# Congestion Management for China's Transit Metropolis Cities

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This report combines three activities:

- Research on the international experiences on introducing congestion charging or other traffic reduction measures, including detailed summary of experiences in London, Stockholm and Singapore, and
- Overview of policy mechanisms related to traffic growth and congestion management (international experiences)
- Develop policy and technical framework for traffic growth and congestion management strategy in cities


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## Contents

# 1. Introduction

Chinese cities face the twin challenges of rapid increases in residential population, due to rural -> urban migration, alongside rising incomes and a strong growth in household car ownership. A combination of pressures not experienced in Western Europe, where major urbanization preceded motorisation by at least a century.

This is resulting in a rising share of urban trips being made by car, and a range of consequential negative impacts, including:

- Traffic congestion, poor air quality and high accident rates
- A poor quality, vehicle dominated street environment, with
- Negative consequences for public health and economic and social activity

All these negative consequences put pressure on city authorities to try and control traffic levels, through limiting vehicle – particularly private car – use.

Western European cities have faced very similar pressures arising from motorization, starting around 50 years ago, and have experimented with a wide range of measures to address these problems. As a consequence, rates of car use have peaked in many cities. These experiences are summarized in the remaining chapters of this report, with a particular focus on the role that can be played by traffic restraint and pricing measures.

But first, Chapters 2 and 3 take a broad perspective, placing traffic restraint in a wider policy context. Chapter 2 shows how five Western capital cities have been successful over time in reducing car use, despite growing incomes and population. It outlines a 'transport policy development cycle', which has typically played out over forty/fifty years - and suggests that Chinese cites could learn from this and short-circuit this development cycle to more quickly achieve reductions in levels of urban car use. Chapter 3 summarises the comprehensive range of transport/land use policy measures typically included – to varying degrees - in the comprehensive urban transport strategies implemented by cities that have succeeded in reducing car use.

Chapter 4 then briefly considers measures for limiting vehicle ownership, particularly car ownership, before the rest of the report focuses on influencing use rather than ownership of cars.

Chapters 5 and 6 consider strategies for managing urban road traffic, first (Chapter 5) looking at the full range of options and then focusing more specifically on parking and moving vehicle restraint measures (in Chapter 6).

The remaining four chapters look at different forms of road user charging, with a particular emphasis on congestion charging. Chapter 7 considers different types and uses of urban vehicle use charging, and Chapter 8 provides examples of both successful congestion charging schemes and those which failed to be introduced. Chapter 9 draws out the lessons learnt and Chapter 10 considers how these might be applied to Hangzhou and similar Chinese cities.

## 2. Congestion management – a long-term perspective

### 2.1 An urban transport policy development cycle

The problems currently being experienced by China's larger cities are not unique, but have been faced by many cities in Europe which have experienced rural->urban (and inter-country) migration and rapid increases in car ownership and use triggered by economic development. This affords China the opportunity to learn from others' experiences and speed up the transition of its cities to being supported by more sustainable urban transport systems – collapsing what has typically been a 40-50 year transport policy evolution into a much shorter period of time, and avoiding what in some cities is now regarded as 'wasted' investments in major road infrastructure.

This evolutionary urban transport policy development process is characterised by successively different views about the attention which should be paid to supporting car ownership and car use, and the emphasis placed on encouraging sustainable transport modes (i.e. due to different prevailing political priorities and transport policy paradigms). This, in turn, leads to the promotion of different policy objectives and measures at different points in time, contributing substantially to differences in urban travel behaviour. This historical, evolutionary process can be observed in many leading Western European cities, but may also be found in some cities in other parts of the world (e.g. Seoul).

To date, we can identify three sequential stages (Jones, 2013), moving towards ever more comprehensive, multi-modal policy packages, as summarised in Figure 2.1.

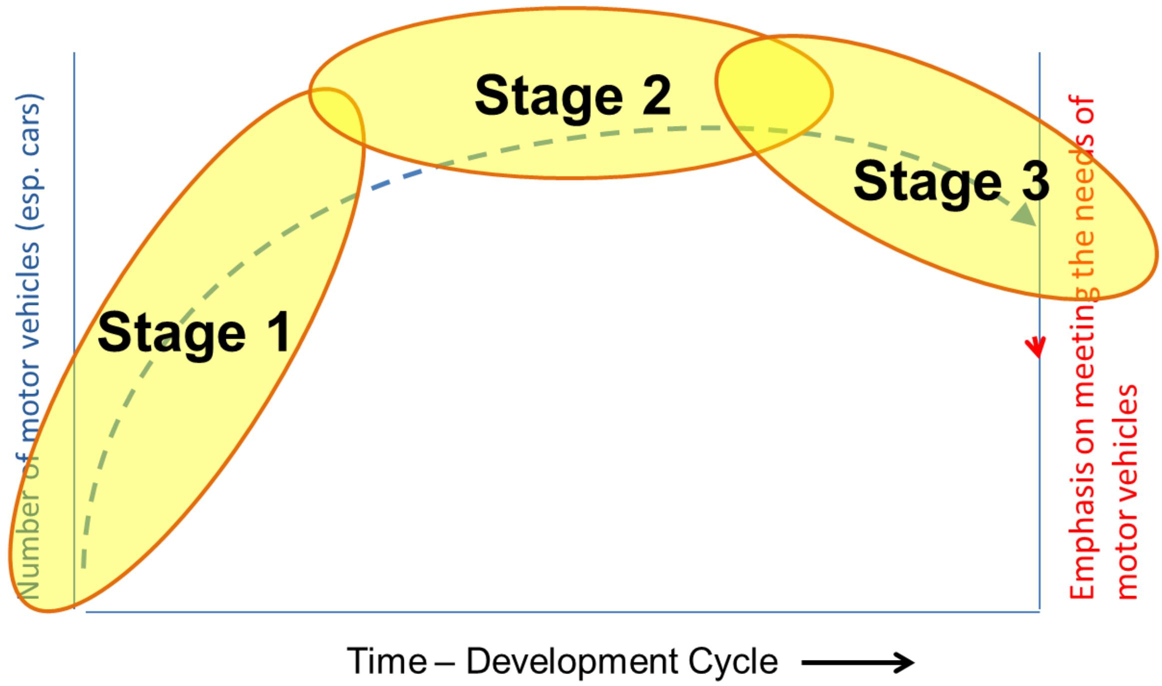
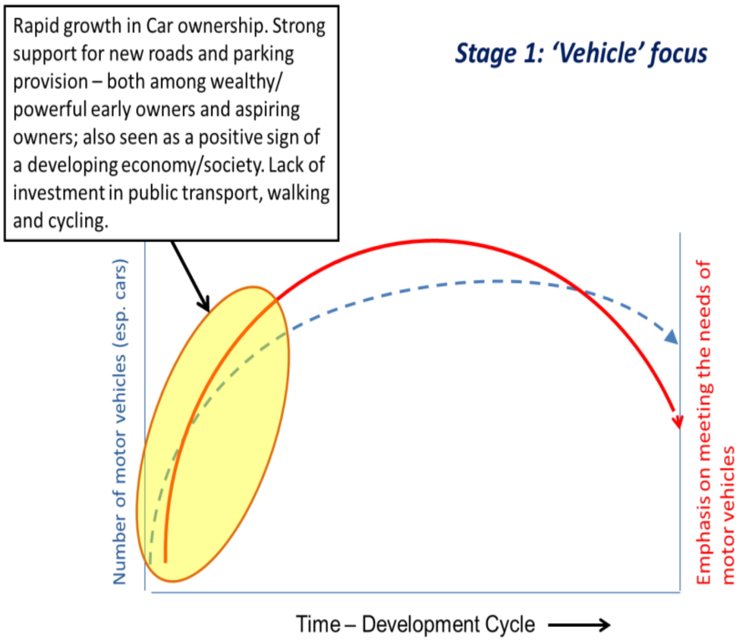



Figure 2.1: Stages of the Urban Transport Policy Development Cycle

Each stage is discussed in more detail below.

