in peak-hour use. Often, only a modest reduction in use during congested periods is required to significantly improve road traffic flow. But, still, that behavioural change is required, and that change depends on some drivers reducing their travel or changing their departure times, routes or modes.

For any congestion charging system to work (in that the cost of the system can be justified by the gains from the behavioural change), these alternatives must have some attraction. Authorities generally have little influence over flexibility of road users' departure time and are similarly constrained in providing alternative routes. Thus, they logically focus on encouraging the use of alternate modes—in particular, public transport.

To be successful, a scheme needs to reduce vehicle numbers on the road. Often, only a modest reduction in numbers delivers a significant increase in traffic flow.

However, even with the cost of private motoring increasing when a congestion charge is introduced, there are many challenges to achieving a mode shift. As observed by March:

> … if the transit system does not provide adequate service between auto users' trip origins and destinations, particularly in the growing suburban communities outside the urban core areas, the shift to transit [will] probably not occur (March 2006, p. 8).

The difficulty that authorities face in providing public transport that matches the comfort, flexibility and travel time of private vehicles is often a function of the urban form.

Table 3.2 presents population and population densities of a range of cities—one perspective of the urban form. This form strongly influences the ability of cities to justify and provide comprehensive modes of transport that complement and substitute for private vehicles.

Table 3.2 Population and population densities of selected cities

City	*Population (million)*	*Population density (persons/km^2)*
Hong Kong	6.5	29 400
Singapore	4	8 350
Mexico City	18.1	7 150
London	8.3	5 100
Tokyo-Yokohama	34.3	4 350
Berlin	3.7	3 750
Beijing	11.3	3 700
Moscow	14	3 600
Vienna	1.6	3 400
Paris	10.4	3 400
Glasgow	1.2	3 250
Rome	2 8	3 200
Stockholm	1.4	2 700
Amsterdam	1.1	2 650
Los Angeles	13.8	2 400
Brussels	1.6	2 150
Sydney	3.5	2 100
Auckland	1.1	2 100
Montreal	3.2	1 850
New York City	19.7	1 750
Melbourne	3.2	1 500
Lyon	1.3	1 400
Adelaide	1	1 350
Perth	1.2	1 200
Brisbane	1.5	950

Source: Demographia (2007, pp. 9–30).

The table illustrates that Australia's cities have relatively low population densities. This makes it more difficult for Australian cities to justify provision of the good quality public transport systems that may be necessary to bring about driver behavioural change without cripplingly high congestion charges that could undermine the economic case for a scheme.

Good public transport could be key to behavioural change. Australia's urban form tends to work against good public transport. This makes it less likely that a congestion charge can be successful.

In those cities where the population size and density result in severe and costly congestion, it can be easier to justify good alternative (public) transport systems. Ironically, this provision then makes it easier to achieve behavioural change. As well as population level and density, highly-centralised retailing and business combined with high levels of tourism all contribute to high levels of congestion but also serve to underpin the provision of high quality public transport.

Of course, congestion can occur in the smallest of settlements and in modest towns—such as Durham and Valletta. But here a mode change is possible without major enhancements to the public transport system. The cordon zone for these cities is so small that private vehicles can readily access the perimeter of the zone and walking or short-distance shuttle buses can readily penetrate and service the small area within the zone. The mode of access to the zone can remain unchanged while the alternative cost for movement within the zone can be modest or minimal.

The important, and often-neglected, point is that successful zone (*cordon*-based and *area*-based) congestion charging schemes rely on good public transport for movement to, and within, the charging zone. Without good public transport it is likely that an extortionate level of charges would be required to achieve the necessary driver behavioural change.

Good governance requires that the allocation of funds for public transport be subjected to standard public finance assessment.

While the role of good public transport is generally recognised, this is widely misinterpreted as providing a justification for automatically channelling funds to public transport. This is not the case. Good governance requires that the allocation of funds for public transport be subjected to standard public finance assessment. Lack of transparency for funding of public transport in cities where congestion charges have been introduced makes it difficult to draw conclusions about the rigour of the approach adopted. Regardless, the standards of public transport that can be justified for other cities may not be warranted in Australia: the population densities and urban form of Australian cities is considerably different from those cities where congestion charging is currently implemented and/or being considered. For instance, New York's Metropolitan Transit Authority (MTA) operates North America's largest transit network, serving 2.5 billion riders annually, accommodating 80 per cent of all daily trips to Manhattan's business district. Even within the US, New York City stands out:

> There are no other US cities with ridership like New York City. Approximately one out of five US transit trips are made in the New York area (Schrank and Lomax 2007, p. B28).

This is a considerably greater task than is performed by public transport in Australian cities. However, while the relatively dispersed form of Australian cities is a handicap when delivering public transport services, it ensures that the city centres avoid the worst of the congestion found in the centres of other major cities across the world. While Australian cities experience congestion beyond the city centre akin to that found in other cities around the world, it is worth remembering that, thus far, most schemes have focused on city centres. Zone (cordon and area) charging in Stockholm, Dubai, Valletta, Durham, London, Milan and Rome apply to city centres and not to the suburban hinterland.

Much attention has been directed at the London scheme and to the New York City options. However, for Australia, city-centre cordon and area charging is harder to justify due to business and retail dispersal away from the centre and the difficulty in providing attractive alternative public transport. Facility charging (focusing on congested routes linking the dormitory suburbs with city centres) has more relevance for congestion relief than a city-zone charge.

However, the private ownership of many of these links adds another layer of complexity to an already challenging policy option.

The cordon scheme contemplated for Manchester is targeted at influencing city-centre commuting. Under the proposal, the scheme will extend well beyond Manchester's central core area and is therefore of practical interest for Australian cities seeking to apply a scheme on a large-scale.[42] The plan is to establish an inner-city cordon and an outer cordon near Manchester's outer perimeter. Weekday inbound traffic will be charged in the morning peak (£2 for crossing the outer cordon and £1 for crossing the inner cordon) and outbound traffic will be charged in the afternoon peak (£1 for each crossing). That is, a motorist would incur a total of £5 by crossing both cordons during peak periods. A lower charge will be levied in the afternoon as congestion is lower at that time.

The larger the congestion charging zone, the less effective it is as a comprehensive tool. In this context, area charging is more effective but also more complex and costly.

Manchester's scheme is likely to 'bite' on travel because it targets specific traffic flows at specific times. However, it is important to recognise that the scheme is unlikely to affect traffic flows within the cordon zones. This is something that, in principle, London's area charge does tackle, although the complexity of the scheme inevitably increases implementation costs considerably. The lesson, then, for Australia is that the larger the charging area, the less effective the cordon charging becomes as a comprehensive tool to tackle congestion.

3.11 Primary benefits of congestion charging schemes

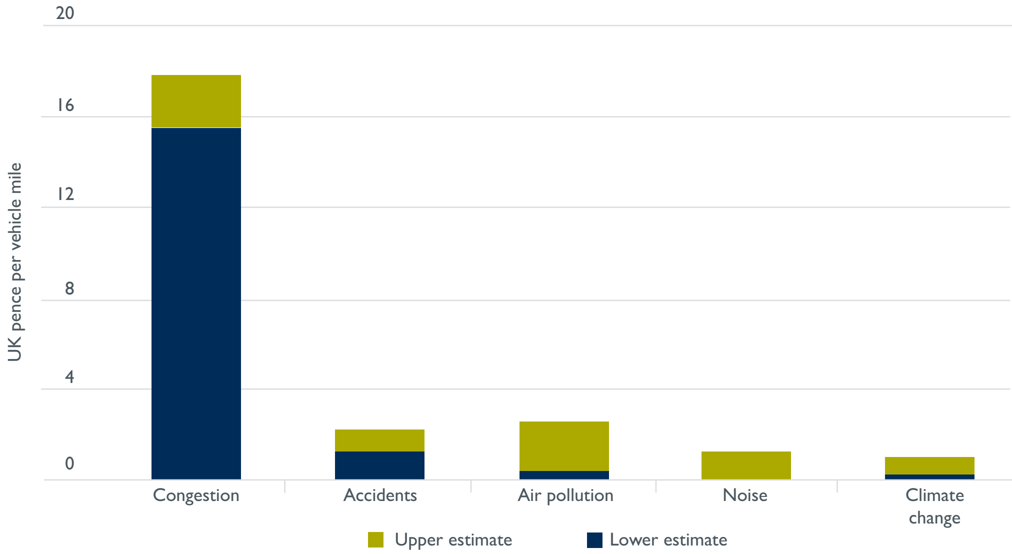
In this section we consider the primary benefits that are attributed to congestion charging schemes, the main one of which is to internalise the external time delay costs that drivers can impose on each other as rival users of scarce road space on a highly-utilised road. To the extent that the charge modifies behaviour, it can also be perceived to improve the environment. Finally, scheme proponents may see the revenue raised as being a benefit to the extent that the proceeds can be applied to funding road maintenance or investment or to public transport. This is often referred to as the 'double dividend'.

Internalising external costs

Congestion charging is a relatively unique policy instrument in that it holds appeals for both environmentalists and governments. Environmentalists embrace the point-of-use charging aspect as a tool to discourage driving and encourage alternate modes of transport, with a subsequent reduction in emissions. For budget-constrained governments, congestion charging can be viewed as a solution to the current and forecast debilitating levels of congestion while bolstering their 'green credentials'. The access to a previously untapped source of revenue can also be an attraction.

42. See, for instance, Greater Manchester Passenger Transport Authority (undated) for details of the proposal.

Figure 3.6 Congestion dominates road user externalities



Source: Adapted from CfIT (UK) (2002a, p. 17).

For most countries, congestion costs represent the single most significant external cost of road use, as illustrated by the (European) estimates of external costs in Figure 3.6.

Thus, it is not surprising that many road authorities see the primary purpose of congestion charging as reducing congestion. While not always explicitly stated, it is often implied in statements such as 'to encourage casual motorists to clear the toll road during commuter rush hours'; 'to impose road pricing regulations to control traffic' (Southampton City Council undated) or 'a management technique that can be employed to moderate demand' (Georgia State Road and Tollway Authority 2005, p. 2).

Some references are even more oblique, such as the discussion of pricing policy in the Netherlands, where it was noted that 'not all ambitions for the roadways can be achieved with investment alone' and that different 'methods are being developed to pay for mobility … A pricing policy is inevitable' (UNECE 2004, p. 1).

When he was United Kingdom (UK) Transport Minister, Stephen Ladyman stated that the national congestion charging scheme plan, that was mooted for introduction in 10 to 15 years (but subsequently abandoned), was 'entirely about relieving congestion. It's not about the environment or raising additional revenue.' However, Ladyman added that 'it may be that a system that meets our needs with regard to congestion can then be tweaked to address environmental issues as well'. This is exactly what has occurred with the 2008 evolution of the London Congestion Charge into a congestion/environmental charge.

Estimates of reductions in pollution costs due to congestion charging could make this 'tweaking' worthwhile. The analysis in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (DEFRA (UK) 2006, p. 115) indicates that congestion charging could generate health benefits of up to 398 000 life years saved and significant benefits to society of around £200 million per annum of air quality benefits alone (while recognising that the total benefits of a national scheme may be much higher than this). The study also indicates that a national system of congestion charging also has the potential to reduce by around two-thirds exceedences of PM10 (particulate matter 10 microns and smaller in dimension) near urban roads by 2020.

Ensuring a return on investment and as a signal for infrastructure expansion

Another, less used, justification for congestion charging is as an efficient way to recoup the capital cost of a road investment. Whether this is expressed as 'to give a private toll road operator the tools it needs to best run the toll road' (Guinane 2006), or as 'a less-distorting way to achieve a given revenue flow', the intention is similar. If a road is to be subject to tolls to recoup some or all of the capital cost then, from an economic perspective, appropriately structured congestion charging has the potential to significantly reduce the economic loss generated by a flat-toll funding option.[43]

A useful attribute of congestion charging is that it can signal when it is more efficient to allow the roads to become more congested and when it is appropriate to expand capacity. In theory, when the marginal cost of congestion becomes greater than the marginal cost of infrastructure expansion, then expansion is warranted. While, in reality, the application of this principle is more complex, it still provides the essential link between the phenomena of congestion and infrastructure investment.[44]

An added feature of congestion charging is that it can signal when to expand capacity.

Improving the environment

Increasingly, both existing and planned congestion charging projects specify environmental benefits as one of the objectives. Indeed, it can be difficult to distinguish between charges introduced in city centres for environmental reasons from those introduced for traffic management reasons, as with the Milan trials that started in January 2008. The Milan system is variously labelled as a 'congestion charge' and as an 'environmental charge'.

There are two sources of environmental benefits from congestion charging schemes:

- by reducing congestion, vehicle emissions decline; and
- once a charging system is in place, the charges can be differentiated to encourage the use of lower-emission vehicles.

Exhaust emissions represent the main source of pollution from motor vehicles.[45] When engine conditions are optimal, (fuel/air ratio, temperature and running engine) emissions are minimised. There are two causes of the higher emissions associated with congestion: slower speeds and stop-start travel. Both lead to suboptimal engine operations, higher fuel usage, incomplete combustion and, ultimately, higher emissions.

43. 'Potential', because the final contribution depends critically on the cost of the implementing the technology.
44. See Hau (1992) for an excellent exposition of this point.
45. Other sources are evaporation from heated engines and fuel tank source evaporation during refuelling.

> **A golden rule in policy development is 'one objective, one instrument'.**

The impact on congestion and on emissions is illustrated in a number of ways. One US study compared emissions from congested traffic conditions at toll plazas with free-flowing traffic conditions following the implementation of electronic toll collection. Saka, Agboh, Ndiritu, and Glassco (2000, p. 13) estimated that there was a 40 per cent decrease in hydrocarbons and carbon monoxide emissions per hour, following the removal of the physical toll plazas obviating the need for vehicles to stop.

Schrank and Lomax (2007, p. 1) estimated that in the US, traffic congestion resulted in the use of 2.9 billion gallons of extra fuel due to engines idling in traffic jams, with a concomitant increase in emissions. In Australia, it has been estimated that the introduction of 'optimal congestion charging' in capital cities could reduce fuel use by almost 30 per cent (BTCE 1996b, p. 530), with a similar decline in emissions.

Congestion charges are increasingly being differentiated across vehicle types, as a second method of pursuing environmental goals. The London Congestion Charging scheme was initially targeted at reducing congestion and during the first stage (prior to the Western Extension) did not claim to reduce emissions, given the fact that it accounted for only 2 per cent of the London area. Nonetheless, when introduced, the scheme had an environmental component to the extent that alternative fuel (electric, biofuel and hybrid) vehicles were exempt from the charge. This differentiation was strengthened in 2008 when higher charges were introduced for higher emitting vehicles.[46]

As discussed on page 48, sound policy requires one policy instrument per objective. Hence, using one policy instrument—congestion charging—to achieve two objectives can be problematic. As observed in the context of rail infrastructure pricing, 'the charge is often performing too many tasks' (BTRE 2003, p. 170).

The result is that, first, there is a high risk that charges calibrated to achieve more than one objective will end up sending complex signals. The more complex the signals, the less likely it is that road users will respond as desired by policy makers.

Secondly, the objectives may conflict. In the case of London, TfL (2007) recognises that the removal of congestion charges for a wider range of (low emission) vehicles is likely to contribute to higher congestion levels (TfL 2007, p. 2).

As an 'innovative' source of finance

In this section we consider the benefits that flow from using congestion charging as an 'innovative' source of finance. The accrued revenue may then be applied to roads, other transport (notably, public transport), or may serve as a source of general revenue (not earmarked for any specific sector or activity).

Three issues are addressed. First, whether trends in conventional funding require us to turn to alternative sources of finance. Secondly, the efficiency of congestion charging as a revenue-raising source, relative to other taxes and charges. Finally, the merits or otherwise of earmarking of revenue must be assessed; this issue is also discussed further on page 85.

46. Although, from some complaints, it seems that not all vehicles with the same emission profiles are treated equally.

Trends in traditional financing

Congestion charging is increasingly regarded as an important new and 'innovative' revenue source for transport investment. There is a concern among road authorities that traditional revenue sources will not keep pace with the growing demand for road space. Depending on the substance of this premise, it means that governments will be forced to consider alternative—innovative sources of finance. Of course, if this premise did not hold, then the pressure to adopt congestion charges, in order to make up the shortfall in road finance, would diminish.

Congestion charging is seen as an important new source of investment funds.

Concern with the level of infrastructure provision in it self (irrespective of congestion issues) can lead to calls for infrastructure to be provided earlier than could normally be provided through traditional financing means. Thus, 'innovative' funding such as PPPs (see page 12) and congestion charges (such as the proposed Dutch 'Acceleration Price', (see page 80 and Ministerie van Verkeeren Waterstaat (undated) can certainly be seen as policy responses that bring forward—accelerate—the delivery of road infrastructure.

Box 3.1 What is 'innovative' finance?

'Innovative finance' for surface transport infrastructure is a term that encompasses a combination of techniques and mechanisms to supplement traditional grant-based funding sources, including the following:

- new or non-traditional sources of revenue
- new financing mechanisms designed to 'leverage' resources
- new funds management techniques
- new institutional arrangements.

Source: AASHTO (undated).

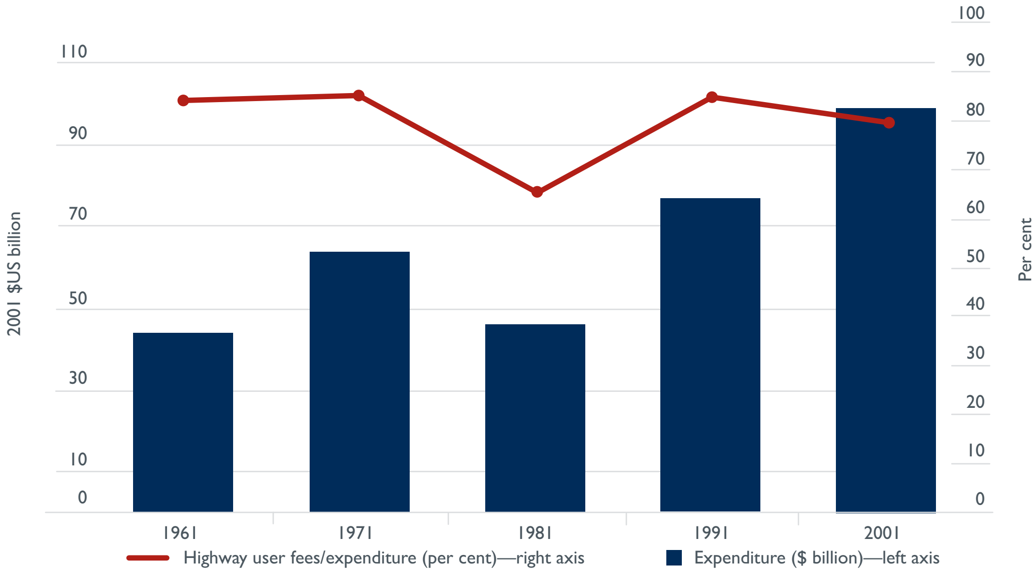
The term 'innovative' financing should be seen on a continuum of instruments. For many decades, the standard source of funding for roads has been general (consolidated) revenue with taxes and charges associated with road use exceeding the funds allocated to that sector, even after a general contribution to consolidated revenue is taken into account.

Government may also provide, or use its fiat to enable a private company to provide, a road for which a direct charge—a toll—is levied at point of use. If this toll is differentiated to directly reflect congestion levels, as a congestion charge, it can provide a rich seam of revenue for the cost recovery of infrastructure.

The case of the Dulles Greenway toll road in the US State of Virginia illustrates the potential role for congestion charging in cost recovery. The Greenway was constructed in 1999 as a PPP but 'lost money every year it has been in existence' (Commonwealth of Virginia 2007, p. 4). In 2007, the State regulator approved the introduction of congestion charging (embodying an increase in the charges) to improve cost recovery, concluding that the case 'presents the private part of that partnership, and the piper must be paid' (Commonwealth of Virginia 2007, p. 4).

Thus, congestion charging can facilitate cost recovery in facilities; this is a crucial consideration when that infrastructure is privately-funded. Indeed, as we considered earlier (see page 12), the application of PPP systems may rely upon such charging options in order to secure this model of infrastructure provision.

Figure 3.7 Historical trends in US National Highway spending, user fee revenue/expenditure ratio



Source: Adapted from Transportation Research Board (2006, Table 2–3, p. 28).

A more general case for applying congestion charging to generate funds for infrastructure is the argument that conventional road user-funding is losing its effectiveness as a source of revenue.[47] As explained by a US state transport authority, after adjustments for inflation, the improved fuel efficiency of cars had reduced the tax revenue per mile driven on Oregon's roads from 2.31 cents in 1970 to 1.16 cents in 2003' (Whitty and Imholt 2007, Table ES.1, p. 1). Oregon's response to this threat to its road revenue is examined in Section 3.12.

Since fuel tax revenues in the US are hypothecated for road funding purposes, there is concern at the national level that the Highway Trust Fund could find itself in a deficit situation as early as Fiscal Year 2008. Figure 3.7 illustrates US National Highway expenditure and the ratio of expenditure to payments from road users.

Apart from the blip during the first oil price shock, Figure 3.7 shows that expenditure grew steadily, with user fee revenue accounting for around 90 per cent of expenditure. More recently, the share of expenditure accounted for by highway user fees has declined to 80 per cent. It is this decline that generates doubt over the continued 'viability' of the fuel tax, where viability is defined by the Transportation Research

47. This is a concern that arises irrespective of which infrastructure ownership/control is adopted.

Board as ‘the capacity of the tax to fund transportation programs at an inflation-adjusted rate comparable with that of the past 20 years’.

Note that during the 40-year period illustrated, revenues were sufficient to fund growth in highway spending and capacity and some improvements in service but not sufficient to prevent growing highway congestion (Transportation Research Board 2006, p. 16).[48]

But the case for pursuing ‘innovative’ finance, such as congestion charging, because of these financing concerns may be somewhat overstated. There may be undue anxiety that traditional road funding and budgetary trends will result in a funding crisis. The reason for reviewing these concerns is, firstly, that fuel economy trends may not continue. Further, public transport’s share of the transport budget may not be maintained. Crucially, analysis by the Transportation Research Board concluded that:

> … the existing revenue sources will retain the capacity to fund transportation programs at historical levels (Transportation Research Board 2006, p. S2).

The Board identified three key reasons why improvements in fuel efficiency are unlikely to continue at the same rate as in the past:

- hybrid and electric vehicles are not expected to make a significant impact over this time. None of the studies reviewed by Transportation Research Board projected a significant market share for hydrogen-fuelled cars or electric vehicles;
- during periods of stable fuel prices and rising incomes, consumers have shown a preference for taking advantage of efficiency improvement technology by buying larger, higher-performance vehicles rather than by reducing their dollars-per-mile operating costs; and
- future efficiency gains will be more costly than past ones and hence the rate of improvement in fuel efficiency will decline (Transportation Research Board 2006, pp. 4–10).

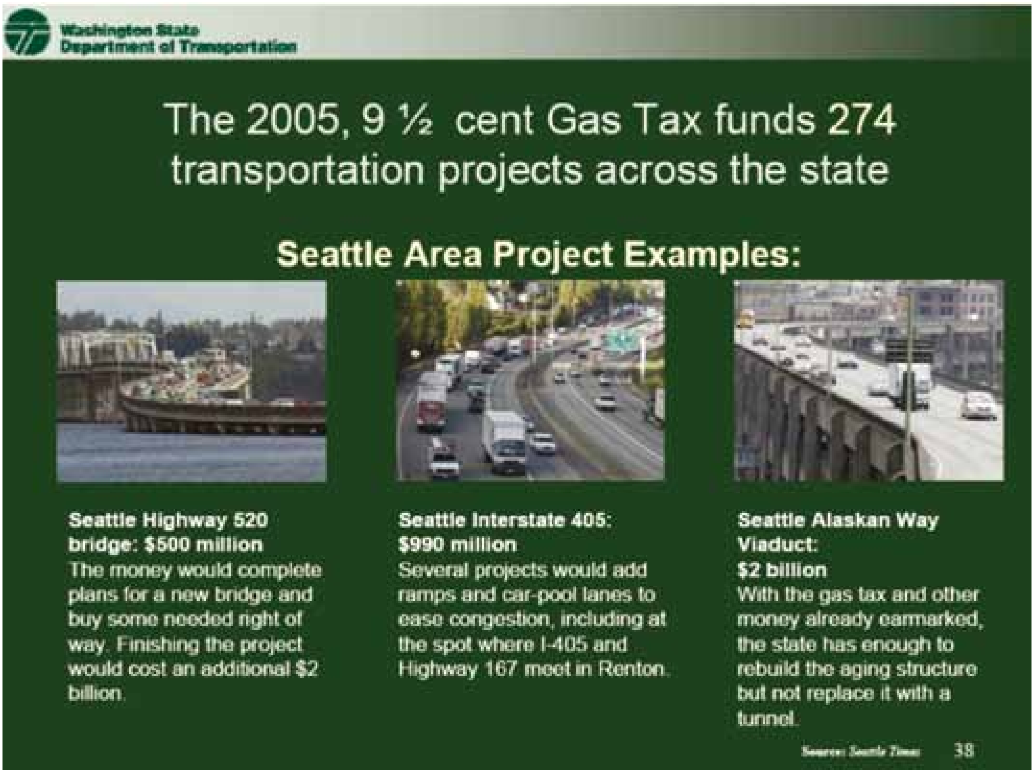
The Transportation Research Board concluded that, in the absence of large fuel price increases and new government intervention—such as an increase in corporate average fuel economy—fuel economy improvement is likely to be no more than a few per cent by 2025 (Transportation Research Board 2006, pp. 4–14).

More importantly, in light of the rapid and sustained fuel price increases since the Transportation Research Board report was completed, even a 15 per cent decrease in unit fuel consumption, could be offset by an increase in the fuel tax of about US$0.07 per gallon (in 2002 dollars), or increases in other user fees.

Also, while it is commonly argued that raising the fuel tax is not an option, apparently it can be achieved where there is the political will to do so. For instance, in 2005, Washington State raised its fuel tax by 9.5 US cents per gallon—albeit to be phased in over three years. This followed an earlier increase in 2003 (Bremmer 2005, p. 21). In California, a number of local counties have voted for an increase in sales tax to fund specific road expenditure projects.

48. However, this is not to suggest that growing highway congestion was an undesirable outcome. The optimal level of congestion is determined, in part, by the cost of expanding highway capacity and the value of time saved by the expansion by the network. If expansion costs are high relative to the value of the time savings, then increased congestion could be in the community interest.

Figure 3.8 The 'selling' of the Washington gas tax increase



Source: Bremmer (2005, p. 38).

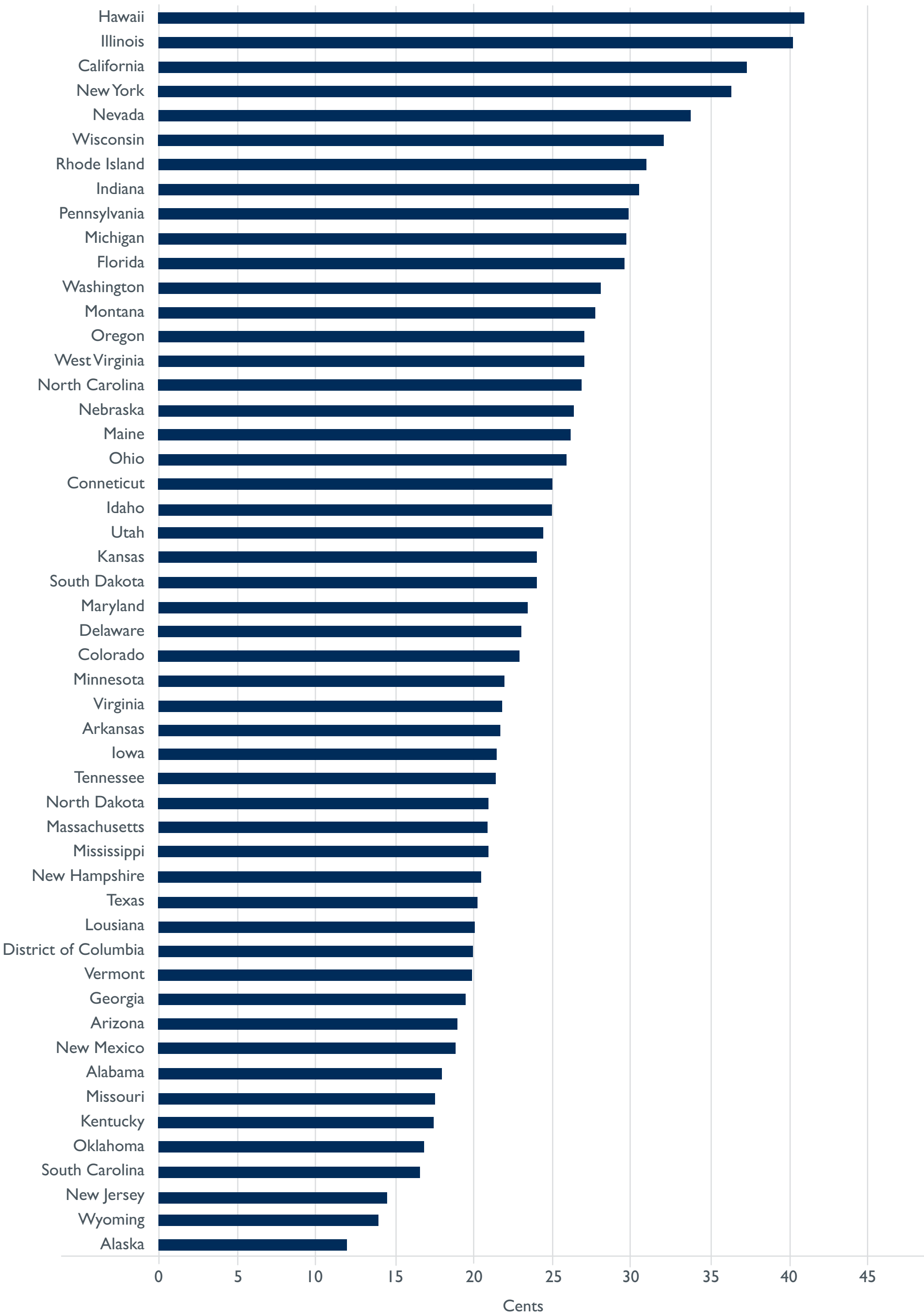
Figure 3.8 illustrates the 'selling' of the 9.5 US cents per gallon fuel tax. Details of the 274 transportation projects funded by the tax in 2005 are available for public scrutiny.

Furthermore, the wide disparity in state and local fuel taxes in the US reduces the credibility of the argument that 'higher fuel taxes are not possible'. As illustrated by Figure 3.9, combined US state and local fuel taxes can vary widely between the states—from 12 US cents per gallon to over 40 US cents per gallon. Federal tax brings the highest tax rate up to around 60 US cents per gallon (15.85 US cents per litre)—still quite low by international standards.

It is evident from this wide range of state and local gas taxes that there is no one specific tax rate that is deemed acceptable. Community support for fuel tax increases appears to be more forthcoming if the extra revenue is spent on specific road projects.

In brief, while innovative sources of funding should always be explored, it seems premature to conclude that the fuel tax will be 'non-viable' over the longer term.

Figure 3.9 US state and local combined fuel tax comparisons, by state (US June 2005)



Source: Bremmer (2005, p. 30).

However, even if a funding shortfall were apparent, this would not mean that congestion charging is necessarily the appropriate instrument for making good that shortfall. Introducing congestion charging as an 'innovative source of funding' depends on a combination of this funding shortfall as well as the absence of more efficient alternative sources of revenue. If other lower cost revenue streams were available, then the case for congestion charging would be weakened.

The case for congestion charging as an 'innovative source of funding' depends on a combination of a funding shortfall and the absence of more efficient alternative funding sources.

However, as the Transportation Research Board pointed out, where the primary concern shifts from finance, there may be valid reasons for considering a congestion charge. Essentially, the fuel tax may be declared non-viable if it exhibits structural shortcomings. In this regard, the Transportation Research Board, quoting AASHTO Journal (2004), observed that:

> In the 1950s and '60s, when the interstate system was built, a gas tax made sense because virtually every driver benefited from a new, nationwide highway system. But today, capacity and maintenance are largely urban and suburban problems unique to the short lengths of highway used by commuters. Raising gas taxes does little or nothing to improve commuter congestion and punishes the millions of drivers and businesses that don't use busy urban highways (Transportation Research Board 2006, p. 47).

In other words, where the problem is congestion, this should be targeted directly. In this situation a congestion charge has significant advantages over a fuel tax. However, this is completely different from the argument that congestion charging is required to raise revenue for road expenditure.

Ultimately, the most suitable funding options for roads will depend on a range of factors. The fundamental challenge is to evaluate the options available for financing the road network (including congestion charging) using the standard public finance criteria of efficiency and equity,[49] where efficiency includes the full scope of costs, including environmental costs. Under some circumstances, congestion charging could represent the more efficient option, but where traffic is thin and technology costly, it is likely that a fuel tax would be preferred.

Where traffic is thin and technology costly, the outcome of the evaluation of congestion charging is likely to conclude that fuel tax is preferred.

Funding public transport

In the previous section we considered the appeal of congestion charging as an ongoing source of revenue for other transport purposes. There is also a well entrenched view that congestion charging is an appropriate source of funds for public transport. This 'twinning' of congestion charging and public transport generally draws on the following logic:

49. It should be noted that while the equity implications will always need evaluating, infrastructure provision is rarely, if ever, an effective way of pursuing equity objectives.

- the introduction of congestion charges will encourage increased use of public transport
- the success of congestion charging in achieving behavioural change is more likely if the options to peak-hour use of the road are enhanced (providing 'transport choices')
- improvements to the public transport system will reduce the political fall out from the charges.

There is a twist to this argument for diverting funds raised by congestion charging to fund public transport—the introduction of congestion charging with the aim of raising revenue to fund a public transport project. The Metropolitan Washington Airports Authority suggested that a peak-hour levy (congestion charge) be introduced on the Dulles Toll Road in Virginia (US) to generate funds to extend Metro Rail to Dulles Airport. The Airports Authority offered to 'take over' the toll road to bring this about.[50] Without this 'innovative source of revenue', the Dulles rail extension was unlikely to proceed.[51]

Easy access to congestion charging revenue can reduce the pressure for careful scrutiny of project funding.

Criticisms of the project highlight the extent to which easy access to an assured funding stream risks distorting policy priorities. One irony in the situation is that raising revenue via congestion charging reduces the case for extending the metro because it would relieve the traffic problem on the toll road:

> It looks like the Dulles Tollroad is being tapped to pay for part of the metro extension to the airport. However if the road is tolled using congestion-pricing principles, then it will flow at 60 mph 24/7. At which point there is no transit mobility reason for the metro extension, since buses can travel on the toll road at 60 mph at all times (Padelford 2006).

One way to safeguard the embrace of congestion charging on the basis of its revenue-generating power could be to make the default option revenue neutrality such that no net revenue was generated but, rather, other taxes were reduced.

3.12 Exploring congestion charging options can be costly

Policy makers should be aware that congestion charging schemes involve considerable time, money and political resources. In 2005, a public referendum overwhelmingly rejected the congestion charging scheme proposed for the city by Edinburgh Council. The £2-a-day charge was rejected by 3 out of 4 voters. Total spending on the proposal was over £9 million ($A21 million) between 2000 and 2005, with the publicity campaign alone costing more than £1.5 million ($A3.5 million).[52] This comes on top of a council bid to reintroduce trams, which has already cost more than £16.5 million,

50. A Virginia State Delegate reported that the State of Virginia had previously been offered US$6 billion for the toll road (R. Marshall undated).
51. With capital costs of US$3.5 billion and operating subsidies estimated at around US$65 million per annum by 2015, the project failed to meet federal cost-effectiveness standards (Dulles Corridor Rail Association 2005).
52. As one critic commented, 'that could fill a lot of potholes in the roads'.

with a *potential funding gap of £340 million further down the line if the plans are approved* (Roden 2005).

Prior to the implementation of the Stockholm congestion charge—called *Trängselskatt i Stockholm*—the government undertook a trial operation of the scheme and this was followed by a referendum on whether to introduce the scheme permanently. Two significant costs here are the trial costs and the referendum costs.

> **The case for a congestion charge should rest on a scheme's merits. There is a clear danger that congestion charging will be seen by authorities as a 'Magic Pudding' in that it can deliver an endless source of funds.**

The Stockholm ring congestion trial, launched in January 2006, was estimated to cost around US$430 million (Kr3.3 billion) (Samuel 2006). Traffic levels were reported to have declined by around 25 per cent since the start of the trial. Revenue flowed in at an annual rate of US$80 million. The Stockholm trial, and subsequent permanent scheme, has some standard and some not-so-standard characteristics:

- no toll booths: electronic tolling only
- a seven-month trial (which ended on 31 July 2006) followed by a referendum on 17 September 2006
- when the trial commenced, 80 per cent of the public opposed the scheme
- peak period tolls (20 Kroner or about 2.20) are double those during the middle of the day (10 Kroner)
- tolls apply only on working days except for the day prior to each public holiday
- conventional point tolling (with ANPR) so payment incurred every time a point is passed, with a daily cap of three peak tolls (60 Kroner)
- all vehicles pay the same toll, regardless of size.

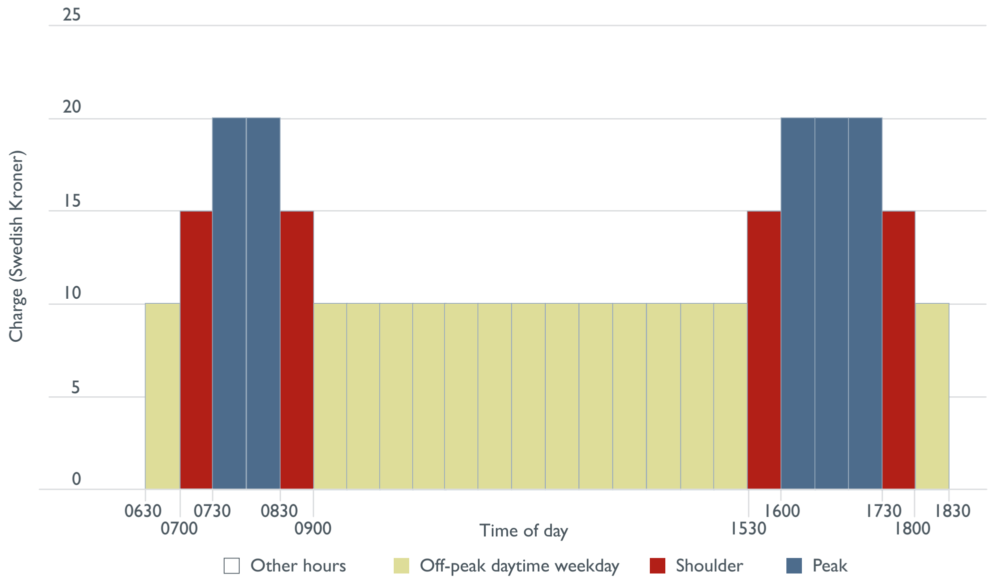
The tolling structure is illustrated in Figure 3.10. No tolls are payable between 7pm and 6.30am.

Project risks

Recent experiences with congestion charging trials indicate that schedulers tend to underestimate the time delays in implementing a project. This risk is higher, the more advanced the technology that is being utilised. For instance, Oregon's road user charges pilot program was recommended to run for months—from 1 January 2004 to 31 March 2006. Due to delays in launching the trial it ended up running for 12 months from early 2006 (Oregon Department of Transportation Policy Unit 2004, Oregon Legislative Assembly, Road User Fee Task Force 2003).

Similarly, Stockholm's congestion charging trial was originally planned to run for 13 months but due to legal delays was shortened to seven months—see Table 3.3.

Figure 3.10 Stockholm congestion charging structure



Note: Maximum charge: Kr 60 per day. Evenings, Nights, Saturdays, Sundays and Public Holidays are free.
Source: Carle (2004).

These unanticipated delays in launching congestion charging trials can significantly undermine the value of trials. The high upfront costs of these trials mean that little is saved from the shortened duration, while the benefits of the trial are significantly diminished.

The 2003 Bristol trials were designed as a forerunner to a fully-fledged system. Extensive data collection was carried out to create a base case against which to evaluate the impact of a future scheme. The necessary research and consultation on the legal and financial aspects of the trial were undertaken. The delay in the implementation of a full-scale congestion charging scheme has been attributed to the failure to construct the principal complementary measure, the Light Rapid Transit system.

Table 3.3 Timeline for Stockholm's congestion charging trial

2003, June 2	Stockholm City Council, decided to implement a congestion charging trial.
2004, July 12	Contract to help build and operate Stockholm's congestion charging system awarded to IBM's Business Consulting Services division.
2005, June 1	Congestion charging trial scheduled to start.
2006, January 2	Congestion charging trial began.
2006, September	Referendum to determine whether the system should be adopted permanently.
2007	Scheme made permanent.

Source: Various.

Planning and coordination of congestion charging

The process adopted for introducing congestion charging determines the efficacy of the scheme. By their very nature, zone charging schemes are implemented by city-based administrative authorities; this application reflects the nature of the local problem and the tailoring of the scheme to local circumstances. To date, facility charging is also locally-based; it is not extensively applied and so, again, generally comes under the jurisdiction of a local authority.

The case for national coordination of local charging schemes is one issue that then bears scrutiny. There could be gains from national coordination of schemes to the extent that different jurisdictions share relevant experiences.

The application of congestion charging to road use is still in its infancy and cross-jurisdictional and international experiences offer invaluable insights.

Apart from sharing experiences, national coordination is an issue with the form of technology that is adopted. With declining technology costs and rapid technological developments, and where direct road use charging is increasingly adopted, the issue of nationally coordinated charging schemes must be addressed. Even with technology, however, the gains from technological standardisation are not always apparent—particularly when technology is changing rapidly, when the 'right' mature technology is still unknown, and when there are low traffic volumes that bridge those inconsistent systems (as discussed in BTRE 2006a, p. 48). An obvious danger is that a nationally consistent approach imposes inappropriate technology on an area or that the uniformity of approach fails to allow more desirable options to evolve (see BTRE (2006a, p. 76) for a discussion on the risks of locking in inferior standards).

The case for national coordination of the other aspects of a congestion charging system is not obvious. Whether coordination is in the interest of the wider community depends on the benefits and costs of that coordination. The costs can often be substantial whereas the benefits of coordination/harmonisation may be small, particularly in the case of geographically-isolated, independent schemes. Customisation may be more in the community interest than harmonisation. In this context, we have noted in this report that scheme costs and benefits are very location-specific; as a consequence of this, to be successful, the scheme must reflect—be tailored to—those local circumstances.

An example of the limits to national, rather than city-specific, approaches lies in the parameters used in economic evaluations of schemes. For instance, as discussed throughout this report, the gains from congestion charging are determined by the value ascribed to time, for different road users and at different times.[53] But, as discussed in Appendix B, there is no 'correct' value of time. We acknowledge that when transport funds are distributed at the national level, the use of a uniform scale of time values may be necessary in order to pursue an objective of 'common wealth'. However, if the charging schemes are state or local-government based (as applies to all examples to date apart from Singapore), then there is no virtue in ensuring a nationally consistent scale of the value of time.

There are two key issues. As with the debate (see page 128) regarding the value of time in London relative to Paris, a case could be mounted to ascribe different values of time between, say, Sydney and Melbourne. The natures of the cities differ to some extent, so the composition of the traffic is also likely to differ.

53. At different times of the day, week, month and year.

Perhaps the more important issue is that there is little to be gained from ensuring a common scale of time values *if there is no interdependence between congestion charging schemes of different cities*. Hypothetically, if City A adopted a value of $100 per hour for the value of peak-hour travel time and City B adopted a value of $150 per hour then, all else being equal, City B is more likely to implement a congestion charging scheme. The value of time saved (through reduced congestion) will be 50 per cent greater in City B than in City A. Is such an outcome undesirable?

In other words, are there gains from enforcing a nationally-consistent value of time when congestion charging is under consideration? If the value of time were unambiguous, then the answer would more likely be 'yes'. If the schemes were financially interconnected—say through relying for funds from a national pool—then again the answer could be 'yes'.

While there are gains in learning from experience of other cities there is no presumption that schemes across cities should be coordinated—apart from the obvious inter-operability of the e-tags.

In contrast, if schemes were financially independent and the cities autonomous, then there would be no purpose in different jurisdictions putting effort into reach agreement to adopt common values of time or of coordinating other aspects of the schemes. Such agreement absorbs scarce resources for little obvious gain. Each jurisdiction/city needs to appreciate why their time values differ—and this can be a powerful check on the robustness of the time value estimations—but once those checks have been undertaken and the figures confirmed, then it would be erroneous to seek convergence on those values.

To conclude this point, there are clear gains in learning from the experiences of other cities. However, there is no reason to presume that coordination of traffic management systems between independent cities—whether by congestion charging or other methods—justifies the cost of achieving that coordination.

The evolving science of congestion charging

In the long history in the development and application of congestion charging there has never been such a dynamic period. This is in no small part due to the advances in technology. The two examples below illustrate this point.

Pay-as-you-drive insurance

Pay-as-you-drive (PAYD) insurance illustrates the potential of deploying GPS for road-user charging. The option of car insurance payments that more accurately reflect accident risk has been offered for a number of years by two companies—Progressive and Norwich Union—initially as a trial but now as fully operational systems. Charges depend on a number of risk factors including distance, location and, in some cases, traffic levels. Involvement is voluntary but those that opt for such insurance generally benefit from lower premiums.

Essentially, savings are possible through pay-as-you-drive (PAYD) insurance because charges more closely reflect costs. PAYD represents a private sector illustration of the scope for shifting fixed charges to point-of-use charges that are determined by a number of factors linking the level of congestion. For more background on PAYD insurance see BTRE (2002, pp. 49–50).

The Oregon Concept

Since 2001, the US State of Oregon has investigated alternative systems for collection of road user fees. The study was prompted by the realisation that the growing adoption of alternative fuel vehicles would undermine the 'gasoline tax' base, upon which road funding depended.

There are two essential parameters in the 'Oregon Concept' (as the approach is known). First, road use is charged on a per-mile basis. Secondly, road use charges are modulated (varied) by the zone/time in which vehicle is travelling.

The distance travelled can be measured by a simple odometer attached to the vehicle. However, knowing that the vehicle is operating in a given location/time period requires more sophisticated equipment. The positioning system can, of course, ensure that road users are paid only for movement within the State and are not charged for the gasoline tax.

Technology and user behaviour were tested in 2006–07. A few options for vehicle location/time were considered and GPS tracking was applied.

The trial volunteers with liquid-fuel vehicles were levied a mileage fee. This fee was collected when users refuelled their vehicles. Equipment was retro-fitted to the vehicles to measure mileage. Different dollar rates were applied to two zones; peak-hour travel in the central zone incurred a much higher per mile rate. In particular, a peak-period charge of 10 cents per mile was applied to peak-hour travel in central Portland; a blanket rate of 0.43 cents per mile was applied to all travel at all hours in the other zone (covering the rest of Oregon). The mileage fee was then added to the fuel bill collected at the filling station. The mileage fee was in lieu of a gasoline tax.

Although it did not form part of the trial, the mileage travelled by non-liquid fuel (that is, electric-based) vehicles would be taxed with the monthly household electricity bill.

A merit of the system is that it does not require numerous expensive gantries and other equipment, which can lead to costly capital and operating costs. Nonetheless, considerable cost would be incurred as each vehicle would need to be fitted with GPS-based equipment. However, there will come a point in time when such equipment is standard.

The merit of the Oregon Concept is that is offers a relatively lower-cost option in area charging.

The Oregon Concept provides a mechanism for collecting road user fees which, to the motorist, appears little different in its payment system—or occurrence—to the gasoline tax. The system also provides a mechanism for congestion charging—the differential pricing for peak time led to a 22 per cent decline in travel in central Portland. Nonetheless, the proponents of Oregon Concept do not believe that the system lends itself to dynamic pricing (where charges vary directly with the prevailing level of congestion at any given time).

3.13 Conclusions

Congestion charging can be used to influence traffic flow at any given time, increasing both throughput and overall traffic speeds. While the theory behind congestion charging is extensive, practical examples are limited. However, different independent and unrelated incursions into congestion charging increasingly provide insights into the practical problems to be encountered and options for overcoming these problems. Possibly most relevant for large-scale charging are the models adopted for the Oregon trials and for the commercial PAYD insurance schemes.

Ultimately, assessing whether a charging scheme is successful depends on the benchmark criteria used. These criteria include political, financial, technical and economic. However, to be in the overall interests of the community, a congestion charge needs to be an economic success. For this to be the case, the efficiency gains of the scheme (the change in road user behaviour) must exceed scheme set-up and operation costs.

The current high costs of schemes cast doubt about the wisdom of using congestion charging as a fund-raising mechanism. The case for this strategy depends on the need for funding revenue shortfalls that would otherwise be incurred in road provision; and the absence of more efficient, alternative sources of revenue. There are often better ways of raising funds.

What is to be done with the net revenue raised? Revenue can be pooled into government consolidated revenue; returned to the road network; or directed to alternative (public transport) modes. However, whatever the allocation, good governance requires that the allocation of funds be subjected to standard public finance assessment.

Finally, there is an issue of the merits of national coordination of congestion charging systems. The case for coordination rests on the degree of interdependence of the schemes and on financial, technical and/or in-traffic use. There is no public finance reason for there to be financial interdependence between the congestion charging systems of different cities. Traffic management is a local issue and, apart from learning from the experiences of other jurisdictions, is best managed at the local level.

Chapter 4 Congestion charging and community attitudes

Summary

- Community resistance to congestion charging is widespread and easy to understand.
- In introducing congestion charging there can be a strong temptation to buy community support regardless of the cost and the damage to the economic integrity of the scheme.
- If there is little response to a charge, the scheme will be difficult to 'sell' because gains from the scheme will be low and the revenue raised high.
- Use of the revenue will be critical and provides the opportunity of changing the ratio of winners to losers through, say, spending on public transport, roads or reducing other motoring taxes.
- However, from some of the case studies, there appears to be a tendency to treat the revenue raised from congestion charging as a windfall that does not merit the same critical assessment that good governance would normally require.
- Earmarking of revenue to specific projects is not efficient as the discipline of competing for those funds is necessary to ensure the highest return to the community from those funds.
- While exemptions are commonly used to garner community support, they lack theoretical underpinnings and rarely contribute to equity objectives.

This chapter reviews the main barriers to community acceptance of congestion charging and explores options for addressing them. We provide a brief outline of the principal objections to congestion charging, focussing on the most pervasive source of disquiet: that congestion charges are inequitable.

We then review the general issue of earmarking revenue raised for specific purposes to offset the adverse impact of the charge on road users. Finally, we consider procedural approaches to gaining community support.

4.1 Introduction

The concept of congestion charging would seem to have instant appeal as a way to unclog our roads. But community attitudes are diverse, notably with some community members being strongly resistant to paying 'extra' to achieve uncongested roads. The

ECMT argues that experience with price-based approaches to tackling congestion has identified two basic types of road user:

- Those people willing to pay in money rather than in time—and who would therefore prefer to have an opportunity to do so.
- Those people willing to pay in time what they are not willing to pay in money (ECMT 2007, p. 134).

This dichotomy in attitudes provides a major hurdle for implementing congestion charging. Perhaps the country that best exemplifies the difficulties in gaining community support for road-user charges that vary with the level of congestion is the Netherlands. That country has a long history of unsuccessful attempts at introducing congestion charging:

- 'Rekening rijden I', kilometre-charge,1988–1990
- 'Spitsvignet', rush-hour charge, 1990–1993
- 'Rekening rijden II', tolling cordons around 4 major cities, 1994–2001
- 'Kilometerheffing', kilometre-charge, 2001–2004.

Extensive research is being undertaken in preparation for the future implementation of a nationwide kilometre-based road user charge in the Netherlands. Implementation, currently scheduled for 2012, relies on continuing declines in technology costs.

While congestion charging has its foundations in economic theory and the potential efficiency gains available from the charges, this does not guarantee community support. Small saw it as a 'status quo bias against economists' recommendations to use the price mechanism to reduce congestion' (Small 1992).

Goodwin attributed this, in part, to its theoretical foundations:

> … there is no spontaneous constituency or pent-up latent market demand thirsting for the idea. It is a creation of professionals, policy makers and academics, derived from pure thought, not personal desires (Goodwin 2006).

Lindsey and Verhoef (2000, p. 22), citing Jones (1998) review of public attitude studies, identified the main barriers to community acceptance of congestion charging:

- its perceived unfairness
- the view that congestion is not that serious or is better dealt with by other measures
- charges will simply be another tax because they will be ineffective in influencing driving behaviour
- the technology cannot be trusted and it will impinge on privacy
- charges will cause traffic diversion, adversely affecting areas outside the charging zone area.

A review of 25 congestion charging options for the Twin Cities of Minneapolis–St Paul in the mid-1990s identified similar community concerns:

- significance of diverted traffic

- impact of the scheme on disadvantaged community groups
- adequacy of transport alternatives to the charged sections of the roadway
- use of the revenues (The CUPID Consortium 2003, p. 23).