**In Stage 1**, car ownership is low but growing rapidly in the city and the policy focus is on **catering for vehicle growth**. This involves:




- Focusing investment on new high capacity urban roads and motorways, and on providing substantial amounts of parking space, both on and off street.
- Re-allocating road space away from buses, trams (where they exist) and the 'slow modes' (cycling and walking), which at this time are associated with poverty and lack of economic development, to focus on the needs of motor vehicles, particularly cars.
- Associated 'de-investment' or lack of investment, in public transport modes, walking and cycling; and taking away space from traditional street economic activities in favour of carriageway widening and on-street parking provision.
- Use of cycling and walking also declines, due to safety concerns and deteriorating network conditions, as motor traffic increasingly dominates urban roads. This also affects 'last mile' access to existing bus and rail services.
- Taken together, these various policies usually have the consequence that public transport becomes unprofitable and requires large subsidies to continue operating, due to deteriorating operating conditions and declines in patronage. Action from government can take the form of providing a substantial investment stream for public transport subsidy (e.g. using some of the national Road Trust Fund income in the USA in the 1960s; or cross subsidising urban public transport from profits made from other municipal services, such as electricity companies in Germany), or by deregulating, privatising and commercialising bus services (as in the UK in the 1980s).

While this early growth in car ownership predominantly benefits the rich and powerful members of society, the policy emphasis on investing in new roads and parking facilities, while rejecting modes associated with pre-industrial development (particularly walking and cycling, and old on-street tram systems), generally has widespread public support as it is seen as a positive sign of city development and 'modernisation'. It also reflects the aspirations of many citizens that, one day they too will be able to own and travel around the city by car.

However, in time, as car ownership and use continues to grow, attitudes to providing for unlimited car use begin to change, for two reasons:

1. It becomes evident that it is not physically, financially, socially or environmentally possible to provide for unlimited car use: there is insufficient space to keep constructing new roads and car parks, without unacceptable

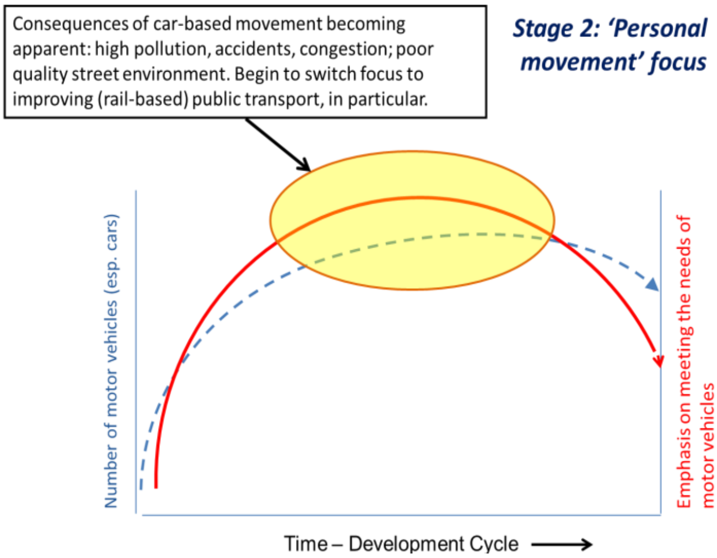
levels of housing demolition and community disruption, and traffic congestion continues to deteriorate despite substantial car-oriented investments.

2. The external costs of high levels of car use become increasingly apparent. In particular:

   - Air pollution deteriorates and becomes a threat to public health;
   - Noise levels also rise and can cause public health concerns;
   - Traffic accidents increase;
   - $CO_2$ levels increase rapidly, and
   - The physical appearance of the city becomes less and less attractive, due to car dominance in historical areas and the visual impact of elevated motorways.

This encourages a new policy emphasis – as is currently to be found in many of the larger Chinese cities, such as Beijing and Shanghai.

In **Stage 2** thinking shifts and the primary emphasis changes from further accommodating flows of motor vehicles to providing for the **movement of people** in cities. This typically has several policy components:

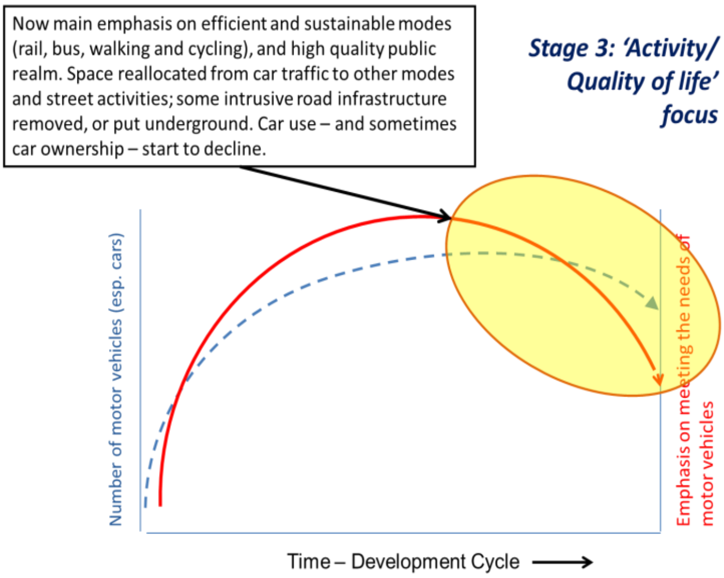



- Much greater investment in public transport services, through the upgrading and construction of new metro, light rail and suburban railway lines, and/or the construction of BRT (Bus Rapid Transit) networks.
- Restrictions on on-street parking, to provide space for bus lanes and to generally reduce traffic levels and congestion, combined with some off-street parking controls to limit the number of car trips attracted to congested areas of the city (in conjunction with improved rail access).
- Use of highway design and traffic management measures to reduce traffic accidents, for example through speed control measures in residential areas and improved pedestrian crossing facilities.
- Restrictions on car access to certain areas of the city during the day, particularly to reduce air pollution and local traffic congestion; either through regulation or pricing; and
- Working with major employers and other trip attractors, to encourage peak spreading of trips and to help in promoting non-car modes of transport.

This stage usually signifies the end of major road construction projects in the city that are designed to provide major increases in vehicle traffic capacity, although targeted road construction may continue, to eliminate a bottleneck or provide access to a new development area.

Not all cities have moved from Stage 1 to Stage 2 (for example, the highly car based, low density cities such as Houston in the USA), but most do. Some have now progressed on to Stage 3, starting with some East Coast cities in the USA and European cities like Vienna in in the early 1990s, and cities such as London in the early 2000s.

**Stage 3** results in a switch in emphasis from movement to activity, and from **mobility to accessibility**. This is associated with:




- A greater emphasis on the improved physical appearance of cities and on urban quality of life
- Removing some of the more obtrusive urban highway schemes (e.g. in Seoul), or placing them underground (e.g. Boston), both in order to improve the environment and to encourage new housing and economic development
- Active encouragement of cycling and walking, through improved facilities, partly to meet transport objectives (e.g. improved air quality), but also to meet other policy objectives (e.g. physical activity to reduce obesity)
- Encouraging policies which 'reduce the need to travel', ranging from providing high density, mixed use developments, to encouraging use of the internet for banking, shopping and working.
- 'Reclaiming of road space' away from general traffic to support more sustainable transport modes and the reestablishment of street economic and social activities.
- Consideration of the 'whole journey' experience, both in terms of looking at providing for movement, door-to-door, and taking greater account of attitudes and subjective journey experiences. This includes considering the provision of suitable interchange facilities (e.g. cycle parking at stations), and planning for easy access to public transport stops/stations on foot and by cycle.

While Stage 1 and Stage 2 seems to represent a policy evolution which can be seen in most large cities, irrespective of administrative structures, Stage 3 appears to be associated with cities with strong devolved powers from central government and with very strong city majors who have popular support among their citizens – as well as cities which have witnessed the failure of Stage 1 and then Stage 2 to meet their evolving aspirations.

In particular, there is growing recognition of the importance of a good quality of life and a high quality urban realm in promoting cities in which people want to live, work and trade, further reducing the desirability of catering for car-dominated movement in cities. In Central London, for example, over the last decade major businesses have been willing to tolerate some increases in traffic congestion in exchange for a high quality street environment with less traffic dominance, as this is seen to attract high calibre employees and international business clients. It is understood, for example, that Google's decision to base its European headquarters in Central London was strongly influenced by the high quality public transport accessibility, improving provision for cycling and a very high quality development (both buildings and public space) in close proximity to leading educational and arts facilities.