Another common criticism of congestion charging is that it is simply a tax in another guise, such as evidenced by the labelling of the London congestion charge as 'a tax to milk motorists and small business' by the Forum for Private Business (BBC News 2006). There is a pervasive view that motorists have already paid to use the road so should not be obliged to pay again.

These concerns are echoed in number of failed attempts to introduce congestion charging in places such as Hong Kong, Edinburgh and The Netherlands and continue to be of some concern in established schemes. When put to the democratic test (election of officials or referendums), schemes face a large hurdle.

There may be more fundamental antipathy to road charging schemes. Some analysts identify a psychological barrier to congestion charging:

> Our generation has grown up thinking that roads are 'free', that traffic jams are acceptable, and that the tenfold rise in UK traffic volume since the 1950s is part of the inevitable wallpaper of civilisation (Navidski and Oswald 2002, p. 1).

The impact of technology on community acceptance can also be pivotal. Lyons, Dudley, Slater, and Parkhurst identified 'a clear connection between the efficiency of the technology and the likely acceptability of the scheme', citing a pilot electronic tolling scheme in Leicester (England) where users encountered major problems in applying the technology. They concluded succinctly: 'if the technology does not work, or is not easily understood by the public, then its credibility is fatally undermined' (Lyons, Dudley, Slater, and Parkhurst 2004, p 17). For a more detailed discussion on technology see Appendix C.

If the technology does not work or cannot be easily understood by the public, the credibility of a scheme is fatally undermined.

The most pervasive theme in objections to congestion charging is the perceived conflict between efficiency and equity. Typical are Ramjerdi's conclusions in the context of the Norwegian toll rings: 'while true congestion pricing will improve efficiency, such improvements may well be accompanied by negative distributive impacts' (Ramjerdi 2003, p. 9).

Dubai's toll system, the Salik, introduced in 2007 to reduce traffic congestion, illustrates the scope for criticism that the system is inequitable. The charges are likely to discourage use of the road by low paid (guest) workers enabling faster travel times for the wealthy.[54]

We note then that, even when the economics of a scheme stack-up, the community concern regarding adverse equity impacts can present a serious obstacle to introducing congestion charging. The population of potential losers becomes particularly important within the context of a democratic process and ready access to

54. The Salik has attracted the 'congestion charge' label because its stated aim is to reduce congestion. However, charges do not appear to vary with time of day and congestion levels so it is more accurately a road toll. Thus the Salik will reduce the level of traffic indiscriminately, rather than spreading it more evenly across the business day.

the Internet. The power of population numbers was demonstrated in Britain when, in 2007, an online petition against a mooted national road-charging scheme attracted almost 2 million signatures in 3 months (BBC News 2007).

In the following section, we review the potential winners and losers from a congestion charging scheme. We then consider how to increase the number of winners, in order to increase community acceptance.

4.2 Winners and losers

Congestion charging, like any other government intervention, produces winners and losers. Only where there is endemic hyper-congestion (as discussed in Appendix A) will all road users benefit from congestion charging—although we note that congestion charging is normally on the policy agenda before such congestion occurs.

In general, some road users will benefit from congestion charging more than others; the relative benefit of charging scheme will tend to be a function of users' values of time. Thus, as ECMT has noted:

> Even if the proceeds of the congestion charges are redistributed to road users, in the form of lower fuel taxes for instance, a congestion charge is likely to benefit people as a function of their values of time. Road users as a group gain but some gain much more than others (ECMT 2007, p. 21).

The actual winners and losers and the extent of their wins and losses, will depend on the detail of the scheme and on the local conditions including alternative transport options. However, some general conclusions can be drawn regarding the initial impact of congestion charging schemes.

Winners

The clear winners from congestion charging will include:

- the revenue-collecting agency
- those involved in the establishment and operation of the scheme
- road users with a sufficiently high value of time to offset the charge
- those eligible for exemptions or discounts. Local residents will most likely benefit from reduced congestion. In London and Stockholm, those living in the charged zone are more supportive of the scheme than those that drive into or through the zone.[55]

By its very nature, a congestion charge creates more losers than winners because there is one main winner—the revenue-collection agency. As Hau (1998, p. 47) identified, the total payment generally exceeds the value of the time savings, leaving the average motorist worse off.

55. However, protest meetings were held by the residents of the area encompassed by the Western Extension of the London scheme. This prompted British journalist, Christian Wolmar, to observe that this was 'a case of turkeys failing to support the abolition of Christmas' (Wolmar 2007).

Losers

Interest in the distributional impact of congestion charging, or more specifically, the impact on the losers from congestion charging, is a relatively recent phenomenon. Historically, the focus of the literature has been on operational matters such as accuracy of the charges, the reliability and the cost of the technology, such as typified by the 1964 UK Smeed Report in Road Pricing. At this time, 'fairness' was mentioned as important, but was not a critical factor (Ministry of Transport (UK) 1964). Similarly, with the pioneering scheme introduced in Singapore in the 1970s, the emphasis was on ensuring the efficient operation of the scheme.

As noted earlier (on pages 75–76), the power of modern communications in a democracy can be used to mobilise large numbers of the population. For this reason, the equity question, and the more general question of who loses, gains prominence and potency.[56]

Hau identifies three groups that lose from congestion charging:

- those that pay and stay (the 'tolled'). For this subgroup, while value of the time savings is more than the charge, their net benefit of road use will decline[57]
- those that abandon peak-period road use, either reducing travel, using other modes/routes or time shifting (the 'tolled off')
- users of other roads outside the charged zone that now encounter more congestion (Hau 1992, pp. 13–15).

How the losses incurred by these groups impact on public policy equity objectives warrants closer analysis. The term 'equity' embraces a wide range of meanings, from a general concept of 'fairness' to tighter definitions used in the taxation literature of 'regressive' and 'progressive'. A tax is labelled 'regressive' if it falls disproportionately on the poor and 'progressive' if on the rich.

Perceptions of congestion charges as regressive

Perhaps the most fundamental groundswell against congestion charges is that the less well-off bear an unfair burden. For the London scheme, there was understandable sympathy for low-paid nurses with little choice of shift being forced to pay the £8 charge.

Possibly the greatest opposition to congestion charges arises because of the perception that the less well-off bear an unfair burden.

There has been limited research into whether congestion charges (a) represent a heavier burden for lower income earners and (b) provide most benefits to those with a high value of time—arguably, high-income earners. In the US, this view is reflected in the term 'Lexus lanes'— the term is applied to the optional tolled lanes, referring to the wealth required to buy a Lexus motor vehicle and, ostensibly, to use the free-flowing tolled lanes. Similarly, in the London charging

56. While the UK scheme was labelled a road pricing scheme, charges were envisaged to vary by congestion levels and hence would qualify as a congestion charging scheme.
57. Hau (1992, Appendix 1) illustrates why the revenue paid by motorists exceeds the valuation of time savings, making the average motorist worse off.

zone, those who can pay the premium to buy a Toyota Prius and other nominated 'environmentally-friendly' cars have also been exempt from the charge.[58]

There are two key equity issues with congestion charging: whether it is a relevant objective for road user charges and whether, in fact, congestion charging infringes equity objectives.

Congestion charging has its roots in seeking a more efficient allocation of the community's resources. Thus, to add an equity objective can compromise its primary objective. Pricing of everyday consumer goods, such as bread, milk and movie tickets is not generally evaluated against an equity objective. The fact that purchasing such items is a greater burden on low-income earners than on high-income earners is rarely a source of disquiet in the community.

Essentially, a congestion charge is imposed for the (arguably) voluntary use of a road to achieve efficiency objectives and so it possibly should not be expected to also fulfil equity objectives.

The second equity issue is empirical: who actually wins and who loses from the introduction of congestion charging. Given the range of schemes available and the different locational characteristics, it cannot be presumed that low-income earners will be the losers. Consider the evidence of London, New York and California.

a. London

In London, social-impact surveys were commissioned prior to the introduction of the congestion charge, to determine the effect of the congestion charging scheme on various categories of road users and, in particular, on different income groups. It was found that higher income households and those without cars were most likely to say that they have personally gained from the charging scheme. Lower-income households and those who drive in the zone were most likely to say that they have personally lost from the scheme.[59] These findings have been interpreted by some analysts to mean that London's scheme is regressive (MORI 2003, p. 4).

However, such results are not sufficient to conclude that the London Congestion Charging scheme offends the basic tenet of equity. The fact that some low-income earners feel worse off does not mean that the scheme is regressive. Regressive is a relative term requiring that low-income earners pay proportionately more of their income in congestion charges than high-income earners.[60] Both groups could feel worse off but this provides no guide to the 'regressivity' or 'progressivity' of the charge.

b. New York City

In New York City, research by the Port Authority of New York and New Jersey suggests that congestion charging on New York's East River bridges is unlikely to be regressive and may even be progressive. The primary users of the bridges (and hence those

58. Curiously, until 2008, the exemptions in London were not available to all low-emission cars but only those specified.
59. Income may not be an accurate indicator of wealth, as low-income earners may be asset-rich and high-income earners could be asset-poor.
60. This would be the case if low-income earners paid the charge as frequently as high-income earners.

that pay the congestion charge) tend to be the higher income earners. The public transport users (possibly the lower income earners) would benefit from the extra funding source for public transport (Hsu et al. 2004, p. 7).

c. California

Usage patterns on the 91 Express Lanes in California also indicate that higher income earners are frequent users, although the pattern is slightly more complex, as outlined by Sullivan:

> Income correlates positively with use frequency; being female, middle-aged, and highly educated also correlates with greater use. Nevertheless, many frequent users are low income, and many high-income commuters are infrequent users or non-users (Sullivan 2003, p. 40).

An important message from the research to date is that it may not be valid to assume that a high value of time (as manifested in WTP tolls for a less congested trip) is correlated with high income. As Verhoef and Small warned in the context of 91 Express Lanes (SR91) in California, 'the correlation between value of time and income is actually far from perfect':

> One of the most striking findings from actual experience on SR91 is that most people who use the express lanes do so intermittently, and the mix of incomes using the express and the free lanes on any given day overlaps considerably (Verhoef and Small 1999, p. 2).

This may reflect users' desire for fast, congestion-free journeys at specific times and for specific purposes. That is, optimal tolled lanes provide users with a choice where, on occasion, they may be prepared to pay for faster travel times.

Conclusions on regressivity

Lee (2003) noted that 'those travelling on urban highways at the peak period in the peak direction are substantially more affluent than the population as a whole, and those who choose to pay the toll are more affluent still' (Lee 2003). From this, Lee concluded that the distributional impact of congestion charging appears to be mildly regressive, but not regressive enough to be a significant obstacle to introducing the charges.

Lee went on to point out that the regressivity of raising revenue from congestion charging needs to be compared to alternative forms of revenue-raising. Put another way, even if congestion charging were regressive, this would need to be compared to the alternate way of raising the revenue, such as 'fuel excise taxes, sales taxes, and local property taxes'. These taxes, Lee observed, are also mildly regressive under typical conditions. Lee concludes that 'congestion pricing is probably a progressive policy from the standpoint of redistributional equity, and no worse than mildly regressive' (Transportation Research Board 2005, p. 50).

In summary, equity is a complex issue and to determine the distributional impact of congestion charging would require case-by-case analysis.

Perception of the charge as a tax

The community attitudes to congestion charging also depend on whether the charge is perceived as a tax. The labels assigned to the charge may influence community perceptions. Hence, use of the terms such as 'community charge' for Britain's council poll tax and the proposed Dutch fee as an 'Acceleration Price' (since the revenue generated would allow projects to be accelerated).

The focus on scheme losers reflects a tendency for people to view the charge as a compulsory tax.

Box 4.1 Diplomatic dispute over the London congestion charge

Since 1 July 2005, the US embassy in London has refused to pay the London Congestion Charge, amassing a bill of £926 650 to end-September 2006 (Mayor for London 2006). The embassy argues that it is exempt from the charge that it regards as a municipal tax; under the 1961 Vienna Convention, embassies are exempt from such taxes.

The argument therefore pivots on whether the £8 fee is a tax or a charge. London's mayor, Ken Livingstone, and the body responsible for implementing the charge, Transport for London, argue that since it is optional, it is a charge. They point out that the US Embassies in Singapore and Norway pay the tolls in those countries.

The embassy counters that the tolls in Singapore and Norway are used for maintenance of the road system and hence are a charge for the use of the road. In contrast, the revenue raised by the London charge is earmarked for London's public transport system.

The increase in the charge from £5 to £8 per day has been seen as further evidence that the fee is a tax. Tony Travers, transport specialist at the London School of Economics, claimed the 60 per cent increase in the charge in July 2005 indicates that it is a tax rather than a congestion charge (Tumposky 2005). Transport for London argues that because there is no compulsion in the payment (road users choose to drive into the charging zone) then the charge is not a tax.

The perception of congestion charging as a tax is reinforced by instances, such as has occurred in London, where the level and imposition of the charges is applied in what could be regarded as an opportunistic manner. When the £5 congestion charge was introduced in 2003, the Mayor committed to a fixed charge for 10 years. In June 2005, the charge was increased to £8. For some high CO_2 emitting vehicles, the charge was due to be increased again in 2008.[61]

61. Since February 2008, London's congestion charges have been modulated (varied) to reflect average CO_2 emission levels of different vehicle categories. This charge should not be confused with the low-emission zone (LEZ) charge introduced in February 2008 but aimed at improving improve local air quality in Greater London—a considerably larger area than the congestion charge applies to. The LEZ charge applies to heavy vehicles at all hours.

The importance of this distinction between a 'charge' and a 'tax' is highlighted in the long running conflict between the Mayor of London and the US Ambassador to Britain, detailed in Box 4.1.

Distinguishing between a tax and a charge on the element of compulsion involved has definite appeal. Unfortunately, such a litmus test has shortcomings. In particular, adhering to the 'compulsion test', we would conclude that Australia's Goods & Services Tax (GST) is not a tax because the purchase of goods and services is optional. Hence, the feature of compulsion provides little guidance in separating taxes from charges.

Another distinction made between a tax and a charge is whether something is actually being purchased. In the case of London, it could be argued that the right to drive during peak hours is being purchased.

Yet another suggested litmus test is whether the charge brings about a significant change in behaviour: i.e. less peak-hour road use. The smaller the response to the charge, the more the charge would feel like a tax because it would not be achieving its purpose of reducing congestion.[62] However, it is probably a little simplistic to assume that because a charge may feel like a tax (because those that pay feel that they have little choice) then it should be classified as a tax.

There are two basic flaws in the 'it-has-no-impact-and-therefore-it-is-a-tax' argument:

- This idea would never be floated in other sectors such as power and water. At certain charging levels, there may be little impact on consumption patterns. However, few would argue that the lack of consumer response to higher charges mean that the charge is actually a tax.
- There are many factors that determine the response to a charge. These factors could change over time. It would seem untenable to change the terminology adopted according to the behavioural response. For instance, if the current charge were having little success shifting traffic from peak-hour use, then the charge could be increased until the required reduction was achieved. Hence, doubling a charge under the 'it-has-no-impact-and therefore-it-is-a-tax' argument could see the term applied shift from 'tax' to 'charge'.[63]

If behavioural change does not provide a litmus test, then is the answer in how the funds are used? If, for instance, the funds serve to bolster consolidated revenue, then it would not be surprising if the charge were perceived as a tax.

Perception is the key. The fact that the charge can *appear* to be pure revenue raising, because the revenue generated is not hypothecated to the source of the revenue, is not sufficient for it to be technically labelled a tax. If it were, then this would mean that the *purpose* to which the funds were directed would determine whether a payment is a tax or a charge.

Yet, the use of the funds generated by the charge would be expected to change over time as the highest returns were sought for the community at large—be it enhancing the road network, improving public transport or reducing other burdensome taxes, such as payroll tax or stamp duty. The reader will immediately recognise the dilemma.

62. This point is pursued further with the Acceptability Index below.
63. Similarly, if factors behind demand changed (such as the price of fuel tripled), the original low charge may then appear to have an impact.

If, as is likely, the high-yielding use of the funds varies over time and *if* the choice of terminology depended on the *use* of the revenue, then the term applied to the payment would flip-flop between the 'tax' and 'charge' depending on the end use of the revenue raised. Hence, the use of the revenue is clearly not a sensible criterion for distinguishing between a tax and a charge.

So how critical is the terminology? Take the case of fuel excise for passenger vehicles in Australia. This is widely regarded as a tax. The funds raised go directly to consolidated revenue. However, fuel excise for heavy vehicles is technically a road-user charge and calculated accordingly (but still ending up in consolidated revenue). It would not be unreasonable to regard as least some of the excise paid by passenger vehicles as a road-user charge.

Alternatively (or additionally), fuel excise paid by passenger vehicles could be labelled as a carbon tax, for which it serves as a very good proxy.[64] In this scenario the excise would be serving the same role as a congestion charge in that it would be 'internalising an externality'. Even as a road-user charge it could be seen to be performing this role since if the charge is not made on road users then they are shifting their costs onto the community: externalising their costs. The corrective mechanism is a charge that internalises the cost.

The situation is similar for the sulphur dioxide tax in the US. It is called a tax and the revenue is presumably treated as any other tax revenue, yet it is a charge for the environmental externality, just as a congestion charge is a charge for the congestion externality.

This would indicate that the label is irrelevant from an economic perspective—it is only the impact that counts. Once the congestion charge has served its purpose of 'internalising the externality' then it has performed its economic *raison d'être*.

From a political perspective, the matter is clearly different. If it was clear to the public that a congestion charge was not achieving the objective of reducing congestion, it would tend to be labelled as a tax. The challenge for policy makers would be then to convince the community that the revenue raised was being put to good use—whether by reducing other, even less popular taxes or providing community goods or services.

Hence, the issue confronting those considering a congestion charge is whether the balance of winners and losers would be acceptable to the public.[65] One indication of the acceptability of a scheme is a comparison of the revenue raised with the efficiency gain achieved—the Acceptability Index (BTCE 1996a, p. 28).

Acceptability Index

An Acceptability Index is a theoretical concept useful in shedding light on the acceptability of a congestion charging scheme. The index is calculated as the ratio of revenue raised to the efficiency gain from the scheme.

64. The current excise rate, $A0.38143 per litre, is equivalent to a carbon tax of around $A170 per tonne of CO_2 emissions.
65. Drawing on public choice theory, the issue is more complex. Concentrated and significant winners could overwhelm small and widely dispersed losers even for a project not in the community interest.

The revenue generated by a congestion charging scheme serves as a proxy for the 'pain' felt by the community.[66] The efficiency improvements from the scheme illustrate the gain. The higher the revenue and the lower the efficiency gain, the greater the resistance to the scheme is likely to be. Conversely, the greater the response to the charges (efficiency gain) and the lower the revenue, the more likely it is that the scheme will achieve community acceptance.

The revenue raised can be readily identified, but the efficiency gain is more obscure and is influenced by a number of factors, principally the propensity for behavioural change and the cost of the scheme.

High revenue-to-benefit ratio characterises a scheme that generates considerable revenue and few efficiency gains: many pay the charge, but few benefit from it. Such a scheme would fare badly on the Acceptability Index. A scheme is most likely to have a poor index value when there is only limited behavioural change and when the cost of the scheme is high. One reason for limited behavioural change would be the lack of options for commuters: alternative transport modes in the short term and alternate employment and residential options in the longer term.

In this context, timing the introduction of a congestion charging scheme can be critical for community support. For instance, Dubai introduced the Salik (congestion charge) in 2007—months *before* the opening of the city's new railway metro system. Thus, community acceptance was low, relative to a situation where the Salik introduction coincided with or followed the opening of the Metro.

Hence, the Acceptability Index provides theoretical underpinnings for enhancing alternative transport options before the introduction of a scheme: the more attractive the options to, say, time shift or use other modes, the greater the behavioural change. In circumstances where motorists have few options except to pay the charge, a congestion charge would look and feel very much like a tax.[67]

The efficiency gain is likely to be high where a scheme results in a significant reduction in road use *and* where costs of the scheme absorb only a small share of the revenue. A significant reduction in road use following the introduction of the charge also reduces the revenue take. The resultant low revenue and high efficiency gains would result in a favourable Acceptability Index.

Hence, the greater the efficiency gain from the scheme, arising from a significant behavioural change, the more likely that the scheme will be acceptable to the community. Other options for improving the acceptance of a scheme are discussed below.

4.3 Options to change the ratio of winners to losers

There are two main mechanisms for increasing support for congestion charging: exemptions/discounts and through the strategic use of the revenue raised.

66. Recall that the revenue generated by a scheme is not a gain to the community but simply a transfer within the community. In contrast, the efficiency gain reflects improved use of the community's resources.
67. Indeed, under these circumstances, congestion charging could be perceived as an efficient form of taxation, albeit an unpopular one.

Exemptions and discounts

Those eligible for exemptions or discounts for congestion charges are generally regarded as benefiting from congestion charging. As Banister observed: '… they should benefit from lower levels of congestion, with faster and more reliable journey times, but at the same time not paying any more' (Banister 2003, p. 261).

The proposition

The rationale behind exemptions appears to be simple: exempt the members of those interest groups necessary to win adequate community support. Typical is the London scheme, where the following groups benefit from an exemption or a large discount:

Residents	The residents of the charging zone benefit from lower traffic levels and less congestion. They also pay only 10 per cent of the congestion charge. The improvement in the amenity of their residences would also increase property values.
Private hire	London-licensed taxis and mini-cabs are exempt from the charge. They also benefit from higher speeds and greater reliability. Competing cabs from outside London are required to pay the charge.
Public transport	Buses do not pay the charge. Bus patron's benefit as service has improved considerably due to lower congestion and congestion revenues flowing into the system.
Bikes	Riders of all two-wheeled vehicles (motorbikes, bicycles and mopeds) are exempted from the charge.
Alternate fuel vehicles	Owners of hybrid vehicles and other alternate fuel cars enjoy an exemption, even though other cars with similar emission levels are not eligible. Since a premium is paid for hybrid vehicles, it is unlikely that this group will be from low-income earners.
Large vehicles	Heavy freight vehicles pay the standard £8 per day despite their relative size and contribution to congestion.
Emergency services	These vehicles receive either exemptions or heavily discounted charges.

In contrast, the Singapore scheme has very few exemptions.[68]

Analysis

As we note in Chapter 5, all vehicles that contribute to congestion should be subject to congestion charges—including the 600 rickshaws that ply their trade around London's West End. Exemptions appear to have widespread community appeal and so their contribution to bringing about the introduction of schemes should not be underestimated. However, removing the compulsion of payment for select groups

68. Most were removed in 1989.

means, in effect, that these groups are enjoying a subsidy, equivalent to the payments forgone. Even if the 'subsidy' were justified, in this form it is not subject to the normal public accounting scrutiny.

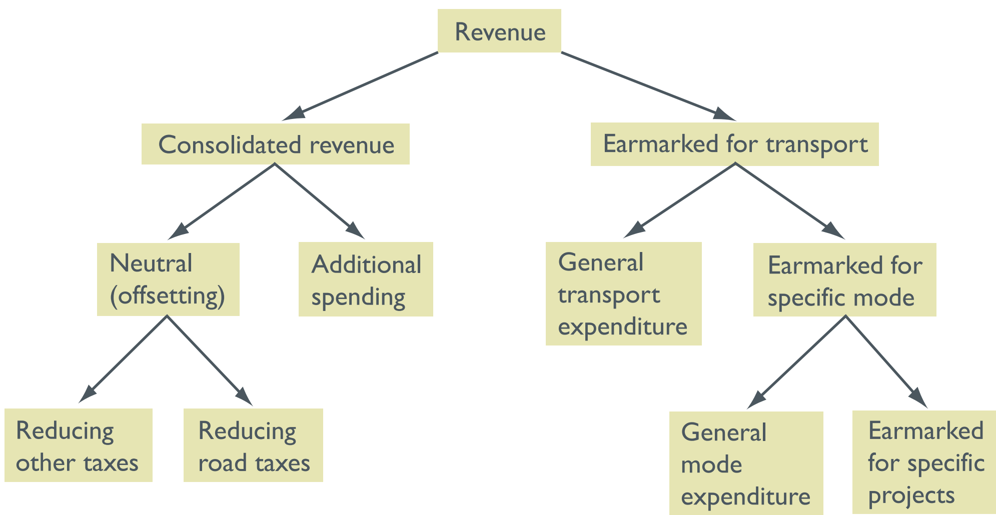
There would be considerable advantages in terms of good governance to provide subsides directly (and in a transparent way) and to ensure that all those that impose congestion costs on others, are forced to face those costs.

The issue of exemptions and discounts is considered further in Chapter 5.

Strategic use of revenue raised (or earmarking)

Potentially the most important instrument for increasing the number of winners and reducing the number of losers from congestion charging is the strategic use of the revenue raised from the charges. There is a range of options, as illustrated in Figure 4.1. The first decision is whether to earmark revenue for transport or to absorb it into consolidated revenue. If revenue is absorbed into consolidated revenue, then the pivotal question is whether it is treated as additional revenue to a treasury or whether offsetting tax reductions are made elsewhere.

Figure 4.1 Options for disbursement of (net) congestion charging revenue



Early theoretical work on congestion charging focussed little on the revenue, treating it strictly as a 'transfer payment'. As Goodwin observed:

> Motorists pay more, and the Treasury gets more, these two amounts cancelling out in welfare terms as the Treasury can be assumed to spend the money wisely, in ways that it was not necessary to define (Goodwin 2004a, p. 502).

This issue goes to the heart of congestion charging policy frameworks. There is a widespread presumption that the revenue raised by a congestion charge will be hypothecated to transport. However, the fact that efficiency gains are created in the generation of the revenue (in contrast to the efficiency losses in raising taxation revenue) appears to remove or weaken the discipline that is normally associated with the allocation of public funds.

Goodwin observes that the revenue disbursement is critical in the evaluation of any congestion charging scheme. However, regardless of the main objectives of congestion charging, he argues that treating revenue use is of secondary importance:

> … did not provide an implementable policy, and that it was necessary to replace it by explicit consideration of the revenue, in which the beneficiaries were as visible and influential as the motorists who paid it (Goodwin 2004a).

This view is echoed by others. Ison (1998) noted that 'experience abroad suggests that equity and the use of the resulting cash flow are likely to be the most significant points that would need to be addressed'. In this context, Graham and Glaister (2006), from their modelling of the impact of the spatial effects of the mooted national road pricing scheme for Britain, also concluded that the use of the revenue was critical to the distributional impact and hence to scheme acceptability.

The differential impact of pursuing 'revenue neutrality' (where other taxes are reduced to offset the revenue raised) and 'revenue additionality' (no offsetting tax reductions) was explored by Graham and Glaister.[69] Both cases produced net benefits for the community but, not surprisingly, motor vehicle users were worse off with revenue additionality. They are paying higher charges for road use with no offsetting reductions in other taxes and charges. Under the proposed revenue neutrality package, rural areas experienced an increase in congestion around 25 per cent, compared with a small reduction under the revenue additionality option. The increase is due to the lower average cost of road use in rural areas because of the reduction in other motoring taxes.

Small (1992) has suggested what is, in effect, a compromise between revenue neutrality and additionality. In this case there would be some additional expenditure combined with some offsetting reductions in taxes and charges. In essence, revenues from congestion charging could serve both as a substitute for other revenue sources (revenue neutrality) while still contributing to substantial new services, along the following lines:

- replace regressive sales and fuel taxes
- provide a travel allowance of US$10 a month for every employee in the region regardless of mode of travel to work
- rebate local rates, and/or
- improve transportation throughout the area (Small 1992).

Earmarking revenue to transport is generally supported, particularly when compared to the option of 'swelling the government coffers'. Earmarking can certainly be effective in influencing community attitudes. One study that found that acceptance ratings for a proposed pricing scheme rose from 35 per cent to 55 per cent once the scheme included a commitment to dedicate the revenues to transport rather than towards consolidated revenue (Wachs 2003, p. 12).

69. Note that current UK legislation requires that all revenues raised by a local authority through congestion charging must be spent on transport purposes within the area for a period of years. (Also, the contribution from the Central Government is meant to take no account of the congestion charging revenue).

While earmarking is pivotal in community attitudes, so too is the choice of the specific transport project to which funds will be directed. Allocating funds to low-return transport projects that do not make the grade under normal budgetary circumstances would not necessarily generate community support.

Earmarking congestion charging revenue is pivotal to how the community views the scheme.

Community attitudes to congestion charging are likely to be strongly influenced by the application of the revenue to areas from which they would benefit directly including transport investment and tax relief. The general options for the use of the revenue are to enhance public transport, to improve the road network or to reduce other, more distorting taxes. Each of these options is explored below, followed by a brief analysis of the practical limitations that are often encountered.

Enhancing public transport

The proposition

An obvious use of revenues is to expand public transport, for two basic reasons. Firstly, the demand for public transport is likely to increase following the introduction of congestion charging (reflecting a fall in the relative cost of public transport). Secondly, the desired behavioural change ('getting people out of cars') is likely to be greater the more attractive are the alternatives to driving. Politically, enhancing the alternatives of driving reduces the burden of the new charges on road users by providing greater 'transport choices'.

Box 4.2 Funding for public transport encourages community acceptance of congestion charging

An important consideration of congestion charging schemes is the automatic presumption that the revenue raised will be allocated to public transport. However, the causality was reversed for one of the pioneering congestion charging schemes in the US: the I-15 High Occupancy Toll (HOT) lanes in California were introduced to fund a new bus service in the corridor (Schreffler 2003). While the service did not achieve the mode-shift aims, the charging system is generally regarded as successful:

> … the I-15 corridor bus service that provided much of the political support for the HOT lane approach did not necessarily fulfil expectations. The intent was to attract new bus riders in the corridor in order to remove cars from the I-15. Instead, the new bus service attracted reverse commuters and riders who did not switch from driving alone (Schreffler 2003, p. 21).

From an equity perspective, funding public transport is commonly regarded as a way of offsetting the perceived 'regressive' nature of congestion charging. For instance, when exploring the option of introducing congestion charges to the East River Bridges in New York, it was observed that 'using toll revenues to improve communities as well as mass transit options in Brooklyn and Queens also addresses the equity issues raised by these pricing schemes' (Hsu et al. 2004, p. 7).

The Economist advocated allocating revenue to public transport to provide benefits for the less well-off, offsetting any regressivity that may be associated with congestion charging:

> Those who argue that road pricing is unfair because it discriminates against the poor ignore the fact that people too poor to own a vehicle, together with the young and the very old, suffer the ill-effects of congestion without the benefits of personal mobility. Moreover, if the revenues were used to improve public transport, the poor would benefit disproportionately (The Economist 1997, pp. 16).

The second rationale for applying scheme revenues to public transport relates to encouraging a greater response to the charge by improving transport alternatives. To the extent that responsiveness to the charge increases, it produces a greater efficiency gain. The higher the efficiency gain relative to the revenue take, the higher the Acceptability Index (see Box 4.2).

The London scheme illustrates the earmarking of revenues for public transport, with net revenues dedicated to the funding of transport improvements in London for the first 10 years of the operation of the scheme.[70] Prior to and after the introduction of the scheme, London's public transport system was significantly enhanced by modernising and enlarging the bus fleet, and expanding bus priority. Button estimated that in the five years to 2005, about £500 million has been used to enhance the bus network, and has included doubling traffic lanes exclusively for bus use (Button 2006, p. 236).

The use of revenues for funding public transport has also gained support in Norway. The revenue from the cordon charges around Norwegian cities were originally earmarked for specific road improvements. However, the second generation of packages dedicated a small share of revenues for the environment and public transport. The third generation of packages (with a greater focus on congestion charging) will fund large-scale public transport improvements (Bekken and Osland 2005). The earmarking is now set out in law. Under an amendment to the national road laws, approved in June 2002, proceeds from congestion charging schemes must be used for local road and public transport purposes (Ramjerdi 2003, p. 49).

Analysis

There is no doubt that persons affected by congestion charging expect to have practical alternatives to paying the charge. The policy danger is that the scheme revenue is regarded as a 'Magic Pudding' and, accordingly, not subject to rigorous scrutiny in its disbursement.

While enhancing public transport is rarely questioned as a use of congestion charging revenue, not all investments in public transport are equally beneficial. Some produce a higher return for the community than others. Some produce a negative return. Button queried whether the (then) £500 million spent on enhancing London's bus network was subjected to rigorous scrutiny:

> '… there is no way of knowing if this money, including that taken from the congestion charge, is being spent efficiently, and even if public transport is a good investment' (Transportation Research Board 2005, p. 237).

70. This earmarking also applies for other congestion charging schemes that are implemented under the Transport Act 2000 (UK). However, this commitment appears to apply for only the first ten years of the project.

Prud'homme and Bocarejo were also critical of the unquestioned allocation of the London revenue to public transport. They argued that this is a negative feature of the scheme, since the bus system is already heavily loss making and that further funding increases the losses and has more than doubled the subsidy per passenger (Prud'homme and Bocarejo 2005).

Scheme revenue has an opportunity cost and the community is best off when the allocation of revenue is rigorously scrutinised.

There are two issues here: equity and efficiency. While public transport clearly provides a community service, it does not necessarily follow that subsidising public transport is the most effective way of pursuing equity objectives; indeed, whether it contributes to equity objectives at all. In many cities, the most heavily subsidised public transport services are in the older and generally wealthier areas. Low-income earners often live in more remote areas where housing is more affordable.[71] Also, low-income earners may be less likely to be engaged in the type of regular employment (in terms of both hours and location) that readily lends itself to public transport use. Hence, increasing public transport subsidies may not contribute to vertical equity.

While little research has been done in this area, a review of urban transport in Australia tentatively concluded that public transport subsidies are neither regressive nor progressive in that they generally 'boost the income of the more affluent by virtually the same proportion as those who are less well off' (Industry Commission 1994, p. 195).

The International Transport Forum (ITF) has highlighted the potential for misdirection of subsidies underlying public transport funding, arguing for a 'need for greater clarity in the setting of fares, with subsidies focused on those people in particular need'. Further, it argued that 'pricing needs to be consistent across transport modes, with charges approaching the marginal costs of travel' (ECMT 2005, p. 13). For public transport, this could imply significantly higher charges (congestion charging) during peak periods.

The supply of strong alternatives to driving in congested areas is critical to both scheme success and acceptance, nonetheless the non-empirical earmarking of congestion charging revenue to public transport can seriously undermine the economic credentials of the scheme.

For a scheme to be successful, behavioural change is necessary. This requires strong alternatives. However, such a link does not obviate the need for rigorous assessment of revenue use.

Community acceptance of congestion charging may be won through applying funds to public transport but an indiscriminate application can leave the community relatively worse off. Thus, to the extent that the scheme funds public transport projects, it requires the same rigorous evaluation that is applied to funds raised from other sources. These funds have an opportunity cost and the community benefit is maximised if they are allocated to their highest value use, which may or may not be public transport.

71. Ironically, housing is more affordable partly because of the limited access to public transport.

Enhancing road infrastructure

The proposition

Congestion charging may be introduced because an alternative road expansion strategy is politically unpalatable and/or economically unjustifiable. However, to the extent that road investment is still practical, it might be argued that scheme revenue be applied to roads. Investment in new roads is commonly advanced as an appropriate use of revenues. Newbery and Santos (1999) reasoned that 'earmarking taxes for dedicated expenditure on highways is an obvious application of the benefit principle of taxation, which, properly applied, should lead to a more efficient structure of road charges' (Newbery and Santos 1999, p. 127).

Others have argued that earmarking the revenue for road infrastructure would result in a more efficient level and structure of investment. Essentially, rather than complicated and imperfect methods for determining road-users' willingness to pay, congestion charges can serve as a trigger to indicate when the gains are greater from expanding road capacity than allowing congestion to increase (see, for instance, Hau 1998). In this context, Starkie identified the fact that investment decisions would benefit from the information provided through a system of congestion charging:

> If road congestion pricing was in place and the costs of expanding the network were known, the investment decision from an economic perspective would be reasonably straightforward: capacity should be added when the marginal cost-based price for the road use exceeds the incremental costs of adding to the network (Starkie 2002, p. 11).

Hence, there are two elements underlying the proposition that revenues from congestion charging should be earmarked for road infrastructure enhancements: the application of the benefit principle of taxation and the use of the congestion charging to reveal the true preferences of road users.

Analysis

The basis of the benefit principle of taxation lies in the view that community members should benefit from public expenditure in proportion to their contributions. This could have popular appeal with community support high for a clear link between road-user charges and road expenditure, particularly where there is a strong geographical overlap. In a way, this could help overcome the widespread criticism of congestion charging as 'yet another tax'.

In addition, public finance theorists point out that by strengthening the link between benefits and payments, much lobbying by powerful interest groups and wasteful rent seeking activity could be eliminated. As Gwilliam and Shalizi observed:

> Where individual preferences for public goods differ, it can be shown that separate earmarked funds could potentially increase general welfare if the payments to those funds by each of the different individuals reflect that individual's relative marginal utilities for different public goods (Gwilliam and Shalizi 1996, p. 6).[72]

The second point is that related to the potential improvements in investment decisions through the information provided by the congestion charge. The current

72. Gwilliam and Shalizi note that 'This proposition, derived from Wicksell and Lindahl, is elegantly proved in Johansen (1963)'.

use of benefit–cost analysis in the absence of congestion charging assumes road-user charging that reflects average rather than marginal costs. The result is that the '… value of an investment when the existing network is not subject to congestion pricing will generally be greater than if the existing network is tolled' (Starkie 2002).

Ultimately, however, there are major practical problems relating to indivisibilities when pursuing a goal of expanding infrastructure to the point where the marginal cost of expansion equals the marginal cost of congestion.

> If infrastructure can only be incremented in lumps, expanding capacity whenever short-run marginal cost is greater than long-run marginal cost may result in over-investment. On the other hand, the Verhoef rule, which guarantees that the last unit of investment is valued precisely at cost (and that all preceding increments are valued at greater than or equal to their cost), may result in under-investment if the total willingness to pay exceeds the cost of the additional capacity (MOT (NZ) 2005, p. 27).

Furthermore, in most cities where congestion charging is under consideration, there may still be limited scope to improve infrastructure capacity. Notwithstanding the developments in tunnelling technology, the technique remains costly and complex.

Finally, as with public transport, the use of congestion charging revenues to fund infrastructure expansion needs to be rigorously evaluated.

Conclusions on strategic use of revenue

Congestion charging is politically difficult to sell to the community. It is understandable that there is a temptation to gain community acceptance by applying scheme revenue to high profile projects.

Should congestion charging be earmarked for specific purposes or should it simply become part of consolidated revenue, allowing general increases in spending or an offsetting reduction in other, more distorting sources of revenue? Lee warns against earmarking revenues for specific purposes, noting that such an approach:

> … can be dangerous economically and misleading politically. Spending toll revenues to increase highway capacity, subsidise transit, or support the freight rail system may be inefficient if those sectors receive more funds than they can use efficiently—that is, apply in ways that generate positive net benefits (Lee 2003, p. 50).

Singapore, in particular, learnt this lesson the hard way after earmarking a share of revenue from their Area Licensing Scheme for 'park-and-ride' car parks at the edge of the city. Poor patronage led these to be abandoned and all revenues now go into consolidated revenue:

> Congestion revenues are not earmarked for transport related projects. All transport projects need separate economic justification or financial allocation from a central pool of development funds (Menon 2003, p. 136).

Application of this principle would not exclude any particular area, such as public transport, from benefiting from the funding. Rather, it would mean that all claimants would need to compete for the funding on merit. While the introduction of congestion charging would generally strengthen that case for the expansion of public transport, the discipline of actually competing for those funds is necessary for sound corporate governance.

Automatic earmarking of revenues guarantees an automatic revenue flow and, by doing so, removes the rigour of sound planning and scrutiny of different projects. In a televised debate in June 2005, London's mayor, Ken Livingstone, announced an increase in the congestion charge to £10 in 2008, to provide an increase in funding for public transport. Such access to ready funds would invariably reduce the pressure that might be otherwise brought to bear on optimising the public transport system.

Funding claims need to be assessed on individual project merits.

The main defence for such earmarking is that the public would not willingly commit to such a radical scheme unless they could see clearly where the funds are being spent. However, this underlines the fact that earmarking is generally not justified on efficiency grounds but is aimed at improving community acceptability of congestion charging.

Efforts to ensure community acceptance of a scheme may undermine the efficiency gains that the scheme can potentially deliver.

In reality, the potential conflict between efficiency and acceptability is one of the major issues confronting policy makers contemplating the introduction of congestion charging. The dangers were succinctly identified by Lindsey and Verhoef:

> Indeed, it is worth repeating here that general equilibrium studies of road pricing strongly suggest that revenue allocation schemes designed solely to improve the public acceptability may induce welfare losses elsewhere in the economy, leading to efficiency losses that may even outweigh the initial improvements. A trade-off between efficiency and acceptability impacts of revenue allocation schemes will generally exist, and should be given careful attention in their design (Lindsey and Verhoef 2000, p. 23).

In brief, there is considerable danger that efforts aimed at improving acceptability of a congestion charging scheme can significantly reduce the efficiency gains from the scheme, to the extent that while it may benefit select interest groups it may no longer be in the overall community interest.

Reducing other taxes

The proposition

An obvious way of dealing with the objection to congestion charging because it is perceived as a tax is to reduce other taxes in line with the revenue generated by the charge: revenue neutrality. This would be even more convincing than earmarking the funds for the enhancement of either public transport or the road network as it could be argued that such enhancements may have taken place anyway.

However, as with other options, the specific detail will be important: in this case, the choice of taxes to be reduced. For the ill-fated British national road pricing scheme, a key option was to reduce other motoring taxes thereby ensuring that, on average, road users would be no worse off (See CfIT (UK) 2002c).

Opposition to returning the revenue to road users comes from a number of sources but generally reflects an aversion to any reductions in the cost of road use. From a more practical perspective, Button and Pearman concluded that returning the revenue to motorists was difficult to achieve without negating the crucial price signals conveyed by the congestion charges and that offsetting other forms of taxation elsewhere in the economy was the 'least objectionable' option (Button and Pearman 1985, p. 37).

Sharp supported this approach arguing that returning the revenue to road users would increase the demand for road space, partly negating the impact of the congestion charge. Instead, he suggested that this problem would be overcome by directing funds to an unrelated area of spending (such as to the elderly) (Sharp 1969). Lee also concluded that 'using toll revenues to reduce general taxes or to provide income transfers based on need is probably the safest way to recycle the revenues generated through pricing schemes' (Lee 2003, p. 50).

Analysis

There are three issues here:

- scheme transaction costs
- the actual impact of the revenue recycling
- the theoretical basis for congestion charging.

The ability to pursue revenue neutrality is reduced (or it disappears entirely) if the costs of implementing the scheme are high—a large slice is already taken out of the 'revenue pie'. For instance, operating the London scheme absorbs over half of the revenue generated. For the British national road pricing scheme, estimated establishment costs were around £62 billion with annual operating costs of £8 billion per annum. The Dutch have recognised the importance of containing scheme costs by setting an ambitious target of costs no greater than 5 per cent of revenue (see page 43).

Wolmar was also sceptical of the claim of revenue neutrality of the mooted national road pricing scheme, which involved replacing fuel tax and vehicle excise duty:

> That did not make sense at the time and makes even less now. The enormous costs and the political capital needed to introduce a national road-pricing scheme would be disproportionate if its aim were simply to reduce congestion a tad on a few overcrowded roads (Wolmar 2007).[73]

Wolmar's perspective seems to have been borne out by events, with the national road pricing plans abandoned and with Central Government pursuing congestion policies through encouraging local authorities to implement localised congestion schemes. From a broader perspective, given both the experience with the German truck tolling system and the history of underestimating the cost of major information technology projects in Britain, there is a significant chance that the costs of a national scheme would have ended up much higher.[74]

73. Wolmar goes on to argue that 'the sole rationale for imposing such an expensive and far reaching measure would be to reduce the environmental damage caused by cars and induce a shift to other, greener, forms of transport' (Wolmar 2007).
74. The National Programme for IT in the NHS was estimated to cost £2.3 billion when the scheme was planned and approved contracts were let in 2003 and 2004. Current estimates have the costs ranging from £12 billion to £20 billion (House of Commons Public Accounts Committee 2007, p. EV 18).

The major indirect source of road revenue, fuel excise, has relatively low collection costs of around 2 per cent of the revenue generated. Unlike congestion charges (in principle) indirect road-use charges do not provide the accurate price signals. However, the efficiency gain from the more targeted charges needs to be offset against the cost of implementing a scheme and the fact that the charges will still only be a rough approximation (very rough in some cases) of the external congestion cost.

The actual impact of revenue offsetting other motoring charges is an empirical question: how much the reduction of other taxes and charges would lead to an increase in road use during congested periods. First, the group that pays the congestion charge will only be a very small subset of the group that receives the reduction in registration fees. Second, unlike the congestion charge which is a variable charge imposed at point of use, the registration charge is a fixed annual fee that does not vary with vehicle kilometres driven. So while a reduction in registration fees may encourage a higher level of vehicle ownership, it may not lead to an increase in vehicle kilometres driven on the congestion road.

Similarly, the theoretical foundations of the objections to returning revenue to road users are not strong. Implicit in the objections is the view that, even if the congestion externality is internalised and price signals facing motorists accurately reflect those facing the community, road use should still be discouraged. However, from a community-welfare perspective, achieving an *efficient level of congestion* should be the aim. Charges should be calibrated with this in mind. If reducing other motoring taxes or charges increased the demand for road use then, as long as road users are bearing the social cost of road use, the level of road use is efficient from a community perspective. In other words, a general aim of reducing road use, with no level of use too low, has no foundation in economics.

The crucial point to keep in mind when determining whether revenue raised from congestion charging should be used to offset other taxes (for either economic or political reasons) is that, while undercharging of road users is undesirable from the community's point of view, *overcharging* is equally undesirable. A failure to use some part of the revenue to reduce other motoring taxes could lead to overcharging for road use.

Offsetting other road-user charges

A congestion charge may be justified because it serves (in theory) to internalise the major urban external cost of road use. However, the introduction of such a charging system may require a review of existing road-use taxes and charges to ensure that road users are not bearing an inefficiently high revenue raising burden. In many cases, fixed charges (such as registration charges) have served as an imperfect method of recouping variable costs of road use. If congestion charging assumes this role, then there could be a strong economic case for reducing registration charges and other fixed or variable charges. This would be in line with much of the reform literature, which emphasises the shift from fixed costs of motoring to variable costs once the technology makes it feasible to implement point-of-use charging.

Other taxes, apart from those associated with motoring, could also be offset. For instance, property taxes could be reduced in the local area. This could result in a favourable impact on a large interest group, particularly in an area where say, only around 10 per cent regularly paid the congestion charges.

Economic efficiency aside, the main focus in the US has been on providing an option to paying the congestion charge. In this section, we draw on two US proposals for using the revenue from congestion charging to reward those road users that opt for the general lanes over the faster flowing, tolled lanes.

High-occupancy toll (HOT) lanes

The widespread under-utilisation of HOV lanes[75] in the US has created pressure to convert them to HOT lanes, allowing access to those solo drivers willing to pay a charge in return for reduced congestion.[76] Traffic throughput improves on both the former HOV lane as well as the now less-congested general lanes, ensuring a more efficient utilisation of road space.

However, there is still some community resistance to such changes. Two options have been suggested to reduce this resistance: credit based congestion pricing (CBCP) and fast and intertwined regular (FAIR) lanes.

The CBCP concept has been developed by Kockelman, Boother, and Kalmanje to deal with the equity concerns associated with congestion charging. Under this system, revenues from HOT lanes are returned to all licensed drivers in a uniform fashion, as a 'driving allowance'. The result would be that the average driver would pay nothing, the below average driver would profit and frequent, long-distance and peak-period drivers pay something out of pocket, 'in effect paying others to stay off congested roads' (Kockelman, Boother and Kalmanje 2005, p. 1).

DeCorla-Souza developed a similar concept of FAIR lanes to address the equity concerns surrounding congestion charging (DeCorla-Souza 2002). FAIR lanes would also involve fast tolled lanes alongside of general purpose lanes. Under the FAIR lane proposal, the fast tolled lanes would be tolled electronically, with tolls set in real time to limit traffic to the free-flowing maximum. Drivers using the general purpose lanes during rush hours would be compensated with credits (equivalent to a percentage of the toll) that could be used as toll payments and possibly transit tickets or van-pool credits. Like the CBCP scheme, this payment would be regarded as compensation for increased congestion that drivers in the remaining general purpose lane would face and for giving up their right to use (now) express FAIR lanes.

These schemes aim to improve public acceptance of congestion charging, retaining optional, untolled lanes beside the tolled lane (generally, a HOT lane in the US). Administrative issues aside, such as identifying those road users eligible for the payments without encouraging increased use of the road, these circumstances are not as widespread outside the US and hence the option may be of limited relevance in other countries. Furthermore, as Nelson points out 'because HOT lanes do not appear to inflict large welfare losses on any identifiable group of travellers' then compensation is not such an important issue (Nelson 2003, p.48).

75. 'High occupancy' is often only H2, meaning two occupants.
76. Some, such as 91 Express Lanes (running between Los Angeles and Orange County), have been purpose-built while others, such as those on Interstate 15 (San Diego), involved converting a HOV lane to a HOT lane.

On a more general note, while there is obvious appeal in ensuring that the losers from the HOV/HOT lane conversion are compensated, the use of 'credits' is suboptimal from an efficiency point of view. Cash-in-hand would always be more efficient than payment-in-kind. A scheme that restricts where compensation payments may be spent would not allow the recipients to maximise their return on the payments.

4.4 Other issues

Privacy and security

Monitoring of vehicles is an integral part of any congestion charging system. The application of the charging technology necessary for this monitoring raises privacy and security issues. The fear of an invasion of privacy can be a critical factor in the public opposition to a congestion charging scheme.

> The perceived threat of 'big brother' is a chilling factor to many and can cause the rejection of otherwise reasonable public policy (Worrall 2003, p. 37).

Authorities are faced with the conflicting pressures: to protect privacy while meeting community expectations for service improvements and remaining internationally competitive. As noted by a privacy specialist, 'the whole point of social order has a flip-side of individual loss of privacy' (Laurant 2006).

This trade-off, between privacy and the capture and storage of information necessary to develop a more efficient charging system for roads, is a key feature of all systems. As part of Oregon's direct road-user charging pilot program, a system was developed 'with specific engineering requirements to maintain as much privacy as practicable while still allowing a feasible way to audit and challenge billings' (Whitty 2005, p. vi). The pilot, regarded as a success, was undertaken without the storage or transmission of specific vehicle point location or trip data.

Hence, while privacy and security of data are key issues, there are technological solutions that minimise the risk. The success of GPS-based PAYD insurance also indicates that motorists are willing to sacrifice some privacy in return for tangible gains (such as a 20 per cent discount for car insurance). Furthermore, as other 'tracking devices' such as mobile phones, become increasingly accepted, the monitoring required for congestion charging will not be so extraordinary.

Transparency and accountability

Public acceptance of congestion charging is likely to be greater, the greater the transparency and accountability of the scheme—other things being equal.

The introduction and operation of the London Congestion Charging scheme has set new standards in transparency with extensive background material including monitoring reports and research results available on the web page for the congestion charge.[77] However, it is less clear that this could be said for scheme accountability and 'meaningful' consultation. The expansion of the congestion charging zone and the 60 per cent increase in the charge appear to have been driven primarily by the personal

77. See www.tfl.gov.uk/roadusers/congestioncharging/6722.aspx.

vision of London's Mayor, Ken Livingstone. There was a marked lack of a procedural framework for determining future charges and variations to the charging zone.

Transparency and accountability of a scheme increases public acceptance.

However, this is not uncommon, with transparency and accountability being more the exception than the rule. Some tolls in some countries adopt guidelines for transparency and accountability. In Scotland, legislation and procedures for setting and changing tolls on bridges are clearly defined (Scottish Executive 2006, pp. 17–31). Arguably, the best examples of transparency are to be found with the Singapore system and that used for Orange County's 91 Express Lanes. In Singapore, electronic road pricing (ERP) rates are reviewed at three-month intervals to maintain a speed range of 20 to 30 kilometres per hour on city roads and 45 to 65 kilometres per hour on expressways. Rates are increased or decreased when the average speeds for the three-month period are outside the ranges (Menon 2003, p. 35).

The rules for adjusting the tolls on the 91 Express Lanes are similarly logical and transparent. An increase in the charge requires a *sustained* increase in directional traffic. A formula determines the extent of the increase. Increases are based on the average vehicle volume of the flagged hour, day and direction (Orange County Transportation Authority 2003).

Focusing on the process

In considering community attitudes to congestion charging, thus far we have reviewed policy options for addressing the equity concerns of congestion charging and earmarking of revenue (in order to change perceptions of the charge as a 'tax'). In this section we consider procedural options that may influence community attitudes to charging schemes.

Almost three decades ago, Gunn identified a number of conditions that he regarded as necessary for the 'perfect' implementation of policies (Gunn 1978).