This switch to Stage 3 has, for example, been supported by strong mayors in New York, Seoul, Taipei, London and many other European cities. Ultimately, it depends on city vision and on attitudes and priorities. It is a brave and visionary mayor who is prepared to remove major urban road capacity – in the face of strong beliefs that this will 'bring traffic to a halt' in the city – but evidence shows that doing so can unlock city development and enhance quality of life, providing that adequate public transport movement capacity is in place (see Figure 2.2). Stage 3 is also often associated with the development of high end residential development, with wealthier people returning to the central and inner city areas.

Figure 2.2: Cheonggyecheon Seoul: Before and after removal of the elevated expressway

**Assessment**

This is a highly simplified representation of what has been a complex process of urban transport policy evolution, which has varied in detail between cities. In particular, these transitions from one stage to the next are commonly associated with a change in urban economic structure (i.e. from manufacturing to services), a growing articulate middle class and an increase in educational levels among the population – plus a general public and political recognition that unlimited car use is not a practical or desirable proposition in that city.

It also seems to be strongly influenced by transport network conditions and corresponding land use patterns and policies, which influence the potential for change. For example, a switch in policy emphasis from providing for growth in car travel (Stage 1) to encouraging rail (and bus) travel (Stage 2), can best be achieved in practice in a situation where:

- Traffic speeds on the road network have fallen to a level where public transport can offer comparable door-to-door journey times for many trips, and
- Land use densities and patterns are such that there is a sufficient potential market for high quality/speed public transport to make it a viable proposition.

This leads to the proposition that some cities may not be able to make the transition from Stage 1 to Stage 2, because the construction of an extensive high-speed highway network, and an accompanying low density and decentralised land use pattern, make it impractical to provide an attractive public transport-based alternative. A number of younger American cities have faced this problem, and some Chinese cities may also do so, unless there is better coordination of land use developments and high capacity public transport corridors.

With regard to the introduction of Stage 3 policies, we can often observe ‘early adopters’ in some smaller historical urban areas, which have long valued and protected their architectural and cultural heritage, relying heavily on the tourist industry. In the UK, for example, the earliest traffic restrictions and pedestrianisation schemes were introduced in historical towns, as were the early bus-based ‘Park-and-Ride’ schemes, and the first congestion charging scheme (in Durham). Indeed, some of these towns never really embraced Stage 1 policies, having narrow historical streets and little appetite for widening or for replacing buildings with large car parks.

Very occasionally, there are examples of Stage 3 policies being introduced by cities (or small states) which are transitioning from Stage 1 to Stage 2. The clearest example was the introduction of the congestion charging ‘Area License Scheme’ in Singapore in 1975. It seems that the political arrangements in Singapore enabled them to introduce a car restriction policy **in anticipation** of a growing problem rather than subsequent to the demonstration of that problem (i.e. that public transport improvements alone would not reduce car use in the central area sufficiently to reduced congestion and air pollution to an acceptable level, and improve the quality of the urban environment). A similar scheme was proposed for central London at around the same time – indeed, the Singapore scheme was modelled on the London proposal – but it was not possible to gather sufficient public or political support to introduce the scheme at that time. Londoners had to go through the ‘Stage 2 ‘learning before being willing to accept congestion charging.

Finally, we recognise that different parts of the same urban region (i.e. central city, inner city, outer suburbs, peri-urban areas) may be at different stages of the transport policy development process at the same time – typically with Stage 1 ‘pro-car’ attitudes and policies in some of the peri-urban areas and, at the same time, Stage 3 ‘liveable city’ policies in inner and central city areas. In addition, changes in political administration can speed up, slow down – or, at times reverse – this process.

## 2.2 Impacts on urban travel patterns and modal shares

Some European cities have shown that it is possible to decouple car traffic growth from economic growth, while enjoying a high quality of life; and have found that long-term congestion reduction in cities is best achieved by reducing levels of car use and encouraging sustainable modes of transport, while using road space more efficiently and improving the public realm.

Figure 2.3 is derived from household travel survey data supplied by five ‘Stage 3’ European capital cities, and shows changes in car modal share over time in each city. The data points represent years in which comprehensive travel diary surveys of residents of each city were carried out. What can be clearly seen in each case is an historical pattern of growing car driver modal share, followed by a levelling off and a subsequent decline.

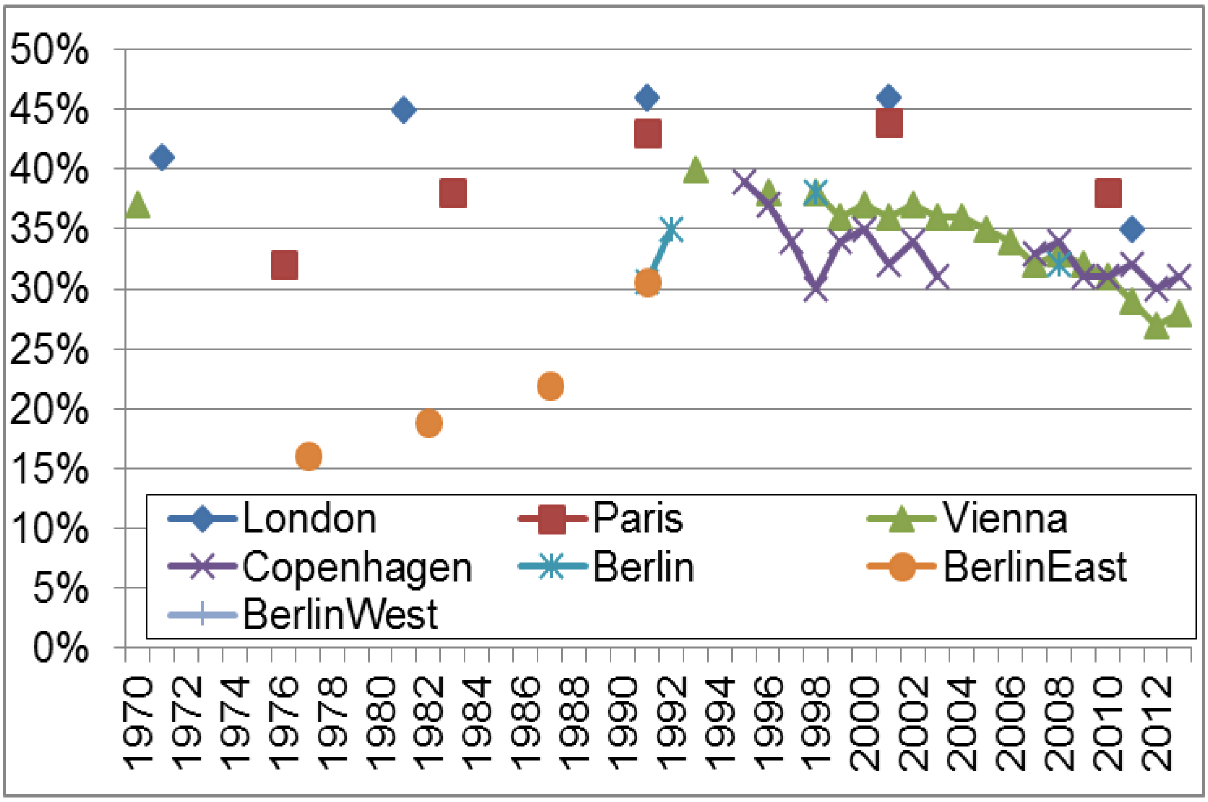



Figure 2.3: Changing modal shares of car driver trips in five 'Stage 3' cities over time

In the case of Greater London, for example, car driver modal share was 41% in 1971, rose to 45% in 1981 and 46% in 1991 and remained at that level in 2001; but between then and 2011 it dropped sharply to 35%. In Vienna, the corresponding figure in 1970 was 37%, increasing to a peak of 40% in 1993 and dropping back sharply to 28% in 2013. Overall, inflection points vary between the early 1990s and the early 2000s. Berlin provides an interesting case study, since it was divided into two parts for many decades, during which time West Berlin had Stage 3 characteristics and East Berlin Stage 1 characteristics, at the same time. However, since reunification, following a short period of net growth, car modal shares have been in decline.