While it is readily appreciated that perfect implementation is not possible, these conditions can be interpreted as 'important factors in the political acceptability of any policy, such as the introduction of a congestion charging scheme'. In brief, the conditions are:

- complete agreement on the objectives to be achieved
- that the policy to be implemented is soundly based in theory
- favourable external circumstances
- having a single implementing agency with sufficient autonomy to ensure a reasonable level of independence from other agencies
- that tasks are fully specified in correct sequence
- sufficient time and resources, including the required combination of resources, are available

- direct link between cause and effect, and
- perfect communication, coordination and compliance.

Table 4.1 The London Congestion Charge relative to Gunn's conditions

Criteria	*London Scheme*
Agreement on the objectives to be achieved	There is both understanding and agreement of the objectives.
Sound theoretical basis	While the theory is well established (Pigou 1920), it is not clear that the charge was determined to reflect social marginal cost pricing. However, Ison et al. observed that the £5 charge appears to be a reasonable approximation.
External circumstances favourable	Congestion had reached unacceptable levels.
Single autonomous implementing agency	Greater London Authority and Mayor enjoy significant autonomy—not answerable to a higher level of government.
Task are fully specified in correct sequence	Condition fully met.
Sufficient time and resources	The scheme has had a very long gestation period with numerous studies carried out over many years.
Direct enforcement link between cause and effect	The manual checking involved creates delays and increased scope for error.
Communication, coordination and compliance	Communication achieved through extensive consultation process and high level of transparency via web site: www.cclondon.com. Coordination achieved through the enhancement of bus services before the introduction of the charge.

Source: Ison, Rye, and Santos (2003).

Ison, Rye, and Santos (2003) evaluated the introduction of the London Congestion Charging scheme against Gunn's preconditions. They scored the scheme well in terms of its design and implementation. Their review is summarised in Table 4.1.

The particular strengths of the London scheme appear to be the 'favourable' external circumstances (severe congestion), high level of communication and coordination and the single autonomous implementing agency. However, the autonomy and support enjoyed by the Mayor cannot be underestimated. Many analysts highlight the importance of a high profile 'champion' (in this case, Ken Livingstone) for the acceptance of a scheme. In this context, we note that the first of the ten strategies listed by Deloitte to achieve a successful transition to road-user charging schemes is to 'recruit an influential champion' (Deloitte 2003, p. 2). Others such as 'use proven technology' and 'keep the public and stakeholders informed' have both been hallmarks of the London scheme.

Any analysis of the apparent success of the London scheme would be incomplete without an acknowledgement of the extensive process, conducted over several decades that preceded it (see Table 5.2).

4.5 Conclusions

While congestion charging schemes have the potential to be in the community interest, unfortunately there is no guarantee that this will be the outcome. However, even where they are, community support may not be forthcoming.

The theory underpinning congestion charging schemes is based on internalising the congestion externality. This is not costless and is technically difficult to get right. The higher the scheme costs, the fewer funds that would be available to attract community support for the scheme.

In addition, governments often treat the revenue raised as a windfall. Consequently, there is a strong risk that officials will not apply the same rigorous evaluation procedures normally required for government expenditure. Thus there is a risk that low-yielding projects will be funded, some of which perversely benefit those that have already won from the congestion charging. This is a particularly core issue where the revenue is earmarked.

In brief, there is a significant risk facing all congestion charging projects that the potential gains from introducing the scheme will be dissipated by poorly considered efforts to reduce community resistance.

Chapter 5 Determining the charges

Summary

- Economic success will be influenced by the level and the structure of charges but it ultimately depends on the cost of a scheme being less than the efficiency gain generated.
- The viability of a scheme and the appropriate level and structure of the charges will be determined by the characteristics of the specific location.
- There are some basic principles that, if followed, can improve the chances that a charging system will be in the community interest.
- These include matching the level of the charge to the congestion externality cost, and ensuring consistency between congestion charges and other transport policy measures.

5.1 Designing successful schemes

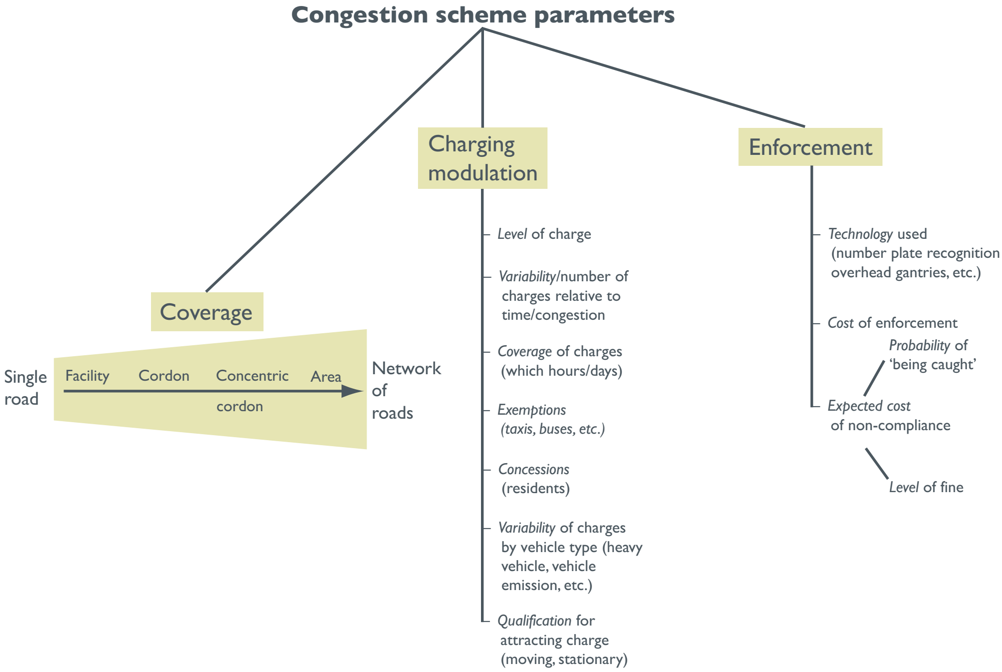
The political success of congestion charging depends on many factors, most of which were discussed in the last chapter. However, economic success is a separate matter: it is the economic success that determines whether congestion charging is in the long-term interests of the community.

Economic success depends on two key factors:

- determining the level and structure of the charges necessary to achieve an efficient level of behavioural change
- ensuring that the cost of implementing the system is less than the efficiency gain achieved from the charges.

The opening premise of this chapter is that it is theoretically simple to reduce congestion through congestion charges—or essentially through any other instrument that increases the cost of road use during congested periods. However, to produce an outcome that is in the long-term interests of the community is a greater challenge.

Figure 5.1 Principal parameters in congestion charging schemes



The key to achieving such an outcome hinges on the relationship between the behavioural change of road users and the cost of the scheme established to achieve it. The behavioural change will clearly be *influenced* by the level and structure of the charges. However, it will vary between locations, at different times of day and between different road users. Hence, no simple rule can be adopted.

Scheme costs and behavioural change are pivotal to congestion charging success.

All this means is that setting the charges can be complex, particularly when there is considerable scope to get the charges wrong. There is no guarantee that a charging system would cost less to implement than the efficiency gains it produces. In such a situation, the charging system would miss its target and so worsen community welfare.

Scheme frameworks are a fundamental determinant of congestion charges. The key parameters of charging systems are illustrated in Figure 5.1.

A key part of the framework is the type of physical road coverage of the scheme. Its simplest application is to a single road—a 'facility' charge. At the other end of the spectrum, there is the area charging scheme. Congestion charging on State Route 91 in Orange County, California is an example of a facility charge; Stockholm's scheme is an example of a cordon scheme, the charging proposal for Manchester is an example of a concentric cordon and London's scheme is the only substantive example of area-charging. The primary examples of these schemes are listed in Figure 5.1.

Figure 5.1 also sets out the primary parameters to be considered in the shape of the charging scheme, that is, the factors that determine what, who to and when the charges are applied. For instance, some facility charges are real-time in that they rise and fall directly with the levels of congestion. At the other end of the spectrum is London's flat charge, which varies with congestion only to the extent that the charges are not levied on weekends or evenings/nights.

The final part of charging scheme frameworks is enforcement of the charges. The ability to achieve behavioural change depends fundamentally on ensuring that charges are enforced. If there is a low probability of detection of non-paying vehicles, then the charging structure is essentially irrelevant to the road users who can easily evade the charge.

This basic framework underlies the following discussion of how scheme charges are determined.

5.2 Common pitfalls

There are two dangers for policy makers in judging the merits of a given charging scheme. First, judging the scheme on a financial basis—the revenue generated relative to the cost of the scheme—rather than an economic basis—efficiency gain relative to the cost. The second danger for policy makers is that 'success' may be regarded as synonymous with 'community acceptance'.

Scheme success should be based on economic evidence and not on net revenue raised.

In this chapter, the economic success of a scheme is narrowly defined as one that represents an efficient use of community resources. In the first instance, this requires an economically efficient level and structure of charges. This, alone, presents a major technical challenge, particularly since location-specific details are important determinants of the appropriate charge. As noted in the review of a series of congestion charging trials conducted in 2003 in Japan: There were significant differences in effectiveness according to the setting of the toll and the project section, the type of vehicles, the discount time zone, and the locational relationship between the general roads and the toll roads (Matsuda, Tsukada, and Kikuchi 2005, p. 145).

The theory for setting the level and structure of the charges is simple—the aim is to ensure that the road user takes account of the cost that he or she imposes on the community, through a charge that reflects the difference between the marginal social cost and marginal private cost facing the road user.

At this point, it will be obvious to readers that the gap between theory and practice can be quite large. Most practitioners recognise that an extremely rough approximation of this theoretical ideal would be the best that could be hoped for. Critically, they would also recognise that there is a point at which the charge would be too rough and too approximate to improve community welfare, particularly after the cost of the scheme is taken into account.

While the specific level and structure of efficient congestion charges are location and time specific, there are some general rules that can provide guidance to establishing a set of charges that are in the long-term interest of the community. The following draws heavily from Vickrey (1992).

5.3 General charging principles

When determining the level, structure and modulation of the charges there will always be a trade-off between ensuring efficient price signals and cost of the charging system, including the costs to the system operators and to the users.

Charges should reflect marginal external cost

Ideally, the congestion charge would serve to internalise the congestion externality at the margin, i.e. it would reflect the marginal external congestion cost. However, by its very nature, this is difficult to determine—particularly since it changes with congestion levels.

Even if it were possible to calculate the changes in the congestion externality at, say, one minute intervals, the charging variations could overwhelm the road user. Hence, for practical purposes, an approximation of marginal external cost would be the best that could be hoped for.[78] Vickrey allowed for charges above that needed to internalise the congestion externality only to the extent of imposing tax surcharges to be in line with others imposed elsewhere in the economy.

Charges should vary smoothly over time

Small, gradual changes to charges encourage a smoother distribution of traffic. With large changes, drivers have a significant incentive to delay their entry to the charging area or to rush ahead of the queue, creating mini peaks. As Ramsey observed: 'It will often be easier and cause less disruption to get drivers to shift the time of their trip by 10 minutes each than to get one person to shift his trip by two hours.'

A 'shoulder toll', between the high of the peak and the low of the off-peak, serves this purpose. The Midpoint Bridge, Fort Myers, Florida has a half-price toll for the shoulder period (the half-hour before and two hours after the morning peak hours). This has encouraged a significant shift from the peak period to the discounted periods (Paniati 2006, slide 16).

London's scheme has a very coarse charging structure: a fixed charge applies during daytimes on weekdays, with no charge at all other times. Given the limitations of London's technology this charging structure might still be the most appropriate. Nonetheless, the charge will rarely if ever be equal to the marginal congestion cost, which will vary across locations and times with varying levels of road use. It remains the case that 'a single charge is likely to be either too high or too low to deal with most locations and circumstances' (ECMT 2007, p. 213).

78. Vickrey actually used the term marginal social cost. However, the marginal social cost is the total of the marginal private cost (MPC) and the marginal external cost (MEC). It is the latter that has to be reflected in the charges to ensure that road users face the marginal social cost.

The ideal number of charging increments will depend on the costs of implementing a scheme with small, gradual changes *and* the road users' capacity to rapidly digest the pricing signals. Technological developments increasingly allow the practical application of graduated charges. For instance, London Transport's 'Oyster' stored-value public transport card allows the application of charges that vary by location and time of day. These cards would also allow charges to be differentiated across the day to reflect the level of congestion. Such profiling should be readily interpreted by network users—for instance, noting that charges rise to a peak between 08:00 and 09:00 and then subsides until (say) mid-afternoon. Users will be able to respond to the general pattern of charges, which does not involve an intimate knowledge of the detailed charging rates.

Technological developments increasingly allow the practical application of graduated charges. Road users can respond to the pattern of charges without needing to understand detailed rates.

Charges should be based on the trip segment

As a rule, traffic over a trip segment provides a more accurate representation of congestion levels than at a single observation point. However, while Vickrey is correct in the narrow sense of achieving a more efficient level and distribution of road use over time, there are trade-offs involved with the cost of the scheme.

A less sophisticated system, such as a facility toll at a single observation point, may be more efficient *overall* in terms of a benefit-cost ratio.

Charges based on the actual cost rather than the anticipated cost

Vickrey reasoned the charges determined on an ex-post basis, for the actual impact that a trip can be calculated to have had on the traffic as actually experienced, may be superior to charging according to a schedule fixed in advance.

Charges that reflect the *actual* level of congestion rather than the expected level of congestion would place the onus on road users to monitor congestion levels. The appeal of such an approach is easily understood. A posted pricing schedule (based on the expected level of congestion) would not allow for increased congestion caused by weather, sporting events and the like, whereas motorists would have the opportunity to inform themselves of these situations and adjust their trips accordingly. In the case of adventitious events such as fires, accidents and the like, one could perhaps allow a grace period of 15 or 30 minutes from the time the occurrence has been broadcast before increased charges become effective, to avoid unduly charging motorists who would have had no opportunity to alter their plans.

However, this is yet to prove practical with road users generally requiring greater certainty of expected tolls when they embark on a journey. The difficulty is, in part, that recognised by Vickrey: 'where congestion threatens, traffic conditions seem often to vary very widely from day to day even when there is no broadly recognisable cause for the variation'. A part compromise would be posted congestion charging that may vary within a range, on the assumption that the road user would have the ways and means to determine the congestion level before embarking on the journey. (See page 71 for a discussion of dynamic pricing.)

All vehicles should be charged without exception

Vickrey was clear on this point: to maintain the integrity of the market pricing principles and to avoid the wasteful lobbying for exemptions, a blanket rule of no exemptions must be adopted. This includes trucks, doctors' cars, press cars, and cars of public officials and diplomats, among others.

While Vickrey allowed a case for charges above the marginal cost of congestion (when applying an economy-wide tax), he was less tolerant of exemptions, concluding that 'there is no excuse for charges below marginal social cost' as there will always be more efficient and equitable ways of achieving the goals of such concessions.

Vickrey maintained that charging public vehicles, such as emergency vehicles, is important even if it is only an accounting transfer. Facing such charges would give a true picture of the cost of these operations and provide an incentive for performing their functions more efficiently, and possibly induce a better budgeting of public funds with due regard for true costs.

This point can be taken one step further. There is due merit in Vickrey's position. The principle of not having exemptions is sound, for efficiency and budgetary reasons. Possibly more important is the fact that exemptions can undermine the objectives of congestion charging schemes. For instance, the introduction of congestion charging in the Seoul Namsan tunnels in 1996 resulted in a significant decrease in traffic levels and an increase in average daytime speed from 21.6 kilometres per hour to 37.6 kilometres per hour (Yoon 2003, p. 4). However, traffic levels have increased again beyond the 1996 level, with 'the greater proportion of this traffic volume increase consisted of toll-free vehicles such as taxies, trucks, and private vehicles occupied by three or more persons'. Similarly, in the London congestion-charging zone, while there has been an overall reduction in traffic, usage by exempted taxicabs has grown.

Exempting any vehicle from congestion charges undermines scheme objectives.

On-street parking should be charged on the basis of clearing the market

Vickrey advocated that the system be dynamic, but with the charging rules being posted. For example if:

> … over a suitable number of weeks, fewer than, say 5% of the spaces are typically vacant during a particular time slot, the charge should be increased, and if vacancies are consistently more than, say 20%, the charge should be reduced, or eventually eliminated. Charges may appropriately be made to vary with the size of the vehicle (Vickrey 1992).

This is probably the most commonly infringed rule: parking charges are very popular among urban authorities as 'proxy road charges', because the community is more accepting of parking charges and because it is also technologically easy to apply and enforce. A review of options for tackling congestion in Auckland, New Zealand, ranked increasing parking charges near the top of the list (MOT (NZ) 2006). Vickrey's view is that parking charges should reflect a market-clearing price.

Other considerations

Exemptions undermine the economic case for congestion charging

The main source of interference is the exemption and concession list. This can be so extensive that it undermines the economic case for the congestion charge. In London, around half the traffic entering the zone is either exempted or enjoys a significant concession (Wetzel 2003).

While economic theory provides an answer to this question, in the popular debate on congestion charging the decision of what to charge tends to owe more to 'what the market can bear' than to complicated economic analysis. As a result, the distinction between charges and taxes can become blurred. This becomes increasingly important when the theoretical literature highlights the conflict between static and dynamic models. A static model can result in congestion charges that worsen rather than improve the situation. Dynamic models can be so complex that they have very limited application.

Complex pricing can inhibit behavioural change in road users

The ideal pricing system would send accurate signals reflecting different levels of congestion at different times without being so complicated that road users suffer from information overload and abandon any effort to adjust their behaviour in line with the charges. Despite the extensive user surveys used to determine the optimal number of different charge rates for California's Express Lanes, a later review concluded that less modulation would be more effective.

Pattern of congestion will determine the level and structure of the charges

The pattern of congestion is an important element that defines the range of appropriate policy options and, indeed, whether direct intervention is appropriate.

Geographical concentration

Headline congestion costs are generally national figures, but congestion typically is highly localised and mainly involves urban precincts.[79] Hence, congestion tends to be a more significant issue in larger cities. Across the expanded European Union, cities account for around 80 per cent of all congestion costs (ECMT 2006, p. 2). In the US, the top 20 areas are estimated to account for 80 per cent of the annual delay (Schrank and Lomax 2007).

79. For densely populated countries such as England and the Netherlands, congestion is potentially a national issue with localised 'hot spots'.

It is important to understand the prevailing pattern of congestion. The same total congestion cost can disguise considerably different congestion costs per kilometre. For instance, Melbourne is characterised by a high but concentrated level of congestion around a relatively small central area near the CBD. Here, the external cost of congestion (and the efficient charge) was estimated to be around $1.26 per vehicle kilometre travelled (BTCE 1996a, p. 74). In contrast, the congestion in Sydney is more evenly spread from the CBD to the Parramatta area. The external cost of congestion per kilometre is lower than that of Melbourne, but prevails over a greater area.

The variation in congestion across a city has implications for the levying of charges.

Congestion in central London is six times that of a typical UK city (TfL undated). Of the 22 French-European administrative regions, 60 per cent of congestion occurs in the Ile-de-France region, corresponding roughly to the metropolitan area of Paris.[80] In Australia, the three eastern seaboard cities—Sydney, Melbourne and Brisbane—account for over 80 per cent of the estimated $9.4 billion annual cost of traffic congestion (BTRE 2007, p. xv).

Between cities the *shape* and *dispersion* of congestion varies, with implications for estimating the cost of congestion and the structure of the charges necessary to internalise that cost. Thus, caution is required when defining the congestion 'problem' in terms of a single monetary value. While it is important to understand the burden imposed by congestion, it is also essential to understand the pattern of that congestion. A concentrated pattern has a strong bearing on the feasibility of applying congestion charges—particularly, area-based congestion charges.

5.4 Charge-setting options

Time costs are the major component of congestion costs and hence the optimal congestion charge will be determined, in part, by the value ascribed to time. However, there is no fixed value of time—it will vary between road users and, for each user, by time of day and function of the trip. Factors external to the road user, such as traffic conditions, which can vary between segments of the network and times of day/week/year, also impact on the optimal congestion charge.

Hence, it is challenging to set charges to optimise capacity. Anderson and Mohring observed that we lack the information that is essential for planning 'optimal road networks and prices for their use':

> We really know very little about what travellers are willing to pay to save travel time. The little we do know derives almost entirely from the choices wage earners make between auto and mass transit for commuting journeys. We know next to nothing about what wage earners are willing to pay to save time on non-work trips. We also know next to nothing about the relationship between the incomes of wage-earning members of a household and the amounts that its non-wage earning members are willing to pay to save travel time (Anderson and Mohring 1997, p. 9).

80. The region is relatively densely populated, having around 11 million, or 17 per cent of the population of 'metropolitan' (European) France and just over 2 per cent of the land space.

Target speeds

When confronted by the challenge of determining the optimal congestion charges, road authorities typically set target speeds, and charges are then calculated to achieve those target speeds. Based on the historical average traffic speed, a target speed of 20 kilometres per hour was adopted for the model tests in Hong Kong. Charges under the test target speed range from $HK8 to $HK31 depending on the period of the day and the traffic demand growth scenarios (Hong Kong Transport Department 2001, p. 5). All travel models have default values of travel time. However, the efficiency gains from the charges will depend, in part, on the accuracy of these travel times. Based on the assumption that average travel speeds of at least 45 miles per hour should be maintained in the managed lanes, and optimising toll rates to achieve or exceed this mobility standard, the model delivered recommended tolls (Georgia State Road and Tollway Authority 2006, p. ES5).

5.5 Second-best charges

Under certain assumptions, ensuring road users face the marginal social cost of road use will maximise community welfare. However, if these assumptions do not hold, then research suggests that such an approach may not be optimal: applying first-best pricing principles could be detrimental to community welfare. Informationally-demanding, second-best charges, may be preferable.[81]

However, when the information needed to calculate second-best charging is not available, it will be difficult to ensure that a pricing structure will improve community welfare—as explained by Rouwendal, et al. (2002):

> In many second-best circumstances, optimal prices are close to marginal costs, and then the first-best rule provides a reasonable guide to policy implementation. However, this is not always the case and there exist examples of second-best situations in which first-best pricing would be harmful. An important finding of the work reported in this deliverable is that the difference between the truly optimal second-best prices and marginal costs often depends on the details of the situation under consideration (Rouwendal, et al. p. i).

However, in reality, there appears to be less focus on determining the 'right' level of charges and more on 'what the market can bear'.[82] Hence, it is not surprising that the distinction between charges and taxes is often blurred and that road authorities may be driven to maximise toll revenue rather than to maximise community welfare (as measured by improvements in allocative efficiency).

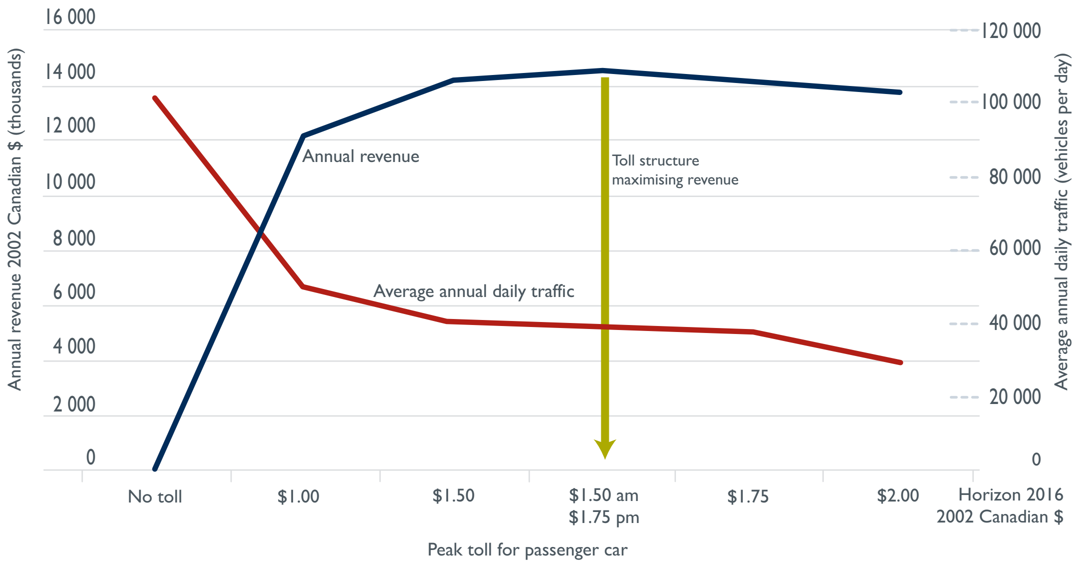
Both the structure and level of the charge that maximises revenue is likely to be significantly different from that which maximises community welfare. de Palma, Lindsey and Proost (2005) showed that time-varying step toll charges will generate higher (as much as twice as high) welfare gains but less revenue, compared with flat tolls.

81. Verhoef and Small (1999) showed that for second-best pricing it is important to know the distribution of values of time, the level of external costs, the demand and cost elasticities and the distribution of values of time.
82. For instance, in preparation for congestion charging few authorities reveal concern over the possibility that they will choose the wrong charges and, by doing so, worsen rather than improve the situation.

5.6 In practice

While there is a great deal of economic theory that can be drawn on to set congestion charges, the reality is that the charges generally reflect a trade-off between technical objectives and political acceptability. An £8 charge may have been difficult to sell to Londoners initially. However, when the £5 congestion charge was increased to £8 just over two years later (July 2005) there was little apparent dissent.[83]

Figure 5.2 Toll level maximisation



Source: Adapted from Benouaich, Audette, and Sultana (2007, p. 15).

Such an iterative approach is common. The level of the congestion charge for Singapore was initially set to simply double the total cost of driving into the city, which was taken to be the cost of parking. Hence, the entry fee was set at the cost of parking, $S3 per day (Menon 2003, p. 121). The charge was later reduced to achieve higher utilisation of the road network.

5.7 Acceptance increases over time

Recent experience suggests that citizens' anxiety about congestion charging projects far exceeds their actual dissatisfaction once a project is in place. In fact, while resistance to congestion charging can be a potent barrier to implementation, recent surveys demonstrate unexpectedly favourable attitudes toward the implemented project (Transportation Research Board 2005, p. 4).

Menon observed that over a 23 year period, motorists in Singapore had come to accept congestion pricing, albeit reluctantly (Menon 2003, p. 126).[84] Transportation officials in Oslo faced significant public opposition when the first Oslo toll scheme

83. This may be due, in part, to the fact that the increase in the charge coincided with the London bombings, generally distracting the press and the population as a whole.
84. However, Singapore has many unique features that may undermine the transferability of any lessons.

was introduced, with one poll indicating the 70 per cent of respondents opposed the scheme (Waersted 2003, p. 4).