All these travel behaviour figures cover the whole administrative area of each city, which vary in size and character: in the case of Paris-Isle de France, for example, it includes a much larger peri-urban area than in the other cases. So the results are indicative, rather than being strictly comparable.

In practice, we can see very large differences in car driver modal shares between cities around the world – as illustrated in Figure 2.4.

In some cases, the low car driver modal share reflects low levels of car ownership due to low average incomes and limited opportunities for driving.  But in other cases (e.g. Stockholm and Tokyo) this reflects the outcomes of transport and land use policies – and, to some extent, local geographical factors – which have encouraged low levels of car use. Notable is the contrast between car modal shares in Beijing (a lower density city with very high levels of radial and orbital motorway provision), and Shanghai, which has not developed in the same way.

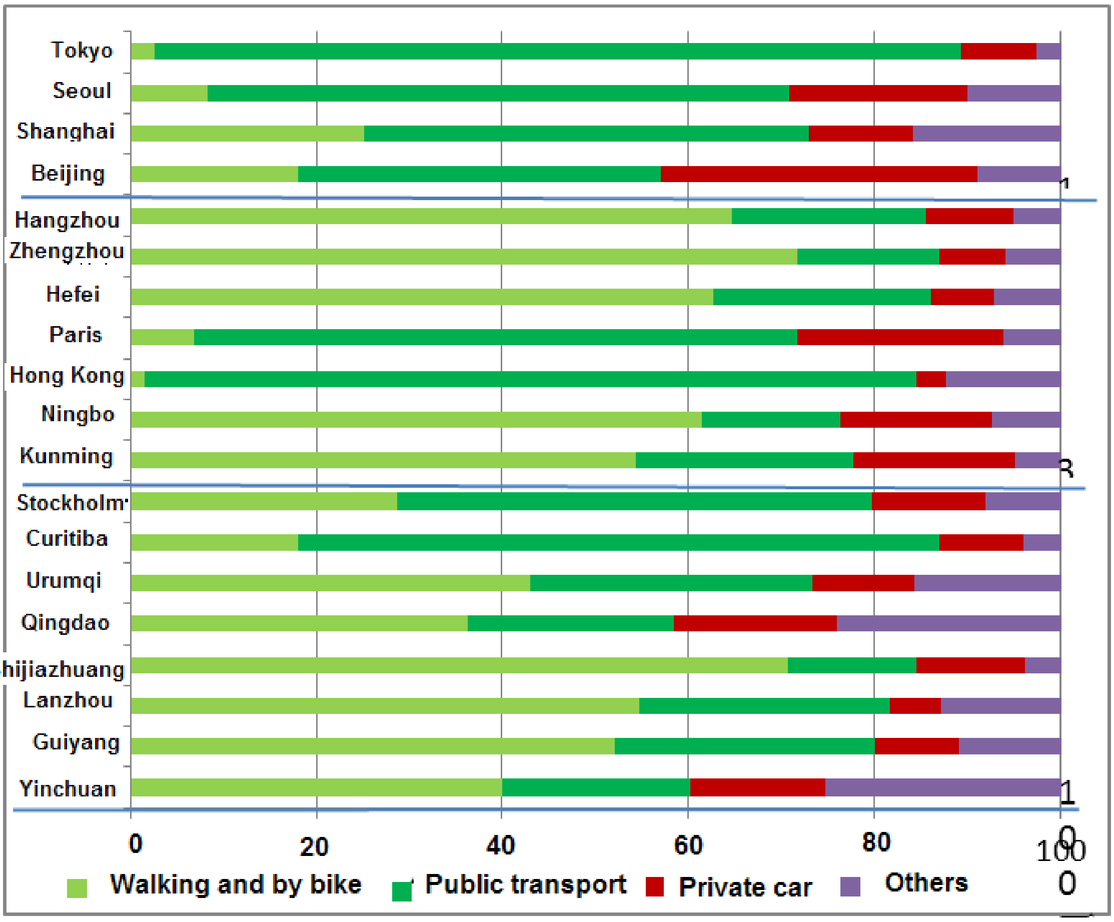
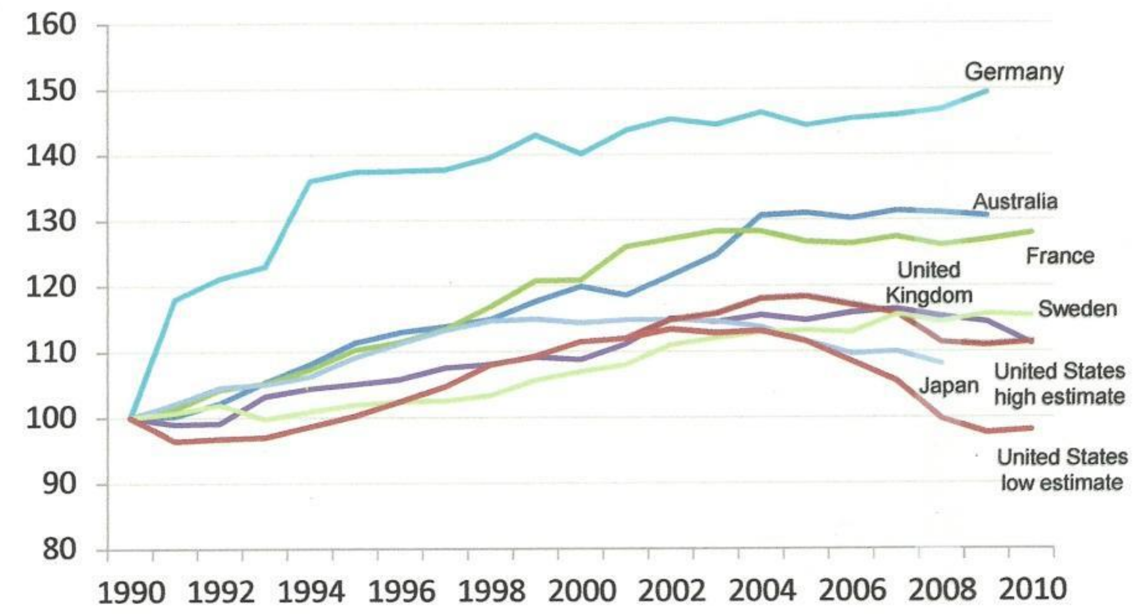



Figure 2.4: Comparison of share rate of walking, bike, public transport and private car in cities of China and other countries

## 2.3 National trends: the 'peak car' effect

There is growing evidence that many of the more economically advanced countries are experiencing what has become to be known as the 'peak car' effect. This does not go as far as resulting in the extent of reductions in urban car use shown in Figure 2.3, but the evidence suggests that the decades of growth in personal car use has come to a halt, and that average car mileage per person has levelled off, and in some cases is showing signs of decline – well before the global economic recession which started in 2008.

Figure 2.5 shows trends in national passenger kms by car (and light van) in six countries, indexed to 1990; note that some growth may be due to an increase in the population of drivers, rather than increasing usage per person. In Germany total passenger kms is rising slowly; in Australia, France, Sweden and the United Kingdom, growth has levelled off; while in the United States and Japan there has been an actual decline in total vehicle kilometres.




*Source:* International Transport Forum statistics.

Figure 2.5: Passenger kilometres by private car and light trucks 1990-2009 in six economically advanced countries (Index 1990=100)

Source: International Transport Form Statistics

The reasons for this decline are not well understood. Work in Great Britain, for example (LeVine and Jones, 2012), found that the observed effect was the net result of several contrasting trends: less driving by men, more by women, less by younger people, more by older people, and less in larger urban areas and more in rural areas. But one trend which seems to be common to most of these countries is a reduction in car ownership and use among men in the twenties.

This chapter has placed the current problems facing Chinese cities in an international and longer term context. It has shown that levels of car use can be contained – and reduced – over time, despite increasing wealth, given changes in transport policy priorities and the implementation of comprehensive transport/land use policy packages. The next chapter outlines the kinds of measures that are typically being implemented by 'Stage 3' cities and the role which traffic restraint – and pricing for road use – plays within the broader policy framework.