5.8 Tackling congestion requires an integrated multilevel approach

One of the most predictable aspects of congestion is that it evokes a call for a coordinated, integrated package. In the words of the Organisation for Economic Co-operation and Development (OECD)/ECMT Working Group on Managing Urban Traffic Congestion: 'tackling congestion requires a integrated multi-level approach and therefore a multi-level framework of planning and decision making' (ECMT 2005). The aim is to achieve synergy between the instruments so that the overall benefits are greater than the sum of the parts (ECMT 2005). The underlying logic has appeal: that if the sources of congestion are multifaceted then the solution will also need to be multifaceted.

The Working Group identified five different levels that required integration:

- operational integration of different services and information, e.g. in public transport (including fares structures) and traffic management
- strategic integration between instruments affecting different modes and between those involving infrastructure, management, information and pricing
- policy integration between transport and land use
- organisational integration of government bodies and agencies with different responsibilities for transport
- policy—and possibly organisational—integration between transport and land use on the one hand and other policy areas such as health, education and society (ECMT 2005).

However, while such subdivisions may be very useful, the fundamental challenge is to integrate policies *within* transport (such as coordination of public transport operations and general traffic management) as well as between transport and other areas of government responsibility (such as transport and land use). It goes without saying that it is always preferable to achieve a high level of consistency between policy areas, so there is nothing provocative about this general push for better coordination. The major (and possibly insurmountable) difficulty appears to be putting the institutional mechanisms in place to bring about the desired level of coordination. This would provide a basis for a completely separate paper.

Similarly, it is difficult to raise issue with a statement such as:

> … a package of instruments is likely to be more effective than selecting any one instrument on its own. In these ways, synergy can be achieved between instruments; that is, the overall benefits are greater than the sum of the parts (ECMT 2005).

To the extent that congestion is identified as a problem with multiple sources, it sounds eminently sensible that multiple instruments will be needed to tackle it. However, there could be a different way of approaching 'the problem'.

Assume for a moment that each of the separate areas that interact to create congestion is optimally managed. In other words, public transport policy is sound, with levels of service and subsidies following a carefully designed plan to achieve the stated objectives. Road management is efficient with advanced technology being implemented where the returns justify the cost. Urban expansion follows clear guidelines involving appropriate cost recovery of the infrastructure and so on.

Under this scenario, even with the separate policy areas operating at their optimum, an inefficient level of congestion prevails. This, as most would observe, is due to the absence of a pricing signal reflecting the cost imposed on others by the entry of an extra vehicle: the congestion externality. The ideal solution in this situation is a congestion charge equal to the difference between the marginal private cost and the marginal social cost. This would ensure that the interests of the road user were aligned with the interests of the wider community.

The key question becomes 'is it necessary that the congestion charge is designed as an element in a wider, coordinated package? The problem with the 'coordinated, integrated ideal' is just that: it is an ideal. The first hurdle in the pursuit of such an ideal is compiling the data required to ensure that the coordination can come about. The second is ensuring the goodwill amongst different agencies as they sublimate their best interest for that of the 'greater good'. The third is compiling the carefully structured package. Each step along the way is extremely demanding.

The alternative is to introduce the appropriate congestion charge, then allow the other policy areas to adapt. In the real world, there would be scope for decision makers in related policy areas to exchange information and hence to anticipate the impact of the congestion charge. For instance, the public transport operators would factor in higher demand for their services and plan accordingly. Housing developers would anticipate an increased demand in those areas that provided more options to car use. Roads that substituted for the charged roads would need to consider options for dealing with 'rat-running' such as speed humps and lower speed limits.

In other words, while 'integrated, coordinated policy making' sounds like an obvious option, it is not clear that an iterative approach (as outlined above) would not work as effectively; possibly more so in that it would be less likely to be become bogged down in reaching agreement among potentially conflicting parties, where efficiency is often the casualty of compromise.

Furthermore, there is a major downside to the multifaceted approach that it is important for policymakers to come to grips with. This is the temptation to justify a wide range of measures because they may help to reduce congestion, without subjecting each measure to separate scrutiny. This 'bundling' of measures tends to result in policy options being adopted on the basis of their aims (rather than on their performance).

Measures aimed generally at 'reducing the current and future need to travel' invariably play key roles in any package to tackle congestion. Generally unacknowledged is the simple fact that travel *per se* is not inherently 'bad' and that the optimal level of travel is not always a *lower* level. If the benefit of extra travel exceed the social cost of that travel, then the community will be better off if that travel takes place. Hence, *more* travel might be better than less, although it may take place at different times and in different places than currently.

In other words, this uncritical embrace of a combination of instruments to reduce congestion may not be in the community interest. In particular, improving the public transport system is often advanced as a policy response to congestion. However, in this as in all cases of government spending, specifics matter. A return to the community cannot be assumed. Any call on public funds, including the funding of public transport, requires transparency and accountability. The introduction of congestion charging would generally enhance the viability of public transport, but it is still required to be judged on its own merits rather than being bundled into a wider package, of which none of the elements are separately evaluated.

Within a multifaceted approach, congestion strategies still need to be subjected to separate evaluation.

To conclude this section, there can be an overemphasis on the argument that there needs to be a 'coordinated, integrated approach' to dealing with the congestion issue. There are many areas of our economies that are interlinked, but this does not necessarily mean that they require a 'chief controller' approach to ensure dynamic harmony. Policy making can be iterative, with one area responding to changes in another area. Clearly, there would be gains from avoiding direct conflict with policies from different areas, but this is unlikely to happen if the ultimate goal is to promote the welfare of the community. Ensuring that each separate area operates efficiently would go a long way to generating an efficient level of congestion.

London

The mid-2005 announcement by the UK Secretary of State for Transport, Alistair Darling, has its genesis in a 2002 report by the Commission for Integrated Transport (CfIT). The report, *Paying for Road Use*, drew the following conclusions:

- the most anti-car policy is to allow the growth and spread of congestion
- a nationwide congestion charging scheme would result in charging for 37 per cent of travel
- such charges would reduce congestion nationally by 44 per cent, while reducing the amount of traffic by only 5 per cent
- costs overall to motorists would not increase. Instead of paying taxes to the government, motorists would pay directly for the use of roads during congested periods. The revenue raised from the congestion charges would be offset by reductions in other taxes and charges, i.e. would be fiscally neutral
- the motorway network and other trunk roads would rarely attract charges: roughly 10 per cent by length and only at times affected by congestion
- travel time reliability would increase significantly
- charging system would utilise Global Positioning Technology
- motorists would pay using prepaid smart card, direct debit and credit cards or by monthly invoice (CfIT (UK) 2002a).

Table 5.1 The long gestation for nation-wide congestion charging in Britain

Date	*Title*	*Other details*
1964	Road Pricing–the economic and technical possibilities	Known as the Smeed Report, this appears to be the first government-commissioned report to advocate the use of congestion charging to influence road use. This report drew heavily on Buchanan 1952 and Walters 1954, 1968).
1967	Better towns with less traffic	Commissioned by the Ministry of Transport, concluding that direct road pricing was the most effective means of traffic restraint.
1993	Green Paper Paying for Better Motorways: Issues for Discussion	DOT (UK) 1993.
1996	Congestion on the Trunk Road Network	DETR (UK) 1996.
1998	A new deal for transport: better for everyone	Congestion to be tackled through 'better use of pricing'. (DETR (UK) 1998).
1998 (Dec.)	Breaking the logjam	The Government's consultation paper on fighting traffic congestion and pollution through road user and workplace parking charges (DfT (UK) 1998).
1999 (Aug.)	Transport and the economy: full report (SACTRA)	Congestion pricing floated as a way of decoupling traffic growth and economic growth.
2000	Modelling using the National Road Traffic Forecasting Framework for Tackling Congestion and Pollution and Transport 2010	Department of the Environment, Transport and the Regions.
2000 (July)	Transport 2010: The 10 Year Plan	DETR (UK) 2000.
2001 (Mar.)	Meeting the local transport challenge	
2001	Seventh report drawing special attention to the following: Road User Charging (Enforcement and Adjudication	House of Lords Joint Committee on Statutory Instuments 2002.
2001 (Dec.)	Perceptions of Congestion—report on qualitative research findings	DfT (UK) 2005.
2002 (Feb.)	Paying for road use	Report by the independent advisory body (CfIT (UK) 2002a, 2002b).
2002 (Dec.)	Progress Report on the 10 Year Plan	
2003 (July)	Managing our roads	A discussion paper contributing to the overall review of the Government's 10 Year Plan for Transport, focusing on the strategic issues we face on the road network (DfT (UK) 2005b).
2004 (July)	Road pricing feasibility study	This study examined how the implementation of congestion charges for road use could help make better use of road capacity, exploring whether and how road pricing might work (DfT (UK) (2004). The study concluded that a nation-wide system of congestion charges could reduce congestion by half and provide major air quality and other benefits.
2004 (July)	The Future of Transport: White Paper CM 6234	Government response to the feasibility study. We must build a public consensus around the objectives for road pricing and how to use the revenues (Transport Secretary, Alistair Darling) (DfT (UK) 2004a).
2004 (Dec.)	Guidance on Local Transport Plans	Central Government asked authorities that might be interested in' exploring innovative approaches to solving local congestion' (including congestion-related charges) to submit a preliminary expression of interest by the end of January 2005.
2005 (Mar.)	Road pricing, the next steps, volume I	House of Commons Transport Committee 2005a.
2005 (Aug.)	Road pricing, the next steps, volume II	House of Commons Transport Committee 2005b.

Source: BITRE compilation.

The CfIT undertook detailed modelling of congestion costs and motoring taxes and charges at a disaggregated level. This enabled them to determine the congestion costs and charges on different sections of the road network, in different parts of the country, in different types of area (urban and rural), on different types of road, and at different times of the day or week (CfIT (UK) 2002b).

Table 5.2 Main steps in the development of the London Congestion Charge

1967	Better towns with less traffic (Ministry of Transport).
1970s	Series of papers on congestion options (Greater London Council).
1991	London Congestion Charging Research Programme (LCCRP).
1995	Findings of the LCCRP submitted to Department for Transport UK.
1998	Congestion charging recommended as an appropriate policy for London in London Planning Advisory Committee's 1998 Strategic Advice to the Secretary of State.
1998	Road Charging Options for London (ROCOL) study. The recommendations from this report formed the basis for the London Congestion Charging Scheme.
2001	Facilitating legislation introduced.
2003	February 15 charging scheme introduced.
2005	July 5 charged increased to £8.
2007	February 19 charging zone extended to the west and hours of operation were shortened by 30 minutes so charge now applies Mon–Fri 7am–6pm.
2008+	Emission charges proposed to be phased in from 4 February. Charges would to rise to £25 per day for high-emission category passenger vehicles and £100 for some utility vehicles that fail to meet Euro 3 standards for particulate matter.

Note: For a comprehensive explanation of the proposed emission charges, see TfL (2007).
Source: Various.

Even for the relatively simple congestion charging scheme introduced in London the process has been long and involved (Dix 2002). As illustrated by Table 5.2, despite the narrowness and basic technical nature of the scheme, there were decades of committees, studies and reports before the London Congestion Charging Scheme was finally introduced.

Hong Kong

The Hong Kong experience reminds policymakers that despite apparent need and extensive preparation, success can never be assured. In the mid-1980s, a dramatic increase in road use in Hong Kong, as a result of a decade of double digit annual rates of real growth, led to a comprehensive Hong Kong congestion charging trial. During this period congestion had increased dramatically as the 17 per cent expansion of road capacity was overwhelmed by the doubling of the number of registered vehicles and concomitant increase in road use.

The Government's initial response to the sharp increase in congestion was to adopt the recommendations of the first Comprehensive Transport Study, which concluded that the 'least undesirable option available to government was the fiscal measure of restraint of auto ownership' (Hau 1990, p. 204). A package of draconian fiscal measures (which included increasing import duty to 70–90 per cent of the import price of a vehicle) was introduced in May 1982. Vehicle ownership declined dramatically for four consecutive years.

Table 5.3 Stages of Hong Kong's foray into congestion charging

1976	Comprehensive Transport Study	Consultants report that identified fiscal measures to restrain automobile ownership as the 'least undesirable element available to government'.
1979	White Paper on Internal Transport Policy	Articulated the government's tripartite transport policy (focus on making better economic use of road space).
1983 (July)	Pilot study commenced	Cost US$31 million (1985 prices).
1985 (March)	Pilot study completed	

Source: Hau (1990, p. 204).

5.9 Concluding comments

In this chapter we have reviewed the principles behind determining the appropriate (most efficient) level and structure of congestion charges. Adopting these principles—summarised in Box 5.1—is fundamental to ensuring that a charging scheme, *if implemented*, will bring about an overall improvement to community wellbeing.

Box 5.1 Keystone congestion charging principles

When should congestion charging not be applied?

- When the charge is higher than the congestion externality that it is designed to internalise. In this case, traffic would be reduced beyond an efficient level, as has been suggested was the case in the early days of the Singapore charge.
- When the cost of the scheme exceeds the efficiency gain from introducing the charge.

What circumstances are likely to lead to the cost of the scheme exceeding the efficiency gain from introducing the charge?

When there is little behavioural change. The economic rationale for a congestion charging scheme is to 'internalise the congestion externality'. However, sound public policy does not require all externalities to be internalised. Externalities that do not impact on resource allocation, regardless of how large they may be, will not result in an efficiency loss. In other words, with or without the externality, behaviour changes very little. In the context of traffic congestion, this means that *if* the demand for road use during peak periods is relatively price-inelastic, then the presence of a congestion externality or, indeed, of a congestion charge, will not have a major impact on behaviour.

When will there be little behavioural change, that is, when will demand be relatively inelastic?

Generally, this will occur when peak-period drivers face few options in terms of shifting departure time, mode or route.

In such circumstances, increasing the congestion charge until a target congestion level is achieved, could simply result in higher revenue but very little behavioural change. This is possibly a useful revenue source but note that this 'usefulness' depends on the cost of the system. The cost of current schemes is relatively high, especially with London, where the topography of the charging zone leads to costly scheme policing.

Chapter 6 Policy implications

The policy focus on congestion charging is born out of a confluence of trends. Policy makers are encouraged to look at congestion charging because of rising road congestion, the decreasing political and environmental palatability of undertaking road construction, the quest for new revenue sources to fund infrastructure expansion and the advances in road charging technology.

Congestion charging has been a theoretical concept for over fifty years, and has been applied in various forms and scales in a few cities from the 1970s. However, it was the adoption of congestion charging in Central London that has led to widespread policy interest across the world.

Arguably this interest arises because the scheme is high-profile and has been subject to political test at the ballot box. In this context it is notable that the major alternative candidates for the London's 2008 Mayor of London election campaign have said they will retain the scheme, but would remove the 'Western Extension' of the charging area.

This is a key factor to remember about the existing zone (cordon and area charging) schemes: none of the schemes covers extensive areas of the cities where they have been introduced—even the relatively large London scheme covers only 2.5 per cent of Greater London, by area. The modest size, in itself, could explain much of the political acceptability. Those who 'lose' from these schemes are relatively few compared with those who win or are indifferent to a scheme.

The small physical size of the cordon and area zone schemes also reminds the policy maker that, thus far, there are no schemes that provide a panacea for all of a city's congestion—at best, the cordon schemes to date offer solutions that apply only to central areas. The Manchester cordon-zone scheme would encompass a large area but the charging 'bite' would be limited to commuting traffic crossing the cordons; it cannot address the congestion arising within the geographically-large zones.

Part of this focus on the central area arises from the pure mechanics of current cordon-charging technology: if you make the charging 'island' too big then everyone is inside the zone and the charge will not encourage sufficient behavioural change. This limitation may be countered by adopting an area scheme but, as London's area scheme illustrates, the capital costs and operating costs rose dramatically and the zone size still remains only a small proportion of the city.

In principle, area charging can provide the necessary bite. However, as the physical area increases, the average charge for travelling within the zone will become less representative of the diverse traffic conditions within that zone.

The consequences of pricing distortions and concessions can also be magnified as area charging is widened. For instance, the Western Extension to London's area scheme significantly increased the number of drivers that were entitled to a 90 per cent resident reduction.

The opportunities for *zone*-based congestion charging in Australia cities are low. Existing international examples of zone-based charging are special cases because of the concentration of retail, office and tourist activities and the complementary high-standard public transport. Neither the concentration nor the (related) standard of public transport is evident to the same degree in Australian cities.

Opportunities for *facility*-based congestion charging in Australia are also limited, for other reasons. Facility charging is common in Australia on a fixed-rate basis: this generally applies to key road sections that can physically be separated from other parts of the network. The first hurdle is the political reality of applying higher charges during peak periods to established road links. International experience reveals that the introduction of congestion charges on such links is limited to new or substantially upgraded facilities.

The second hurdle to facility congestion charging in Australia is rooted in the widespread use of PPPs for new arterial road links. Such contracts normally have a life span of 30 years or more. If congestion charging were to be introduced on these roads, then it would be necessary to renegotiate these contracts. Experience shows that this could be costly. It would also be extremely complex: the contracts would need to be designed to align the profit maximising goal of the private company with the network optimisation goal of the wider community. Indeed, in the case of 91 Express Lanes in California, the transport authority deemed that it was simpler to purchase the road from the private operators.[85]

If we look at the application of international schemes, then, we find that cordon-based congestion charging has been applied on a very limited physical part of a city's infrastructure. For Australian cities, then, these schemes offer little comfort for resolving current congestion problems.

These zone-based schemes also alert us to important concerns about behavioural change and to location-specific scheme characteristics. A successful scheme is based on, at-most, modest charges to induce some drivers to switch from congested periods. But the characteristics of Australian cities work against successful implementation. This is because, first, this sort of behavioural change usually requires very high public transport standards. Australian cities' low-density urban form works against authorities being able to justify and underwrite this very high service quality. Further, the private vehicle remains a very attractive option in Australia compared with the overseas cities we have assessed—despite the congestion that occurs in our cities.

The second concern with applying zone-charging to Australian cities is whether the cities have the natural zone boundaries that help to contain perimeter enforcement costs. Delivering a successful cordon or area scheme in Australian cities (with current technology standards and costs) requires identifying a zone where charging can be applied cost-effectively. In Singapore, Valletta, Rome, Stockholm and Durham (and the facility charge system in Dubai), the natural geography of the city centre and road systems allow a very modest number of charging points to be used. The schemes use the natural island, peninsula or historical pattern to provide natural boundaries to charging zones. This keeps capital and operating costs down. By contrast, London's operation is highly ambitious and costly; the zone is largely without natural geographical boundaries and has more than 200 perimeter check points.

85. Then commissioning the private company to continue operating the road.

The London scheme's high capital and operating costs certainly fuel the debate as to whether that scheme is an economic success. Enthusiasm for congestion charging schemes must be dampened by the reality that schemes may not benefit the wider community. Some estimates of the costs and benefits of the Central London scheme suggest that it is a failure. This would seem to be an amazing conclusion: with bus ridership up and traffic levels down, it might be assumed that the scheme must be successful. But scheme 'success' is not determined just by changes in traffic levels or public transport ridership or the amount of revenue raised. Success depends critically on the cost of implementing the scheme relative to the efficiency gains achieved.

It appears that very few of the overseas cities that have introduced congestion charging schemes have undertaken economic analyses of their schemes, let alone sensitivity analyses. However, it is possible that the issue is lack of transparency rather than a failure to adopt sensitivity analysis.

US experience with facility charging illustrates the potency of charges to modify peoples' travel behaviour. Such charges are typically far less crude than zone charges. For instance, the London charge essentially requires a traveller to not travel to Central London by private car whereas the scale of charges in the main US schemes encourage users to switch to non-charged roads or to delay or advance their travel in order to attract a lower facility charge.

So the principle of congestion charging works but the different cities and the different schemes applied demonstrate that the factors that lead to the success or failure of a scheme are very location-specific. Australian policy makers therefore need to note that whether to introduce a scheme is very location specific; and the nature of the scheme that is introduced is very specific to the type of travel in that city.

This paper has outlined the principles and applications of road congestion charging. Where schemes have been evaluated—and there are few such evaluations—the outcomes are not unquestionably positive, even when the environment should be ideal for such schemes. This is of especial importance for Australian cities, where the nature of our city form and transport infrastructure and service provision makes the environment even less favourably disposed for charging schemes. That said, with scheme experiences gathering and with charging technology costs declining and technological sophistication enabling more congestion-sensitive charging, decision-makers should remain open-minded about congestion charging as a policy instrument. However, they should not, at this point, focus on congestion charging as the instrument of choice in order to keep urban Australia moving.

Appendix A The economics of congestion charging

A1 Economic rationale for congestion charging

Efficiency in resource use is promoted when each road user has to pay the full cost they impose on society as a result of their actions. Then, consumers and producers will only use a road when the value they derive from road use exceeds the cost to society.

The cost of providing an additional unit of a good or service is called the 'marginal cost'. According to economic theory, efficiency in resource use is maximised when all prices in an economy equal marginal social costs. The word social is used here to indicate that all costs to society need to be taken in account, including externalities. In this exposition of the rationale for congestion pricing, externalities other than congestion are set aside and it is assumed there are no taxes on inputs. It is further assumed that all road users are homogeneous.

When an additional vehicle enters the traffic stream, the driver incurs the 'private costs' of vehicle operation and travel time.[86] This cost is both the marginal private cost (private cost incurred by the additional vehicle) and the average private cost (because all vehicles incur the same cost). Under the assumptions of no externalities other than congestion, and no taxes in inputs, it is also the average social cost.

The additional vehicle creates an externality by adding to the congestion, slowing all the other vehicles down. The marginal social cost for an individual road user is therefore greater than the marginal and average private costs incurred by that user. It includes the cost that the additional user imposes on all the other road users. The mathematical relationship between marginal and average cost shows this:

$$MC = AC + q\frac{dAC}{dq} \quad \text{where } q \text{ is the traffic flow.} \qquad (A1)$$

Thus the cost imposed on society (all other vehicles on the road) by an additional vehicle (MC) is the average private cost incurred by that vehicle (AC), plus the increase in average private costs, dAC/dq, that it imposes on the q other vehicles that experience additional delays. Economically optimal road pricing involves imposing a charge equal to $q \times dAC/dq$ to close the gap between the marginal private and social costs.

To illustrate numerically, say on a 10 kilometre stretch of two-lane road in one direction, there is a volume of 4000 vehicles per hour. Travelling at a speed of 30 kilometres per hour, the vehicles take one-third of an hour to traverse the length of road. If the combined cost of time and vehicle operation is $30 an hour, the average

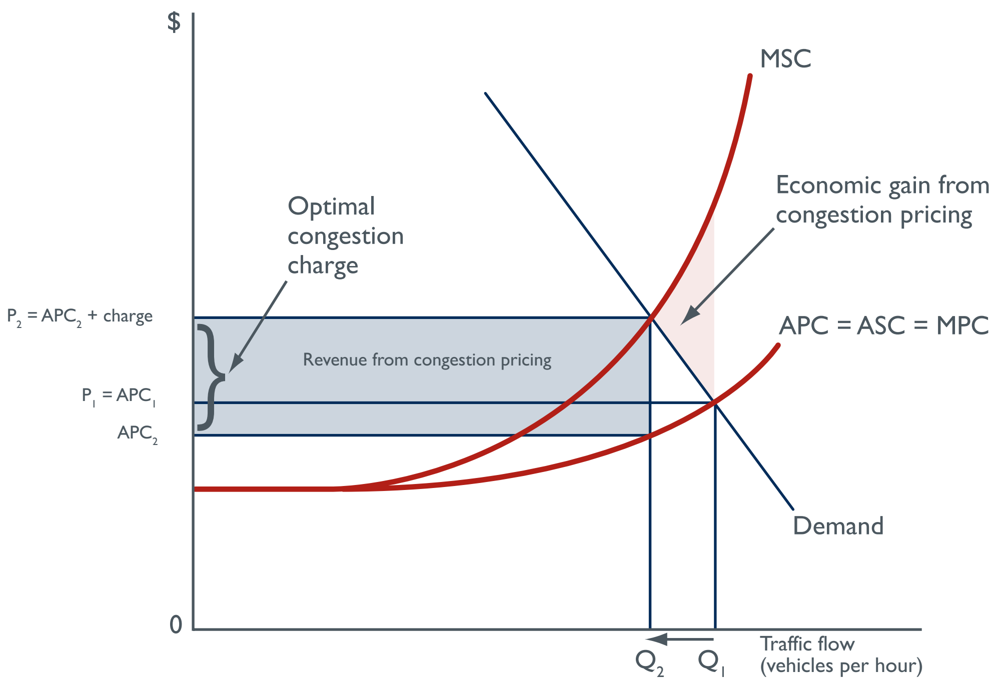
86. All costs referred to in this section are 'generalised costs', that is, vehicle operating costs plus the cost of time. The concept could include other quality aspects of road transport such as reliability measured by the standard deviation of travel time.

private cost will be \$10. The total cost incurred by all vehicles in an hour will be \$40 000. Say the traffic volume was expanded by one vehicle.

Travel speed is reduced to 29.9955 kilometres per hour causing the time taken to rise by 0.00005 hours. The average private cost is increased to \$10.0015 = \$10 + 0.00005 hours × \$30 and the total cost for all vehicles to \$40 016 ≈ 4001× \$10.0015. The marginal cost is therefore \$16 = \$40 016 – 40 000. This marginal cost has two components: the marginal private cost for the additional vehicle, approximately \$10; plus the externality of the extra \$0.0015 imposed on the 4000 other vehicles on the road, \$6 = \$0.0015 × 4000. The optimal congestion charge would be less than \$6 because the charge would induce some road users to alter their travel plans, reducing the traffic volume. The gap between marginal private and marginal social cost would thereby be reduced.

Figure A1 shows private and marginal social generalised cost curves for a length of road together with the demand curve. With each user incurring the average cost, the equilibrium is established at the point where average cost curve intersects the demand curve—quantity of traffic Q_1 and price $P_1 = APC_1$.

Figure A1 Economically optimal congestion charging



For some of the traffic, Q_1Q_2 the marginal social cost exceeds the users' valuation of the service as measured by the height of the demand curve. If the traffic Q_1Q_2 could be eliminated, society would be better off each hour by the shaded triangular area. This would be achieved if a congestion charge was imposed at the level that exactly shifts the equilibrium traffic level to Q_2.

With less congestion, average cost falls from APC_1 to APC_2 . However, for the average road user, the charge more than offsets the cost saving raising the effective price (private cost plus the charge) from P_1 to P_2. The government gains revenue equal to the area of the greyed rectangle.