# 3. Traffic restraint and charging in the context of a comprehensive transport/land use policy package

'Stage 3' cites have all introduced, over a period of time, a comprehensive package of transport and land use measures to address a wide range of traffic-related urban problems. Although policy priorities vary from city to city, objectives typically include reducing:

- Traffic accidents
- Traffic congestion
- $CO_2$ levels from motorized traffic
- Air pollution

Broad strategies for tackling these issues are shown in Figure 3.1.

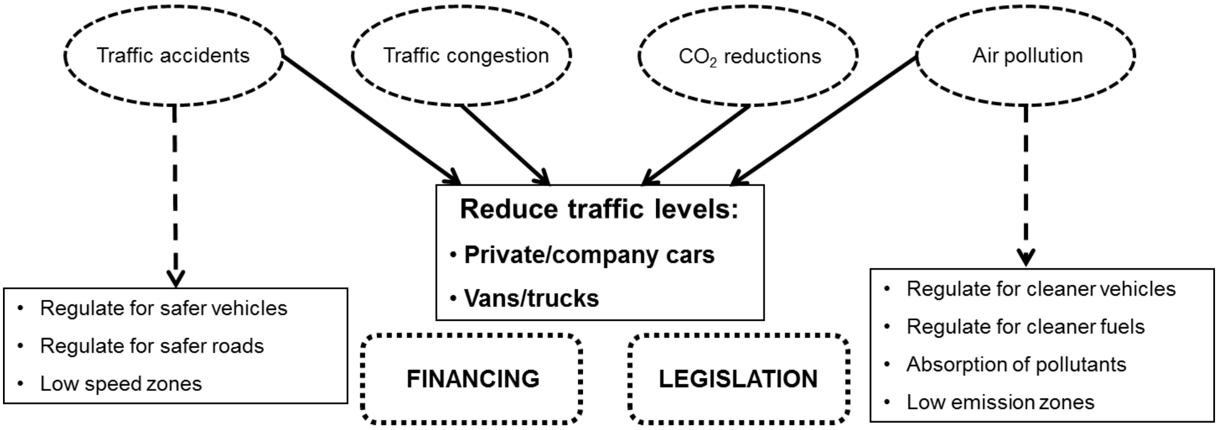



Figure 3.1: Policy objectives and high-level strategies

In the case of traffic accidents and air pollution, in particular, there is much that can be achieved through national or international regulation, to make new motor vehicles safer and cleaner, and at the local level, through the introduction of lower speed limits, low emissions zones, etc.

But all four policy concerns can be assisted by reducing traffic levels – both for private and company cars, and for vans and trucks. And most of the policy measures used to encourage reductions in motorised traffic require finance (e.g. to construct major rail systems, or subsidise bus fares) and/or legislation (e.g. to allow cities to charge for the use of existing road space.

Figure 3.2 expands on the previous figure to show in more detail the various policy measures which can contribute to reducing traffic levels (by influencing behavioural mechanisms explored in more detail in Chapter 5). Broadly speaking, there are five kinds of policy measures:

- Introducing restraints on road traffic
- Improving the provision and quality of alternative modes to car travel
- Adopting land use policies which encourage shorter journeys and the use of sustainable modes of transport

- Encouraging use of internet services, to reduce the need for physical journeys, and
- Using information/awareness and marketing to encourage behaviour change

Some policies can help to support other kinds of policies. For example, restraining road traffic enables some carriageway space to be reallocated from car traffic to sustainable transport modes (e.g. by introducing bus or cycle lanes); and land use policies can support greater use of public transport, walking and cycling.

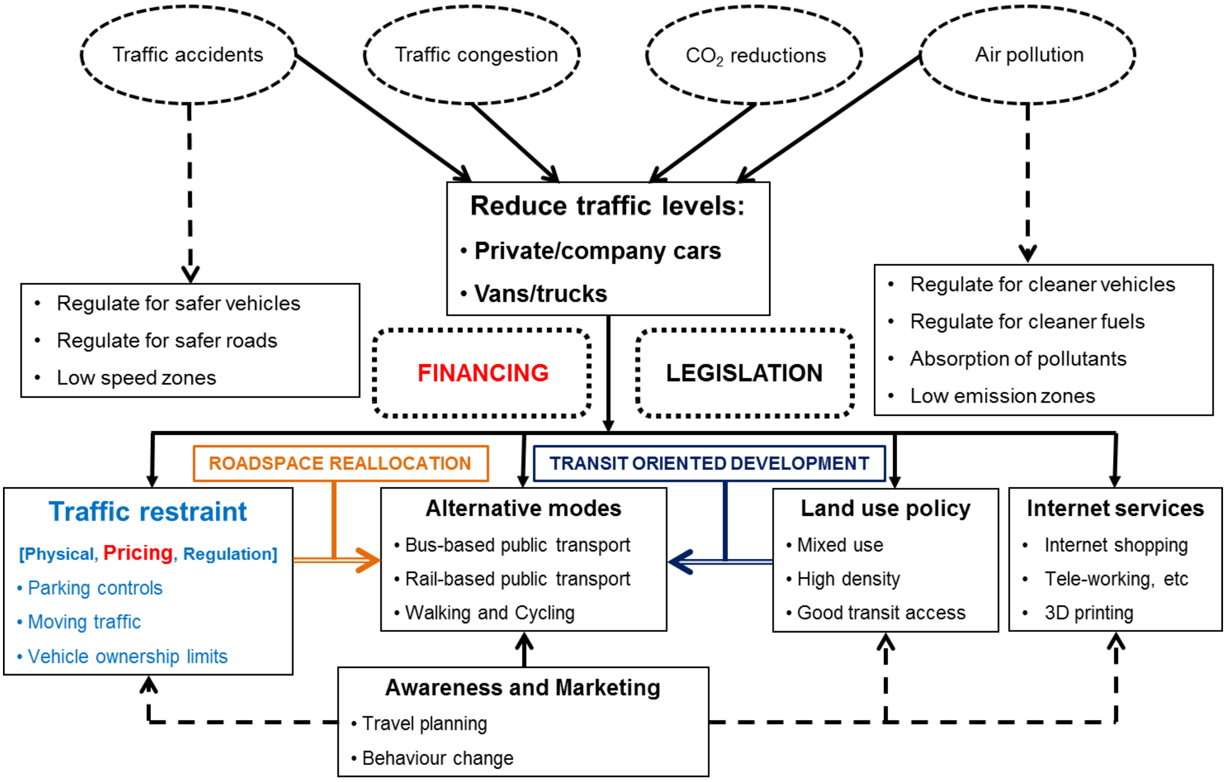



Figure 3.2: Range of policy measures to help achieve transport policy objectives

The remainder of this report focuses mostly on the 'Traffic Restraint' box in Figure 3.2. Chapter 4 briefly looks at policies to limit vehicle ownership, and then Chapter 5 looks broadly at options for reducing traffic congestion. Chapter 6 considers in more detail the full range of traffic restraint options, and Chapter 7 summarises different charging mechanisms and objectives.

Chapters 8 to 10 focus specifically on congestion charging schemes, summarises the lessons that have been learnt and considers their applicability to Hangzhou and similar Chinese cities.

# 4. Limiting Vehicle Ownership

This report focuses primarily on ways of directly influencing vehicle use, but one very effective way of doing this which should also be considered is to limit vehicle ownership, particularly of private cars. Most countries have been reluctant to directly limit private car ownership, partly because this is an unpopular policy with the public and also because it conflicts with high-level economic policies to promote the domestic car industry, but some have tried to influence levels and patterns of ownership.

## 4.1 National schemes

Vehicle purchase taxes have been introduced nationally in many countries, although the primary reason for doing so varies. It may be purely a revenue source, a means of restraining overall car ownership levels, or a means of influencing the type of car which is purchased. Some European countries have substantial purchase taxes to restrain car ownership, in particular Norway and Denmark, where the purchase tax can be 100% of the selling price of the car.

Some countries relate car ownership taxation directly to vehicle $CO_2$ emissions, and so encourage the purchase of more fuel efficient vehicles. In the UK, for example, the annual Vehicle Excise Duty is directly related to $CO_2$ emissions – with zero charges for low emissions vehicles.

In addition, a few countries have directly applied car ownership controls; for example, in Bermuda households are limited to one car, and there are no hire cars on the island, so non-residents have to use buses or taxis, or walk or cycle.

In several countries, car ownership levels have been boosted through the ability of many employees to take advantage of a 'company car' provided by their employer. This is provided, on loan, to the employee both for business and personal use (including commuting to/from work) and, at least in Great Britain, often involves provision of free fuel for private use.

Although company cars may only comprise a small percentage of the total car fleet (around 7% of cars owned in GB in the mid-90s), mileage per vehicle is much higher (around 3-times higher in GB in the mid-90s), so that it may significantly contribute to road traffic levels, particularly at peak times.

Figure 4.1 shows the effectiveness of applying a pricing policy to reduce the levels of company car ownership in Great Britain over a 20 year period. While those employees claiming a company car without free fuel dropped by around 20% (from c.900,000 to 700,000 employees), there was a much larger drop in those claiming free fuel, of around 80% (from 1,000,000 to 200,000 employees). This latter effect resulted from a gradual increase in the notional value of the free fuel, for taxation purposes. In the late 1980s this was uncharged, but by 2011 this has risen to the equivalent of US$10,000 per year (i.e. this sum was added on to the employees' declared salary to calculate total personal tax due). The effect was to reduce national company car mileage by around 40% between the mid-1990s and mid-2000s (before the global financial crisis of 2007/8).

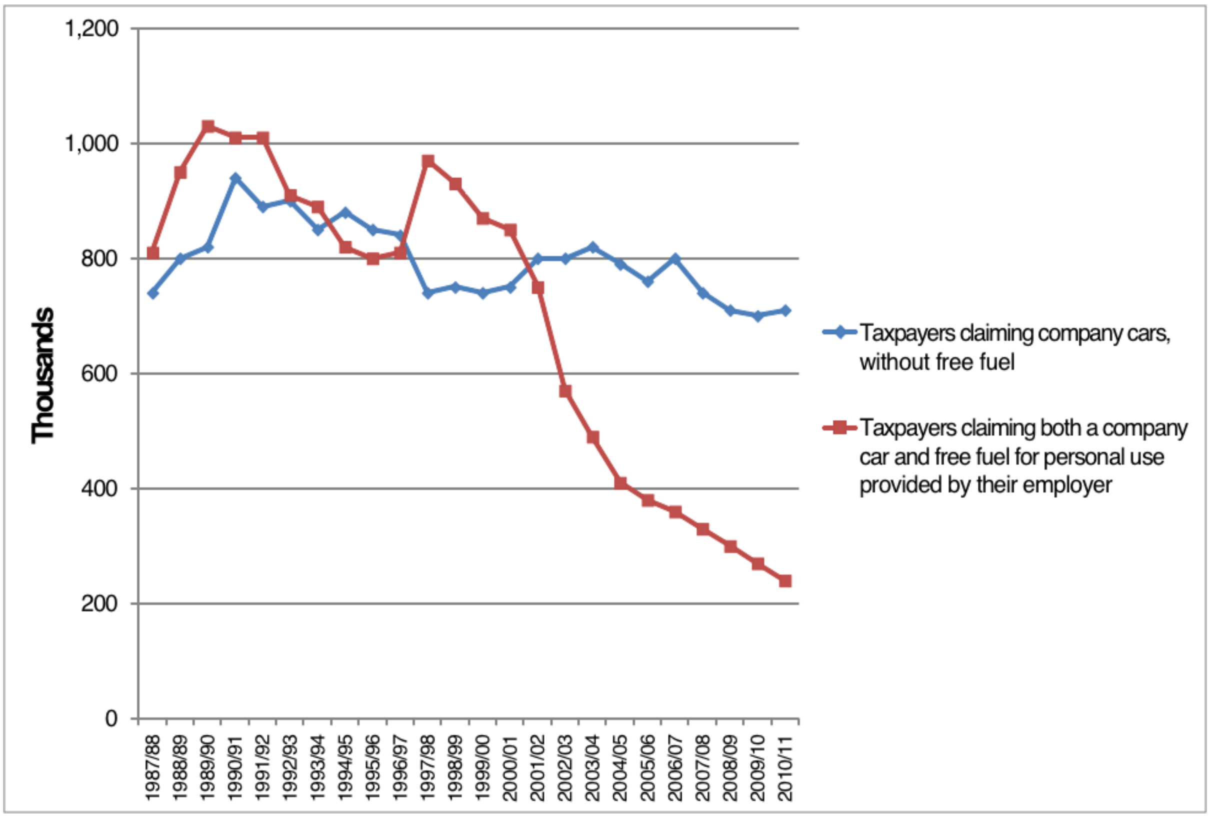



Figure 4.1: Number of company cars declared on annual tax returns in the UK (with/without free fuel), over time
Source: LeVine and Jones (2012, Figure 5.3)

## 4.2 Local schemes

City controls on car ownership levels can be achieved through the introduction of Vehicle Quota Systems (VQS). These are being adopted in a growing number of cities, especially in China. The first VQS was introduced in Singapore in 1990, followed by Shanghai in the mid-1990s. A VQS is additional to vehicle purchase taxes and requires those who wish to purchase a motor vehicle to first obtain a permit to do so.

In Singapore these are called “Certificates of Entitlement (COE),” and provide the right to own a motor vehicle of a certain size class for a period of 10 years. The number of COEs issued is determined by government policy, in order to manage the growth of the overall motor vehicle fleet. Prior to 2009, the motor vehicle growth rate was capped at 3% per year, then cut to 1.5% annually until 2012, and now is set at 0.5% a year. COEs are issued through a periodic open bidding system, using a Dutch auction to determine the clearing price, set at $1 higher than the lowest unsuccessful high bid for the available COEs. At the end of 10 years, a COE can be revalidated for another 5 or 10 years by paying the prevailing rate. COEs have ranged widely in price, but in recent years have been valued at S$50,000 to over S$150,000 – around two to three times the non-taxed base cost of the motor vehicle itself on the global market. This makes the VQS a modest but not insignificant contributor to Singapore’s revenues related to transportation, although revenues are treated as general government resources.

A VQS, as applied in Singapore, can encourage purchase and use of smaller, cleaner, newer motor vehicles, as well as restraining the number of vehicles in use at any given time in an area. It can encourage retirement or export of older, more polluting vehicles. If a VQS employs a lottery, rather than an auction to distribute COEs, as in Beijing, there will be no revenue produced for the local government and it may foster a black market for motor vehicles.

Some city authorities have linked car ownership to residential parking policies. In Tokyo, for example, in order to register a car the owner has to demonstrate that they have access to an off-street parking space. While in London some local authorities relate their on-street residential parking permit charges to the vehicle's emission levels.

## 4.3 Recent experience in Western Europe

For a variety of reasons, some Western European capital cities are now experiencing reductions in car ownership, despite growing incomes and populations. Figure 4.2 shows a mixed picture among five capital cities (the same ones depicted in Figure 2.3), in terms of cars per 1000 resident population. Here we can see that in three cities car ownership rates have clearly peaked (i.e. in London, Paris and Vienna), possibly in Copenhagen too, but not yet in Berlin.