Clearly, in any practical scheme, a great deal of averaging over time, locations and individual vehicles is inevitable. Some compromise needs to be reached between the efficiency gains from a pricing system that more accurately reflects the costs vehicles impose, and the administrative costs of greater complexity.

A2 Immediate distributional impact of optimal congestion charges

The fact that optimal congestion charging improves economic efficiency does not mean that there are only gainers. It implies that when all gains and losses to members of society are combined, the net result is positive.

The main gainer in the first instance is the government. There will be subsequent gainers, and possibly losers, depending on what the government does with the revenue.

Road users paying the charge benefit from the reduction in congestion. They travel faster and incur lower generalised costs. But, as Figure A1 shows, the charge more than offsets the reduction in generalised costs. Overall, road users are worse off.

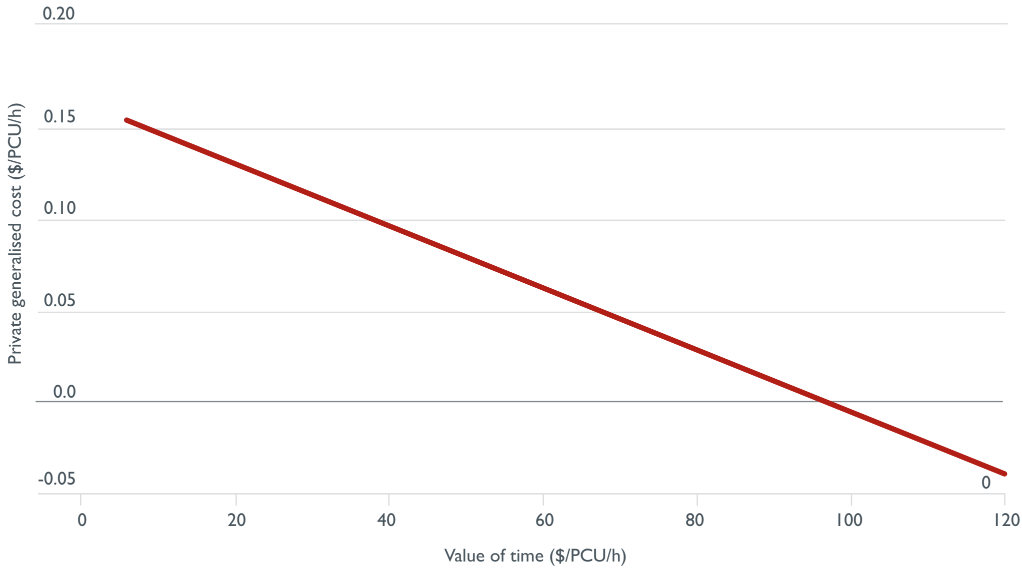
It is likely, however, that road users will have a range of values of time. So different road users will place different values on the reduction in congestion. Car users making work-related trips will generally have higher values of time than those making non-work trips. Cars with higher occupancies will have higher values of time when the time costs for all occupants are combined. Value of time will vary for freight vehicles depending on the nature of the freight.

Demand for road space is measured in passenger car equivalent units (PCUs). Under optimal congestion charging, a truck that uses up the same amount of road space as three cars would be charged three times as much for a car. Although an individual truck may have a high value of time compared with a car, it would be charged more, so it is not clear how freight and passenger vehicles compare in terms of net losses from congestion charging.

Harvey (2005) produced Figure A2 for a hypothetical one kilometre length of road using realistic assumptions about road users and road capacity. The optimal congestion charge was 16.5 cents per PCU. The diagram shows the net impact of the charge on private generalised costs for road users with different values of time per PCU. For road users having a value of time above $96.61 per PCU per hour the reduction in travel time is worth more than the charge, and they are better off. These are predominately high-occupancy business cars.

Road users displaced by the charge, changing their travel patterns to avoid the congestion charge, are worse off, but the amounts must be less than the net increase in private generalised cost had they remained on the priced road. The displaced traffic may generate some increased congestion on other roads or on the priced-road in off-peak times. Displacement of traffic to other roads and times does not have economic efficiency impacts unless (i) there is sufficient traffic on the alternative roads for there to be congestion impacts; and (ii) there is no optimal congestion pricing on the alternative roads or at the alternative times.

Figure A2 Impact of congestion charging on private generalised costs, by value of time



Appendix B Measuring congestion costs

Congestion costs are measured in many different ways. The measurement is important because it strongly influences both the estimate of congestion costs and the ranking of policy options to deal with congestion (as discussed from page 3). Equally important is the uncertainty ranges for each measure. While uncertainty is not systematically reported, a recent analysis of the congestion costs in Australia illustrates its significance:

> … the costs imposed on Australian society by urban traffic congestion are likely to fall in the range of $5 to $15 billion for current levels (BTRE 2007, p. 18).

There is no one definition of congestion costs and no agreed measure of congestion: each approach has its strengths and weaknesses. The relevance of any measure is determined by the end use. This appendix explores the different approaches to measuring congestion costs with particular emphasis on the implications for policy making.

B1 Methodology and assumptions

Aggregate versus network modelling

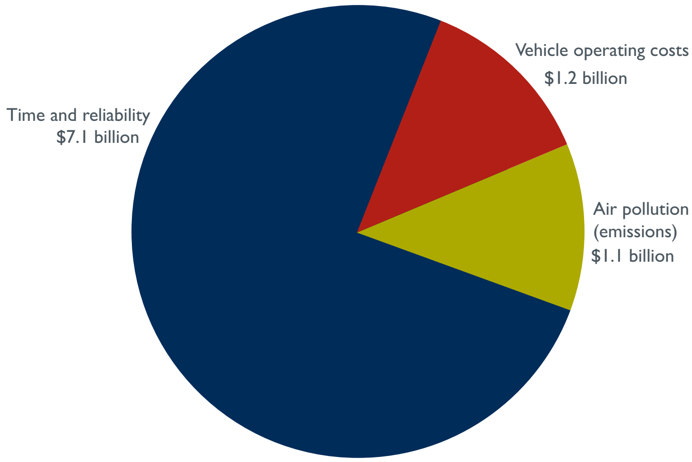
Congestion cost estimates are usually developed using complex models incorporating a variety of simplifying assumptions and approximations. The models themselves may be 'top-down' (aggregate) or 'bottom-up' (using detailed network models). The distinction between the two approaches reflects, in part, the trade-off between accuracy and practicality.

Network models, including microsimulation models, provide the greatest level of accuracy as they aim to replicate the traffic flows on all of a city's major roads. However, they are very 'data hungry' and computationally demanding. Given the cost involved, they invariably raise the benchmark question of whether the costs can be justified by the output.

Aggregate models are less data and computationally demanding, but accuracy is sacrificed to the point that the usefulness of the results is in doubt:

> '… in general, an aggregated analysis that does not consider congestion separately on each road link is unlikely to provide a credible estimate of the costs of congestion' (BTCE 1996b, p. 478).

Figure B1 Components of Australian congestion cost estimates



Source: BITRE (2007).

Economic parameters

Independently of the modelling approach adopted, the congestion cost estimates will be strongly influenced by the values assigned to the key parameters. The main components of congestion costs are:

- travel time, including that due to network unreliability
- vehicle operating costs
- tailpipe emissions.[87]

Estimates of congestion costs in Australia suggest that lost travel time accounts for three quarters of total congestion costs, as illustrated in Figure B1. Private travel and business travel each account for half the delay-related congestion costs.

Value of time

Increased travel time is normally the main element of congestion costs, accounting for around 70–80 per cent of total costs. Hence, total congestion costs are heavily impacted by the value assigned to time. For instance, adopting a 30 per cent higher or lower value of time will mean a 22–24 per cent variation in total congestion costs.

87. The slow speeds and the stop-start nature of congestion prevent vehicle engines operating at their optimal conditions. This results in incomplete combustion and the formation of chemical by-products, such as carbon monoxide and hydrocarbons, that damage the environment and human health.

Table B1 Austroads value of time for different vehicles

Vehicle	*Value of time*
Private vehicles	\$9.23 per person-hour
Business travel	\$29.52 per person-hour
2-axle rigids	\$22.41 per hour
6-axle artics	\$48.51 per hour

Source: Austroads (2006a, Table 8, p. 12).

Despite the academic interest in this issue, there is no simple answer. However, there is general agreement that there is no unambiguously correct figure for the value of time and that there are gains from the consistent application of agreed values, such as in Table B1.

The success or failure of congestion charging projects will often be determined by the value attributed to the time saved. While proponents of the London scheme regard it as an economic success, other analysts have labelled it as an economic failure—a 'mini-Concord'—because it recovers only 60 per cent of its costs (Prud'homme and Bocarejo 2005). The value assigned to time is a key factor in the discrepancy between the disparate conclusions.

Network unreliability

While the time lost in congested traffic is an important element of the costs of congestion, the unreliability of travel time due to the unpredictable nature of congestion, is also a major issue. Indeed, the ECMT suggests that the volume of evidence points to reliability as being more important than travel time and speed (ECMT 2007, p. 37). As noted in the Technical Report, *Paying for Road Use*:

> … congested roads are sensitive to small disturbances. So congestion results not only in delays but in uncertainty as to how long journeys are going to take. That causes problems and costs, often because people need to leave early to make sure they get to their destination on time (CfIT (UK) 2002a, p. 9).

There can be a random element to network unreliability, due to accidents and poor weather conditions. In Britain, it has been estimated that around a quarter of congestion is unpredictable, contributing to unreliable travel times.

It is difficult to quantify the cost of increased network unreliability due to congestion. Unreliability itself is generally measured as the standard deviation in travel time. However, translating this to a cost is not straightforward. Unreliability leads to uncertainty surrounding travel times, requiring extra travel time as a 'buffer'. In Britain, network unreliability is estimated to increase operating costs of freight vehicles by five per cent (CfIT (UK) 2002a, p. 12).

Modelling of the impact of congestion charging in London produced improvements in journey time reliability between 20 and 30 per cent of time savings (between £10 and £20 million compared to between £40 and £65 million a year) (CfIT (UK) 2002a, p. 14).

The contribution of network unreliability to the costs of congestion is yet to be widely applied in international studies. Australian estimates indicate that social cost of congestion based only on travel time and excluding costing for unreliability, extra vehicle operating costs and emissions, was around $5.6 billion in 2005 (BTRE 2007, p. 9). Taking into account the separate estimates for increased vehicle operating costs and emissions, this implies that the cost of reduced reliability of the network is around 15 per cent of the BTRE aggregate congestion estimates of $9.30 billion dollars for 2005 (BTRE 2007, p. 8).

Vehicle operating costs and emissions

Again, while there is no simple figure for these costs, there are standard recommendations for vehicle operating costs (VOC). However, while the increased VOC due to congestion tend to be separately identified, these are not external costs but are borne by road users. Furthermore, they are different to the time costs of congestion because the latter are spread across all road users while the actual decision makers faces the VOCs. Hence, there is no so-called 'market-failure' involved in the increased VOCs due to congestion. Hence, there is a strong case for not implying that they are an external cost that requires addressing along with the time costs of congestion.

The cost of emissions is likely to be borne, in part, by other motorists. However, the extent to which this occurs will be determined by their use of the 'recycled air' button in preference to 'fresh (sic) air'.

B2 Base case

The reference point, or base case, is equally critical in determining congestion costs. The standard points of comparison are between the current situation and:

- free-flow, providing the basis for 'total congestion costs'
- another nominated speed, such as posted speed
- an efficient level of congestion.

Free-flow and total cost measure of congestion

The total cost of congestion is defined as 'the value of excess travel time and other resource costs incurred by the current traffic over those that would have been incurred if the current traffic volumes had been able to operate with unit costs characteristic of uncongested free flow conditions' (BTCE 1996a, p. 26).

The concept is also presented as cost of congestion relative to a situation where there is no congestion at all (BTRE 2006b, p. 7). The oft-quoted figures from the Texas Transportation Institute reflect estimates of the total cost of congestion.

One argument for the use of the total costs of congestion, apart from the costs of deriving them, is that they convey information about the magnitude of the problem 'in a clear way'. Further, it is argued that 'measuring the size of a problem is not identical to stating that this size should or could be zero' (Koopmans and Kroes 2004, p. 7). However, what is intended is not what is always achieved and the lay interpretation of the total cost of congestion estimates is often that the size should be zero.

Estimates of the total cost of congestion can be misleading in that they implicitly compare the current situation to a hypothetical free-flow situation. Such a situation would be untenable from an economic point of view—the cost of providing sufficient roads to ensure that free-flow prevailed would cripple the community coffers.

Since free-flow is clearly an unrealistic comparison, it is difficult to avoid the conclusion that the total cost of congestion is of limited direct policy relevance:

> Current traffic volumes could not actually operate on the existing road system under free flow conditions. The cost of congestion is, therefore, primarily a measure of the scale of the problem, useful in motivating the community and government to address the issues, but not a measure of savings to be made (BTCE 1996a, p. 26).

However, others do not make the concession that such estimates are 'useful in motivating the community'. As UK transport policy specialist Phil Goodwin concluded:

> … it is a mistaken concept and devalues the currency of debate about what can usefully be done in practice. Once such a figure enters into the policy consciousness, anybody who comes along with a smaller figure seems to be saying that congestion is not important, which is not the case (Goodwin 2004, p. 15).

The essential point is that congestion cost estimates that use free-flow as the yardstick may be of use in some areas, but they offer no policy guidance. As VCEC concluded:

> … defining congestion in terms of free flowing traffic … does not guide policy makers towards an appropriate policy response to address congestion. Expanding the road network to the point where all traffic moves at 'free-flow' speeds, for example, would incur costs far in excess of the benefits (VCEC 2006, pp. 23).

Other nominated speeds

Other nominated speeds may also be used as a reference point. While this will generally be an improvement on using free-flow as a comparison, it still means that the choice of nominated speed will have a major impact on the congestion cost figure calculated and can create perverse results.

The implication of this, pointed out by Morton and Mees (2005), is that the estimate of congestion costs can increase or decrease with the speed nominated as the reference case. Say, for instance, that the speed nominated as the reference case is the posted speed limit, then congestion costs are estimated by calculating the speed at which the traffic travels below the speed limit. If congestion resulted in an average speed of 40 km/h in a 60 km/h zone then the 'congestion costs' (based on travel time only) would be double the cost compared to the situation where the limit was 50 km/h for that same part of the network. This is despite the fact that actual congestion is the same under both scenarios.

London congestion charging scheme measure

The figure that has 'proved' the success of the widely-acclaimed London Congestion Charging Scheme is the 30 per cent reduction in congestion (TfL 2005b)—the upper end of the range of the expected reduction. However, this figure is also an artefact of the reference point or the base case selected when estimating the gains.

The definition adopted by TfL was 'the difference between the average network travel rate and the 'optimal travel time' which TfL defines as the uncongested (free-flow) network travel rate in minutes per vehicle-km' (TfL 2003, p. 46). The choice of 'free-flow' as the base case was explained by the difficulty in determining the optimal level of congestion.

The method of calculation was straightforward: the reduction in network travel time (minutes per kilometre) divided by the pre-charging level of congestion. The pre-charging level of congestion was calculated as the difference between the travel time per kilometre and the optimal travel time—designated by TfL as 1.9 minutes per kilometre (around 32 kilometres per hour).

The 'gain' in terms of the reduction in congestion depends critically on the base case chosen for the optimal travel time. There is no unambiguous optimal travel time. In other words, it appears that using the TfL formula for calculating the gains from the congestion charging scheme, the lower the 'optimal speed' (or the greater the 'optimal travel time'), the higher the computed gains from the charging system. If the designated optimal travel speed was 3 minutes per kilometre, rather than the designated 1.9, then the reduction in congestion would be almost 60 per cent, despite the fact that nothing material has changed either in the actual driving speeds before or after the congestion charge was introduced.[88]

This illustrates the critical impact of the choice of the reference point or base case when determining both the congestion costs and the attendant savings in congestion resulting from ameliorating policies. The 30 per cent figure has been touted around the world with few realising the relatively flimsy underpinnings.

Social cost of congestion

Calculations of the social cost of congestion for Australian capital cities were based on the following definition:

> … how much total costs (for time lost and other wasted resources) could be reduced if traffic volumes were reduced to the economically optimal level (BTRE 2007, p. 11).

The economically optimal level of congestion is that achieved if road users face the marginal social cost of travel rather than the marginal private cost—if the congestion externality is 'internalised'.

However, even the social cost of congestion does not present the upper bound of the potential savings from reducing congestion as it does not take account of the cost of implementing policies to reduce congestion, such as a congestion charging scheme. Where the cost of such a scheme is high (as with the current London scheme), the level of congestion in the absence of a scheme may be optimal. Still, the social cost of congestion will be 'a substantially closer guide to actual obtainable benefits than a total delay cost estimate' (BTRE 2007, p. 11).

From Figure B2 it can be seen that the social cost of congestion is around half that of the total cost estimate based on a comparison with free flow.

88. At 4.0 minutes per kilometre (which, at 14 kilometres per hour, would require an assumption of a very low value of time to be regarded as 'efficient') then the calculated percentage reduction in congestion achieved through the charging system would exceed 350 per cent.

The recent estimates of congestion cost in Australian cities compares the total costs of $11.1 billion based only on total annual delay (that is, excluding the cost elements for trip variability, VOCs and air pollution) with the cost of $5.6 billion for the 'preferable deadweight loss valuation' or social cost of delay in excess of the efficient level of delay (BTRE 2007, p. 15).

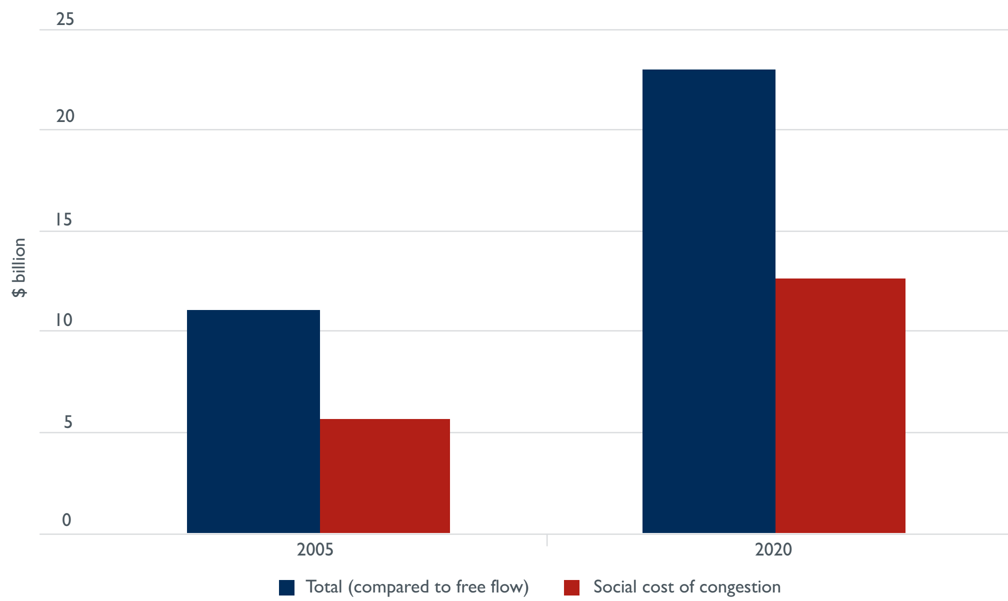
Other metrics

Net revenues that can be generated by a congestion charge

Some analysts promote the net revenues that can be generated by a congestion charge as a useful indicator of congestion costs. The figure reflects an amalgam of what road users are willing to pay and the cost of a congestion charging scheme. However, while an interesting figure from a fiscal perspective, using it as a measure of congestion costs would suggest that the higher the revenue and/or the lower the scheme costs, the higher the congestion costs. In fact, higher gross revenue could simply reflect the higher congestion charge or a low elasticity of demand for peak-hour travel, due to a lack of options for alternative departure times, routes or modes.

Figure B2 Annual congestion cost estimates for all Australian capital cities: total based on travel time vs. social cost

Source: (BTCE 1996a, p. 9).



Queue length

In the Netherlands, focus on the cost of congestion has been on estimating the total queue length throughout the year and multiplying this by the estimated average delay per kilometre queue and value of time to obtain an annual congestion cost estimate. While some modifications have been made to this system since its introduction in the late 1970s, it has remained essentially the same (Koopmans and Kroes 2004).

Koopmans and Kroes also distinguished between the observable costs of congestion—time lost in traffic queues—and the unobservable—changes in behaviour in response to congestion: 'motorists can change their time of travel, their travel route, the mode of transport, their destination, or they can decide not to make the trip at all. In the longer run, people can move house, firms can relocate, etc.' (Koopmans and Kroes 2004, p. 2). Koopmans and Kroes argue that as time delays on roads worsen, adaptive behaviour increases and, accordingly, the observed delays may seriously underestimate the true congestion costs.

However, whether or not the congestion costs fail to take account of the 'discouraged road users', depends critically on how those costs are measured. If a simple time delay measurement is used, comparing actual travel time to, say, travel time under posted speed limits, then the cost of the behavioural change by discouraged users would not be picked up. However, if an economic measure were used, the slope of the demand curve would reflect the propensity for behavioural change. The cost when calculated as a deadweight loss would be determined, in part, by this propensity.

Texas Transportation Institute's indicators

The Texas Transportation Institute (TTI) has been closely monitoring congestion costs in US urban areas for over 20 years. In their 2007 Urban Mobility Report (Schrank and Lomax 2007, p. 3), a range of congestion indicators was adopted, including a Travel Time Index—the ratio of travel time in the peak period to travel time at free-flow conditions (see Table B2 for the key indicators reported). The development of indices facilitates the monitoring of trends and simplifies the communication process. For instance, the report notes:

> Traffic congestion continues to worsen in American cities of all sizes, creating a $78 billion annual drain on the US economy in the form of 4.2 billion lost hours and 2.9 billion gallons of wasted fuel—that's 105 million weeks of vacation and 58 fully-loaded supertankers (Schrank and Lomax 2007, p. 1).

Measuring the impact of congestion in terms of weeks of vacation or the number of fully-laden tankers has obvious appeal. A disadvantage is that it implies that all the hours and fuel absorbed by congestion is a waste. It does not take account of the fact that zero congestion is not a sensible concept for an urban area. Nor is it clear that it is in the community interest for the index to remain static, particularly if that index loses its currency or relevance to changing circumstances. The development of many factors that make vehicle travel both more valuable and comfortable (mobile communications, in-vehicle entertainment systems and 'climate control') has meant that time in traffic is not necessarily 'dead time'.

The TTI has modified their methodology, adopting the new procedures to re-calculate all of the historical values such that the delay and fuel amount and cost

Table B2 Texas Transportation Institute Congestion Indicators

	1982	*1995*	*2004*	*2005*
Annual delay per peak traveller (hours)	14	31	37	38
Travel Time Index	1.09	1.19	1.25	1.26
Urban areas with 40+ hours of delay per peak traveller	1	11	28	28
Travel delay (billion hours)	0.8	2.5	4.0	4.2
'Wasted' fuel (billion gallons)	0.4	1.3	2.2	2.3
Congestion costs (billions of 2005 $)	14.5	45.4	73.1	78.2

Source: Schrank and Lomax (2007, Exhibit 1, p. 1).

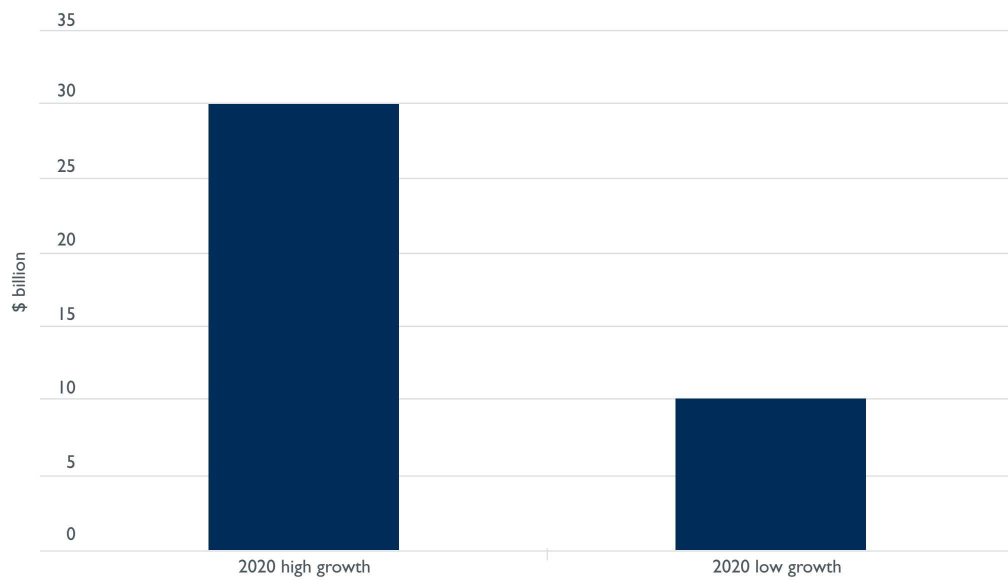
trend information is correct. This revision of methodology has led them to conclude that 'estimated speeds on the most congested freeways are better in the 2007 Report than in the 2005 Report' (Schrank and Lomax 2007, p. 2).

Impact of growth rate assumptions

Projections of future congestion costs depend on the underlying growth assumptions, as illustrated by Figure B3. The high growth reflects the highest likely economic and population growth over the projection period, 'coupled with minimal levels of future traffic peak spreading and significantly higher trip variability costs' (BTRE 2006b, p. 10).

In the past, economic growth and population growth have been the main factors behind the increase in vehicle kilometres travelled (VKT). The higher incomes that result from economic growth have translated into more travel per person. However, it would appear that, for Australian capital cities, 'saturation point' has been reached and the nexus with economic growth has been broken:

Figure B3 Impact of growth rate assumptions on congestion cost estimates: Australian capital cities 2020



Source: BTRE (2006b, p. 10).

> Eventually people are spending as much time on daily travel as they are willing to commit—and are loathe to spend any more of limited time budgets on even more travel, even if average income levels continue to increase. So growth in per capita personal travel is likely to be lower in the future than for the long term historical trend (BTRE 2006b, p. 50).

This conclusion is qualified by the observation that freight movement trends are not expected to follow this pattern but 'tonne kilometres performed per capita are still growing quite strongly ... there is no saturating tendency evident yet' (BTRE 2006b). However, since freight vehicles tend to involve a greater proportion of travel outside of the traditional peak periods (BTRE 2006b, p. 78), this growth will not have the same impact on congestion costs as would growth in passenger motor vehicles.

Impact of network capacity increase

Clearly, estimates of future congestion costs will be the outcome of the combination of traffic growth and the expected increase in network capacity. The most recent projections of future congestion in Australia concluded that:

> The [linear] growth rate means that the same absolute volume of traffic (in PCU terms) will be added to our capital city roads in the next 15 years as was added in the past 15 (BTRE 2006b, p. 45).

The widely-quoted figure for Australia of congestion costs of $30 billion by 2015 is qualified by the statement that 'these projections do not take account of any measures that might be taken to avert these kind of results, or of any major road developments since 1995' (BTCE 1999).

The figures in BTCE (1999) are derived from the congestion costs estimates in BTCE (1996a). By necessity, this publication used data sets on traffic flows between the late 1980s to those collected in 1993. Hence, the impact of major improvements made to the network as far back as 1992 (for instance, the Sydney Harbour Tunnel) could not to be incorporated in the estimates (BTCE 1996a, p. 2).

An allowance was made for network expansion of 5 per cent per annum. Whether the congestion cost estimates fully capture the impact of many of the recent improvements in the network is unlikely. Table B3 lists the major projects (mainly improvements in the radial network, ring roads and 'internal bypasses') in New South Wales and Victoria that would be expected to have eased urban traffic congestion since the original estimates were undertaken.[89]

These network improvements (introducing major new arteries and relieving critical pinch-points) have meant that some traffic demand growth has been accommodated in the major cities without a notable increase in travel times—in some cases a decline in travel times. However, this may not provide a comprehensive view of urban travel conditions.

Austroads (an association of Australian and New Zealand road transport and traffic authorities) compile a number of congestion indicators, including travel times in the capital cities: more technically, the 'weighted aggregate speed on a representative sample of arterial roads and freeways in major cities'. While as a congestion indicator this measure has limitations, the indicators suggest that travel times during the morning peak on key roads in most major capital cities have not increased significantly over the past five years—see Figure B4.

89. Although, there is some controversy about whether the Cross City Tunnel has led to a reduction or an increase in congestion

Table B3 Major Australian urban road developments since 1992

Year	*Project*
1992	Sydney Harbour Tunnel, M5 Motorway
1997	M2 Motorway (Sydney)
1998	M4 Motorway (Sydney)–upgrading
1999	Melbourne CityLink
2000	Eastern Distributor (M1) (Sydney)
2005	Cross City Tunnel (Sydney)
2006	M7 Motorway, Lane Cove Tunnel (Sydney)
2007	Tullamarine / Calder Freeway interchange (Melbourne)
2008	Mitcham–Frankston Motorway (Melbourne)

Note: While the most often quoted source for the $30 billion figure is a 1999 publication (BTCE 1999), the original source of the estimate is BTCE (1996a), which used data from the late 1980s to 1993. To quote: 'in the case of Sydney for example, it was not possible to capture the effects of the harbour tunnel' (BTCE 1999, p.2). Hence, it is reasonable to include 1992 improvements in the table.

Sources: Annual reports of NSW Roads and Traffic Authority, Victorian Department of Infrastructure and VicRoads.

For Sydney and Melbourne, travel speeds have declined slightly over the period, while Perth speeds are higher than at the beginning of the observation period, they have declined significantly in 2004–05 compared to the previous four years. Travel speeds have improved in Brisbane but exhibited a constant and gradual decline in Adelaide.

It could appear that the travel time indicators do not support the estimates of significantly increasing congestion. However, as discussed above, congestion cost estimates are driven, in part, by population growth. Hence, while time spent in traffic queues may not increase substantially, if there are more people spending the same amount of time, then total congestion costs will increase.

Furthermore, if the value of time increases (as wages and salaries increase) then the cost of congestion will also increase, *even if time spent in queues is unchanged*. This distinction between different measures of congestion is often not well understood.

Also, when observing total traffic rather than travel speeds, the growth is not necessarily 'inexorable'. As discussed above, per capita travel in Australia appears to have reached saturation point and hence one of the key drivers of congestion, rising incomes, may have less impact on future traffic growth.

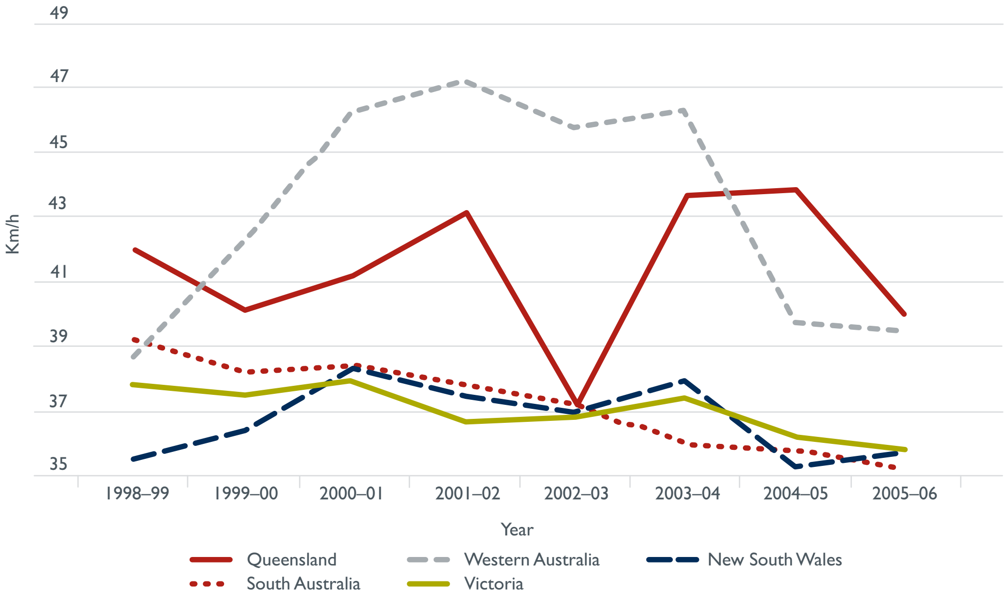
In Britain, a 'decoupling' of income growth and traffic growth occurred around 1992, as illustrated by Figure B5. Gross domestic product (GDP) has increased by 49 per cent while road traffic and overall travel have increased 23 per cent and 18 per cent respectively (DfT (UK) 2007, p. 13). While vehicle kilometres travelled (VKT) increased faster than GDP in the period 1986 to 1992, since then traffic intensity—the ratio of VKT to GDP—has fallen by approximately 18 per cent. As observed in the report:

> The challenge in achieving sustainable development is to ensure continuing economic growth while reducing adverse environmental and social impacts. Measures of traffic and travel intensity illustrate the extent to which economic growth and traffic growth have been decoupled. The comparison here is with gross domestic product (GDP), a measure of the size of the economy (DfT (UK) 2007, p. 9).

While travel speeds during peak periods are virtually unchanged on English urban roads from 2004 and only slightly below average speeds of 1999–2000, there is evidence of 'peak spreading'.

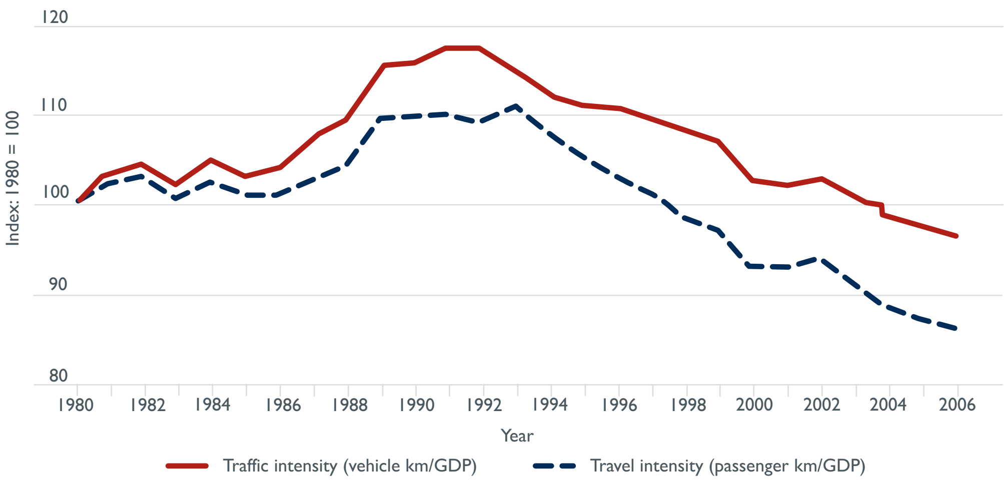
Traffic speeds at off-peak times have fallen over the last seven years. In 2006, the average off-peak traffic speed was 24.1 mph, a fall of 4 per cent from 2 and 8 per cent since 1999–2000 (DfT (UK) 2007, p. 13).

Figure B4 Morning peak actual travel speed in major Australian capital cities (1998–99 to 2004–05)



Source: Austroads (2006b).

Figure B5 Road traffic, passenger kilometres and GDP: 1980 to 2006, Great Britain



Source: DfT (UK) (2007, p. 9).

Appendix C Technology as a key determinant of viability

A prerequisite for a successful congestion charging scheme is appropriate technology: one that meets the system requirements at the right price.

Modern-day technology was foreshadowed almost half a century ago when distinguished economist, William Vickrey, proposed a system to the Joint Committee on Washington Metropolitan Problems involving an in-vehicle unit that would provide a unique signal identified by in-pavement equipment (Vickrey 1959). The data from this equipment would be transmitted to a central computer, enabling bills to be calculated and sent to vehicle owners. This technology is now established practice in many countries.

However, the most technically-advanced solution is not always appropriate. Britain's first congestion charging scheme, covering Durham's historic centre and widely regarded as a success, involves very rudimentary technology.

In contrast, the national road pricing scheme mooted for Britain is currently estimated to cost £62 billion to set up and £8 billion a year to administer. Based on the British Government's experience with large information technology (IT) contracts, the final figure could be many times this estimate. In addition, the cost of the in-vehicle equipment ranges from £15–£500, depending on the sophistication with around £100 for installation. Hence, conservatively assuming £200 for each of the 33 million vehicles registered in 2005, this would add another £6.6 billion.

Hence, an integral part of the decision to introduce congestion charging is choice of technology. As with most technology, there is a trade-off between cost and functionality. The many systems that operate today reflect a wide range of unit costs, capabilities and charging applications. As the price of the technology falls, more congestion charging schemes will become viable.

In Singapore, enhanced requirements and technological advancements accompanied by declining costs led to the migration from a paper-based system to electronic toll collection (ETC) in 1998. The choice of a relatively labour-intensive ANPR system for the London scheme reflected a desire to reduce uncertainty by avoiding 'frontier technology'. In the early years of the scheme, the cost of the system consumed more than 60 per cent of the revenues raised.

By one estimate, after allowing for depreciation and the appropriate cost of capital, the cost of the London scheme exceeded revenue raised (Prud'homme and Bocarejo 2005, Table 1). The equivalent figure for Singapore is around 20 per cent. The Netherlands has set their target for the operational costs of future road-user charging schemes as 5 per cent of revenue.

However, setup and operating costs are only part of the consideration when choosing the technology. Ukkusuri, Karoonsoontawong, Waller, and Kockelman (2003) listed the operational features of a system that need to be taken into account:

- site characteristics (line of sight for visual sensors, power sources)
- reliability
- communication medium
- bandwidth requirements
- administrative and billing needs
- automated enforcement issues
- security/privacy
- real-time communication requirements.

Hence, in developing a case for a congestion charging scheme, fundamental choices need to be made regarding the technology. For all but the smaller systems, such as used in Durham, the main choice is between a land-based or satellite-based system, although Germany opted for a combination of the two as with the German truck-toll system ('Maut').

C1 Land-based systems

Automatic number plate recognition systems (ANPR)

ANPR systems involve roadside cameras that 'read' number plates using optical character recognition software. The details are transmitted to a central site where the images are compared against a pre-registered database. Sophisticated systems are capable of capturing images of driver and front seat passenger, although this option tends to create serious privacy issues.

ANPR technology is relatively simple, consisting of a digital video camera system linked to computer system. In general, it is highly accurate, stable, fail-safe and fast. The London ANPR scheme uses 180 analogue cameras installed at the boundary of the charging zone plus some mobile cameras within the zone.

While images are captured electronically, ANPR is not an electronic scheme in that checking of number plates against a database of registered users is done manually. As observed by DfT (UK):

> ANPR technology involves significant processing overheads and corresponding back-office costs, because of the need for users to purchase a licence to access the charged zone each day, and because identifying vehicles using automatic number plate reader cameras involves significant human intervention to verify vehicle registration mark reads. Back-office costs account for two thirds of establishment costs and over half of running costs (DfT (UK) 2004, Annex J, para. J31).

The (then) UK Transport Minister, Stephen Ladyman, recognised that the adoption of the ANPR technology for London reflected the desire to ensure a deliverable within one mayoral term. While the system is relatively crude and expensive to operate, it was generally recognised as robust and reliable.

Technology trials commenced in August 2003, aimed at providing greater flexibility for paying the charge and/or for reducing operating costs. At the completion of Stage 2 of the trials it was concluded that 'DSRC is completely practical for a congestion charging scheme' (TfL 2006, p. 70).

In October 2007 it was announced that IBM will take over the operation of the London Congestion Charge from November 2009. Consideration is being given to tag and beacon technology.

Electronic vehicle identification (EVI)

Electronic vehicle identification (EVI) requires each vehicle to have a unique identifier, whether a device such as a tag or electronic number plates, or microdots applied to the vehicle at time of manufacture.

A major advantage of EVI over ANPR is the significant reduction in the degree of manual intervention. In addition, since EVI is a multipurpose technology, the cost can be spread across other uses and does not need to be fully recovered from the congestion charging scheme. Vehicle tracking using EVI serves multiple purposes: data collection, vehicle security, law enforcement, traffic and fleet management. With other applications for the underlying technology, prospects also improve for large-scale production and lower unit costs.

Figure C1 provides a schematic view of some the current uses for the EVI in road transport.

The dominant EVI technologies are DSRC and, within that, radio frequency identification (RFID).

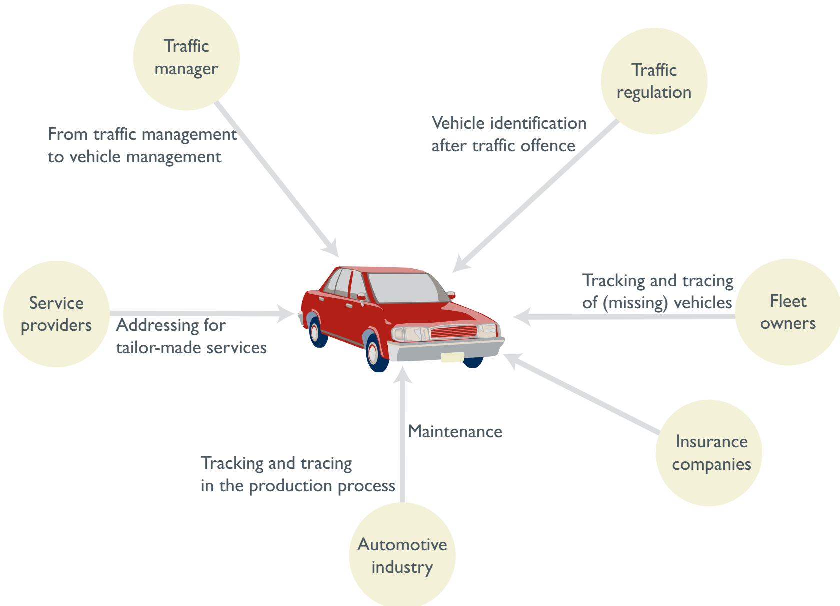
Radio frequency identification (RFID)

Radio frequency identification (RFID) tags are tiny microchips containing a unique serial number with scope for including other information. RFID technology works like a bar code but does not require contact or line of sight for communication and can (generally) be read through the human body, clothing and non-metallic materials. Most electronic toll collection systems use some form of RFID tags.

Tags are distinguished mainly by their read range and whether they are 'passive' (read-only) or 'active' (can take on new information). Read range depends on a number of factors, including presence of a battery, antenna size, radio wave frequency and the power output of the reader.

RFID tags are increasingly being installed in motor vehicles at the time of manufacture for purposes unrelated to road-user charges. One study estimated that around 40 per cent of new cars produced in North America contain RFID tags for security purposes, allowing automatic disabling of the vehicle unless its RFID reader detects the correct tag in the driver's ignition key (Wireless Insight Asia 2006).

Figure C1 Growing interest in vehicle identification from several road transport perspectives



Source: van Koningsbruggen and Oldenburger (undated, p. 2).

A major appeal of RFID is that there is a much wider market than transport, offering the promise of cost reductions due to economies of scale and the spreading of the cost of research and development across a much larger market than transport alone.

Figure C2 illustrates the potential uses for active RFID technology over the next ten years, with agriculture, libraries, manufacturing, financial and leisure sectors accounting for almost 40 per cent of demand. Passenger transport/automotive is roughly of the order of consumer goods/retail, military and correctional facilities.

Tags can become 'electronic number plates', if attached to the car in such a way that the tag is destroyed if attempts are made to remove it. Alternatively, they can be built into the actual number plates (e-plate) designed to shatter if an attempt is made to remove them, and even to transmit a warning of the attempt.

RFID number plates, or e-plates, have been commercially available since 2004. A British firm, Identec Solutions AG, is trialling e-plates with the aim of providing an encrypted and secured ID code that could be registered to a British Ministry of Transport database, preventing tampering, cloning and other forms of fraud that plague the current ANPR systems.

Box C1 RFID tag types

Passive (read-only) tags have information stored on them during the manufacturing process and can never be changed. They can be as small as 0.3 mm and can be read from a distance of about 6 metres. They do not require batteries but are ‘woken up’ when they receive a query from the RFID reader. The RFID tag responds by transmitting its unique ID code and other data back to the reader. Semi-passive RFID tags contain a small battery that boosts the range. WORM tags (write once read many) enable users to encode tags at the first instance of use, after which the code be comes locked and cannot be changed.

Active (read-write) tags include a battery, making them larger and more expensive but permitting them to be read from 100 metres or more.[a] Information on the tags can also be updated when the tag is within range of a reader. They operate as transponders because they contain a transmitter that is always ‘on’.

a. Although the read range is often quoted as 30 metres. Those with an extended range are classified as ‘enhanced’ RFID tags, such as those tags scheduled to be trialled by the UK Ministry of Defence towards the end of 2006.

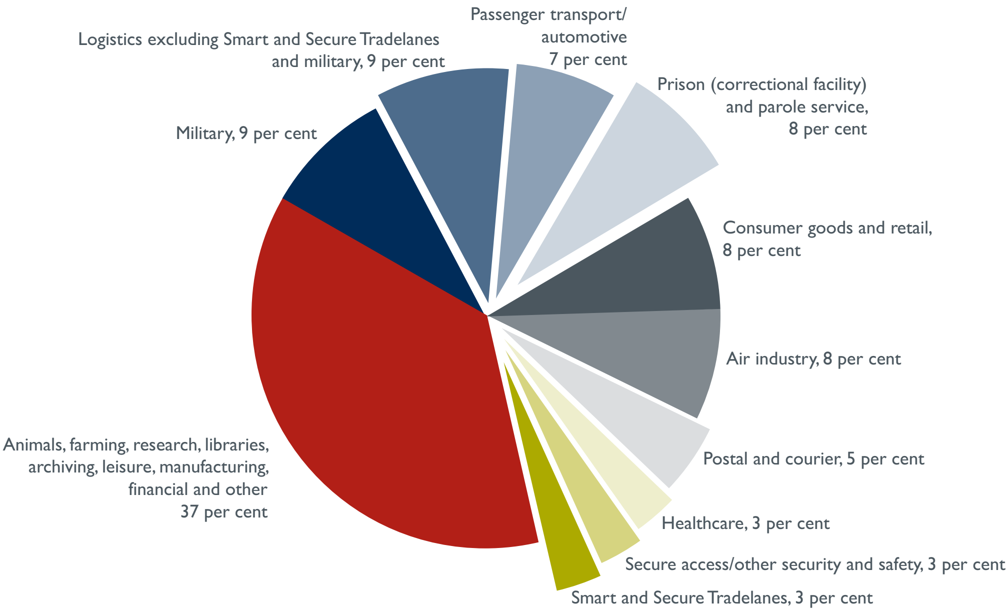
Source: Adapted from Collins (2004).

Dedicated Short Range Communication (DSRC)

Both DSRC and RFID involve a wireless technology based on tags and roadside readers. The terms tend to be used synonymously, although RFID is regarded by some as a subset of DSRC. There is also a view that DSRC is more suited than RFID for road-user charging in that it can operate on a ‘peer-to-peer’ basis, compared with the normal ‘master-slave’ relationship for RFID. Also, the transmission systems differ: DSRC delivers a far greater data rate (25 Megabits per second) and range (one kilometre) than RFID (250 kilobits and a 10 metre range) (RFID Journal undated).

Internationally, there appears to be strong interest in the use of DSRC for road user charges. DSRC is widely employed for electronic tolling in Japan, based on its ‘expandability, high reliability, wide communication area, and efficient use of limited frequency resources’ (Nakamura and Kodan 2003, p. 38).

Figure C2 Expected penetration of active RFID into different application sectors over the next ten years



Source: Adapted from Harrop and Das (2007, p. 2).

In 1999, the US Federal Communications Commission dedicated a large block of radio frequency spectrum to the 5.9 GHz band for DSRC applications. The US Department of Transportation's Federal Highway Administration (FHWA) provided US$1.3m for a DSRC prototype initiative, aimed mainly at safety applications but also with a view to replacing existing highway RFID applications such as automatic toll collection systems.

The Department for Transport (UK) is progressing towards establishing a 5.8 GHz DSRC standard as the basis for road-user charging systems in the United Kingdom. The aim is to facilitate inter-operability between electronic road-user charging systems in the UK, and potentially with systems in the rest of Europe.

The main issues facing the widespread application of RFID technology to road-user charging industry appear to be aligning standards to achieve interoperability and to accommodate privacy concerns.

Satellite navigation systems

To charge for road use, it is crucial that location can determined with a high degree of accuracy. Roadside beacons and overhead gantries work well for limited areas. However, charging for only a small part of the road system can have negative consequences as motorists divert to the unpriced roads.

Satellite navigation systems are the key element of any geographically-broad road-user charging system. The Global Positioning System (GPS) developed by the US military during the Cold War and now made available to all as a public good, has already become a core part of the everyday operations for many. Vehicle location in

Box C2 Transmission frequency

RFID tags use low, high, ultra-high and microwave frequencies. Each frequency has advantages and disadvantages that make them more suitable for some applications than for others.

Low frequency tags operate within the band 30 kHz to 300 kHz, but typically at 125 kHz or 134 kHz. Their read range is one metre and the rate of data transfer is slow, but they are less subject to interference than UHF tags.

UHF tags operate within the band 300 MHz to 3 GHz, but typically between 866 and 960 MHz. They can send information faster and farther than high and low frequency tags, but the radio waves don't pass through items with high water content, such as fruit, at these frequencies.

Microwave tags generally refer to RFID tags that operate at 5.8 GHz. They have very high transfer rates and a read range of 10 metres, but are expensive and use a lot of power.

event of theft, accident or driver's sudden illness is becoming commonplace as the cost of devices fall and an increasing number of vehicles are factory-fitted with the system.

While GPS is currently the only fully functional satellite navigation system, the European Union and the European Space Agency have collaborated to produce an alternative, independent system, Galileo, due to be fully functional in 2008.

There have been a number of hurdles regarding the use of GPS for road user charging. Technical issues involve the question of accuracy and 'urban canyons' where signal is poor. However, these appear to be resolved by the launch of an extra six GPS satellites, bringing the total to 30 and ensuring 'redundancy' in the system.

Pay-as-you-drive (PAYD) insurance, using satellite tracking systems, have been available from two insurance companies (Norwich Union and Progressive) for several years. The sophisticated heavy vehicle charging system introduced in Germany in January 2005 utilises the new Galileo satellite positioning system, supplemented by roadside beacons using DSRC. This system can be readily adapted to vary charges with levels of congestion.[90]

Trials using GPS tracking systems are currently being conducted in a number of countries. The European Union commissioned the European Space Agency (ESA) to evaluate the feasibility of using satellite technology to implement a pan-European road charging system. The research follows a European Commission proposal, published in April 2003, recommending that all vehicle owners should pay road tolls electronically by 2010.

The major obstacle to the use of GPS in the various national and pan-national congestion charging schemes, for which it is currently being considered, is the

90. As the system currently operates, trucks with a gross mass over 12 tonnes pay according to how far they drive along the motorways, with rates depending on the emissions classification. Under the scheme, lorries pay between 0.09 and 0.14 per kilometre depending on their emission levels and number of axles.

privacy issue. For many, the concept of a data centre that can determine location of any vehicle at any time of day is an anathema. The system mooted for the UK has attracted a great deal of opposition via an Internet campaign, reducing its momentum significantly. Genuine as this concern is, it is also relevant to mobile phones that can be readily tracked to determine location.

The most favourable scenario from the perspective of the road authorities would be the widespread adoption of GPS for reasons other than road-user charging. Once they become standard equipment in vehicles, as a tool that provides a wide range of services to the vehicle owner, the incremental cost of introducing road-user charges would fall significantly. Furthermore, if an 'opt-in' system were used, then the loss of privacy would be voluntary and regarded as the cost incurred for the benefits of the system. (Privacy issues were discussed in Section 4.4, page 96.) In brief, technology will be a major determinant in the adoption of congestion charging systems: from a cost, functionality and privacy perspective.

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Abbreviations

ANPR	automatic number plate recognition
CBCP	credit based congestion pricing
CBD	central business district
COAG	Council of Australian Governments
CfIT	Commission for Integrated Transport
DBOM	design, build, operate and maintain
DSRC	dedicated short range communication
ECMT	European Conference of Ministers for Transport
ERP	electronic road pricing
ETC	electronic toll collection
EU	European Union
EVI	electronic vehicle identification
FAIR	fast and intertwined regular
GDP	gross domestic product
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HOT	high-occupancy toll
HOV	high-occupancy vehicle
ITF	International Transport Forum
ITS	intelligent transport systems
IT	information technology
LCCRP	London Congestion Charging Research Programme
LEZ	low-emission zone
MTA	Metropolitan Transit Authority
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
PAYD	pay-as-you-drive
PCU	passenger car equivalent units
PPP	public-private partnership

PT	public transport
RFID	radio frequency identification
RTA	NSW Roads and Traffic Authority
SACTRA	Standing Advisory Committee for Trunk Road Assessment (UK)
TfL	Transport for London
UK	United Kingdom
US	United States
VKT	vehicle kilometres travelled
VOC	vehicle operating costs
WTP	willingness to pay