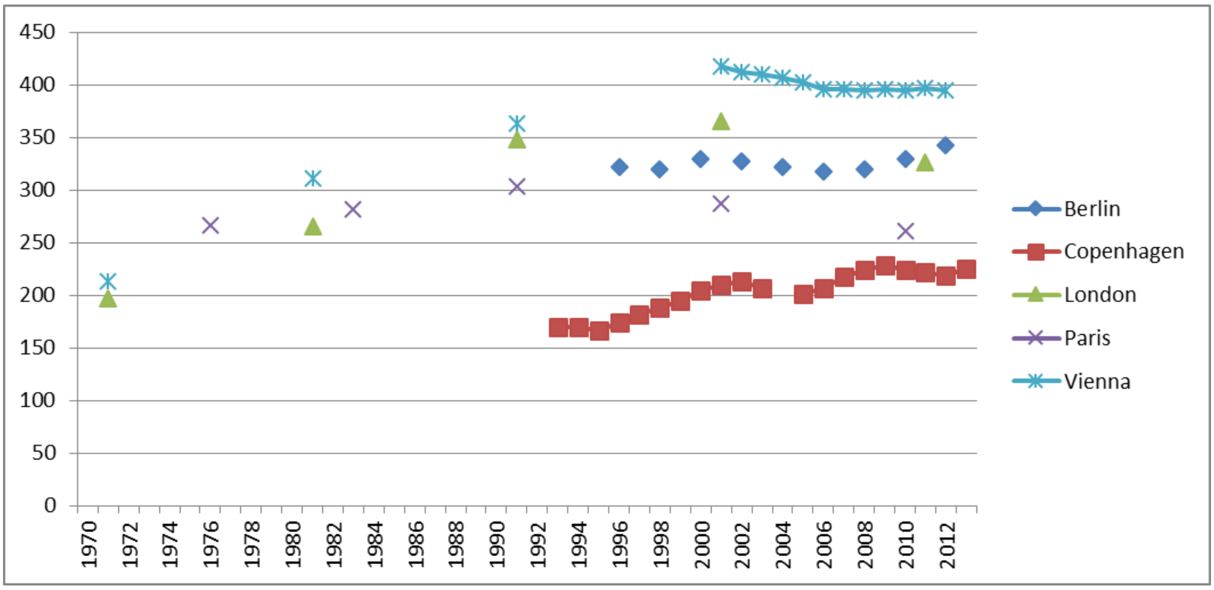



Figure 4.2: Changing car ownership rates per 1000 residents over time, in five European capital cities

Source: EU 'CREATE' proposal

These trends are unlikely to be caused directly by national policies, or by explicit city-level attempts to reduce car ownership, but more likely reflect shortages of residential parking in the centre and inner city areas, coupled with good public transport and attractive walking and cycling environments; and a tendency among younger people and migrants to the cities to have lower levels of license holding and car ownership.

# 5. The Range of Options for Dealing with ‘Excessive’ Levels of Road Traffic

This chapter looks at the full range of options for dealing with parts of the road network experiencing severe traffic congestion, from increasing supply to modifying or reducing demand – particularly focusing on private cars.

## 5.1 Increasing road capacity

Particularly in the early stages of a city’s motorisation, there is often perceived to be a need to build a major high capacity strategic urban road network, both on radial routes to/from the city centre and to cater for orbital movements.

While cities may benefit from having a high quality road network, experience suggests that there can be a number of undesirable side effects, unless carefully managed:

- High-capacity networks can become heavily overloaded and heavily congested
- Given the concentration of motor vehicles, they are often associated with high levels of local air pollution and noise
- They are often seen to ‘generate’ substantial amounts of road traffic
- If not carefully designed, they can sever established communities, making it very difficult for local people to reach schools and health facilities – without themselves driving
- They can lead to the displacement of large numbers of residents whose dwellings are demolished to make way for the new road infrastructure.

Major roads – at least if constructed on/above the surface - become more difficult to build over time, as land prices and construction costs increase, and better educated and organized resident and environmental groups demonstrate against further road building. Indeed, in time, as we have seen in Chapter 2, some cities decide to remove expensive highway schemes that are then seen as damaging to quality of life in that city.

Many cities in Europe have attempted to increase road capacity by widening existing strategic roads, often by demolishing buildings on one side of the street. This may be less disruptive to the overall urban structure than developing completely new routes, but it also results in substantial volumes of building stock being lost and may severely disrupt the lives of established communities.

Within dense urban road networks, most capacity constraints are to be found at junctions, not on road links, and so much can be achieved by increasing junction capacity. This may be realised by:

- Physically widening the approaches to junctions (i.e. increasing the number of traffic lanes)

- Reducing conflicting movements at junctions (e.g. banning turns or introducing one-way systems[1])
- Improving traffic signal control and coordination (e.g. switching from fixed signal timings to demand responsive signal timings)
- Constructing fly-overs or underpasses at busy intersections

There are capacity benefits to be achieved from taking an area-wide approach to traffic management, through introducing dynamic area traffic control systems (e.g. SCOOT in the UK). Such systems can be used to achieve a wider range of policy objectives than simply minimising traffic delays in real time, such as:

- Managing air pollution hot spots, by re-routing traffic or relocating queues, and
- Aiming to reduce travel time variability (rather than minimising travel time), by ‘holding back’ some capacity to be released at times of network disruption (e.g. due to a traffic accident or rain).

Future developments in car manufacturing which could result in the widespread use of autonomous vehicles or ‘connected cars’ are also likely to contribute to increased urban road capacity on the existing network.

Finally, there is the option of changing the allocation of road space by time of day, by modifying the amount of space/capacity allocated to different street users at different times of day.

### 5.2 Re-routeing and re-timing trips

Most urban road networks experience localised rather than universal congestion, in the sense that there are many parts of the network that never experience traffic flows which exceed their capacity, and those parts which do usually only experience these conditions for a minority of the 24 hour day. One broad strategy is, therefore, to spread out demand, in space and time, by encouraging vehicles to re-route or re-time or change their destination.

**Re-routeing** can be achieved through a range of measures, including:

- Redesign of major junctions (to encourage vehicles to exit using one arm rather than another)
- Physical blocking off of streets, particularly in city centres, to discourage through traffic
- Re-timing of traffic signals, to make a ‘longer’ route more attractive
- Regulations restricting certain links or zones to particular classes of vehicle
- Static direction signing, encouraging longer distance traffic to take particular routes
- Dynamic signing, showing drivers which roads are currently congested and encouraging them to follow less congested routes
- In-vehicle route navigation systems, which plan ahead and avoid congested areas, and

[1] Note that cities such as London are now removing these one-way systems, as they led can to fast traffic speeds and make it difficult to undertake local walking and cycling trips.

- Road user charging, with process which respond to varying congestion levels on different parts of the network

More strategically, changes in land use patterns will, over time, modify origin-destination patterns and so change overall network travel patterns and network pressure points.

Note, however, that re-routeing may lead to substantially increased trip lengths which could in some cases result in higher $CO_2$ emissions, and increase the areas of the city subject to high levels of air and noise pollution.

Re-timing can be encouraged through using a number of measures, including:

- Regulations restricting access to particular road links or areas at certain times of day – at least for some classes of motor vehicle
- Only opening public parking spaces outside peak periods (e.g. in the morning after most commuters have reached their destination)
- Managing on-street parking to encourage particular temporal patterns of use
- Encouraging flexible working hours, or staggered opening hours for shops and services
- Encouraging out-of-hours deliveries
- Introducing peak period charges for road use

Note, however, that re-timing may result in higher traffic levels late at night or in the early hours of the morning, and so result in greater noise disturbance for urban residents.

## 5.3 Reducing demand for road space by private cars

Aside from reducing the numbers of cars in cities that are available to use the urban road network (see Chapter 4), reducing overall demand for road space by cars requires a reduction in:

- The numbers of car trips and/or
- The average length of each car trip

Thus, a 10% reduction in car traffic could be achieved either by reducing the number of car trips by 10% and maintaining the same average car trip length, or keeping the same number of car trips and reducing trip lengths by 10% - or some combination of the two.

**Reductions in average car trip lengths** could be encouraged in several ways, by:

- Increasing the awareness and attractiveness of destinations in areas local to where people live, so that drivers do not need to travel so far
- Increasing the density of land use opportunities, so that there are more suitable destinations closer to home

- Using cars more efficiently through ‘trip chaining’, in which several destinations are visited on one journey from home, saving daily distance compared to travelling to each destination separately from home; or
- Reducing the attractiveness of car travel and thereby encouraging shorter car trips, by:
  - Making car journey routes <u>longer</u> (e.g. closing off routes through the city centre)
  - Making car journeys <u>slower</u>, by reducing urban speed limits, switching road capacity to green travel modes, etc.
  - Making car journeys <u>more expensive</u> per unit distance or time, through some form of road user charging

**Reductions in the number of car trips** can be the outcome of various types of travel behaviour change, in particular:

1. Consolidating car travel through ‘trip chaining’ – which also reduces overall travel distances, as noted above. A person planning to visit three non-home destinations during a day (e.g. work, shops and a leisure centre) would make six trips in all if each place were visited separately from home, but only four trips if they are combined into the same journey from home.
2. Switching to an alternative method of travel (e.g. metro), or
3. Reducing non-home travel, in particular, through greater use of the internet; if the person in 1. above modified their activity pattern to work from home, order goods on-line and download a film, then their car trips on that day would be reduced to zero.

The question then is ‘which policy measures could encourage such changes in behaviour?’. Examples include:

- Improving a variety of modal alternatives (Metro, bus, cycle, walking)
- Increasing the range of activities which can be accomplished by using internet-based services
- Discouraging car driving by using similar methods as noted for reducing car trip lengths, namely making car travel less attractive through journeys becoming longer, slower or more expensive.

There is some suggestion of a ‘tipping point’ between car and rail modal choice, depending on the relative door-to-door travel times of the two modes. Once these are competitive, at least for city radial trips, then substantial model shift is likely to occur. But there are limits to what can be achieved in terms of high door-to-door rail speeds, so rail is only likely to become seriously competitive when road speeds fall below a certain level, as noted in section 2.1.

At this point we are faced with what is known as the ‘Downs-Thompson paradox’, based on empirical research in London and Paris (Mogridge, 1990). This showed that average radial door-to-door peak travel speeds by car and rail are roughly the same; and the authors concluded, paradoxically, that the best way to reduce peak congestion and increase average urban road network speeds is to reduce average door-to-door rail travel times – or raise the speeds of other sustainable transport modes. Conversely, if more investment is put into urban roads, in a situation where most people own cars, then there will be a switch from rail to road, rail services will be reduced and average door-to-door rail speeds will reduce – resulting in a new cross-modal equilibrium speed which is lower following the new road investment.

In some cases, a switch from car to another mode may also affect the choice of trip destination and hence change trip length, depending on whether the mode is slower (e.g. walking) or faster (e.g. rail) than driving – since there is some evidence that people maintain a roughly constant daily travel time budget.

It is evident from this brief outline that influencing car use on a major scale will require a comprehensive package of complementary transport/land use policy measures, as discussed in Chapter 3.

In particular, driver attitudes play a major role: there will only be a substantial modal shift once drivers across a wide spectrum of the population – and, in particular, among those of influence - are prepared to use other modes of transport. This is the case in London, where the current mayor of London regularly cycles and uses public transport, and the new Governor of the Bank of England declined the chauffeur driven car he was offered, and instead chose to travel to work by train. But getting senior officials in Chinese cities to voluntarily use non-car modes may well remain a challenge for some time to come.

The next chapter looks in more detail at mechanisms for directly limiting motor traffic in urban areas, including congestion charging.

# 6. Measures for Restraining Road Traffic

Broadly speaking, traffic restraint can be applied at the trip ends (i.e. trip origins/ destinations), through parking policies, or be directly targeted at traffic moving on the road network. In each case there are four broad types of measures that can be applied to discourage car use:

- Physical
- Regulatory
- Pricing
- Information/marketing

Parking and moving traffic controls are considered, in turn.

## 6.1 Parking controls

For people with access to cars, the availability and cost of parking are often major determinants of car use for a particular trip. As noted in section 4.2, parking policy can also be used to influence car purchase patterns, and cities are increasingly providing free or reduced prices for car sharing schemes, or electric vehicles, to try and influence vehicle purchase decisions. Shortage of resident car parking spaces is felt to be a major factor in limiting car ownership levels in wealthy inner city areas.

**Physical measures** are applied by limiting the absolute numbers of car parking spaces, both on and off street in an area, in an effort to restrict the numbers of cars attracted to an area so as to match this to network capacity. This might be achieved through actively managing public car parking spaces and limiting the number of spaces allowed in new developments.

In many cities, the absolute number of car parking spaces is varied by time of day, both by keeping some off-street car parks closed until after the morning peak, and by releasing some on-street kerb space (e.g. that has been reserved for loading during the day) in the evenings and at weekends.

**Regulatory measures** prescribe which types of vehicles are allowed to use certain parking spaces, and often also determine when (as noted above, as a means of changing the number of spaces available by time of day) and for how long.

Typical examples include reserving spaces for local residents, doctors and business people; and limiting total parking duration (e.g. 2 hours maximum and cannot return to the set of parking bays within one hour).

Regulatory controls can also be applied to other types of motor vehicle, for example, limiting at which times loading/unloading can take place at the kerbside.

**Pricing measures** are sometimes used in larger urban areas to attempt to match supply and demand, and may also contribute substantial revenues which can be used to improve modal alternatives.

For example, in the City of Westminster in London, on-street parking charges are set at a level that generally ensures that around 15% of spaces are unoccupied and available at any time – so reducing searching traffic on the network (which on some roads in city centres can comprise 20%-30% of car traffic). Some off-street car parks apply variable pricing, relating the charge to the number of vacancies remaining at that time.

**Information/marketing measures.** Increasingly, cities are providing car drivers with real-time parking information, to reduce search times and enable the parking stock to be used more efficiently. This information has been provided for off-street car parks for many years, using roadside variable message signs, but cities are now beginning to use sensors for on-street parking, buried in the carriageway, to monitor whether spaces are occupied or available (e.g. City of Westminster, London), with the real-time information provided online and via a mobile phone app.

### Other factors

Successful parking controls depend on effective enforcement, but local police forces often give this task a relatively low priority. To get around this problem, increasing number of cities have privatised parking enforcement; this has led to sharp increases in compliance, but is often initially opposed by local police forces who don't like to give up control, and it may require national legislation to introduce such a scheme.

### Assessment

Parking management has an important role to play in limiting traffic levels in the parts of the city where the road network is particularly under pressure. But two major factors need to be kept in mind:

- Effective parking control is best achieved through a flexible combination of physical, regulatory, pricing and information/ marketing measures (e.g. limited number of on-street spaces, which are charged, time limited to X minutes, with availability indicated in real time).
- There are two major limitations as to what a parking policy can achieve in managing urban road traffic in an area:
    - ➢ It can only manage traffic which originates or terminates in that local area: around 25%-30% of traffic in central city areas is through traffic, which is completely unaffected by the city's local parking controls
    - ➢ Depending on local circumstances, a city may only be able to control public parking spaces and on-street residential spaces. In many English urban areas, around half or more of the non-residential car parking spaces are in private hands (PNR spaces = Private, Non-Residential), which may be completely outside the control of the city authorities[2].

[2] In England, some of these spaces could be charged under legislation allowing a city authority to introduce a Workplace Parking Levy and charge larger employers a fixed fee per year for each space they offer an employee, but to date only one city (Nottingham) has introduced such a charge.

## 6.2 Moving traffic controls

Although some forms of controls on moving traffic predate the introduction of formal parking controls in cities, the former have been less well developed or applied in a co-ordinated manner than the latter. For example, discussion of congestion charging does not explicitly consider how it might be used in conjunction with other moving traffic controls – or even alongside a comprehensive urban parking policy.

Again, we consider physical, regulatory, pricing and information/marketing measures in turn.

While there is an inherent limit to the capacity provided by a particular urban road network, **physical controls** limit the amount of road capacity for general traffic below the maximum which could in theory be provided in that locality.

Such measures include:

- Restrictions in the width of the carriageway (often in association with reallocating some carriageway space for a bus or cycle lane, or an increase in footway width)
- Using traffic signals to meter the amount of traffic accessing an area, in order to avoid an overloaded network. Such a technique was used in London in the area around Trafalgar Square (where junction capacity was reduced by around 40% to provide a greatly enlarged and improved public space), and in Zurich where traffic in the city centre is kept below the point where it would delay on-street tram and bus services.
- Reconfiguring part of the street network to make it unattractive or impossible to drive through an area that is considered to be environmentally sensitive. Two techniques are commonly used:
  - ➢ Traffic ‘cells’, where the inner city and city centre areas, typically within a high capacity ring road, are divided into sectors or cells, and direct movement from one to another is limited to buses, cyclists and pedestrians; general traffic has to move out to the ring road and access another sector from there.
  - ➢ Traffic ‘mazes’, in which a well-connected street network, typically in a residential area of the city, is modified using banned turns, selected junctions closures and sections of opposing one-way street along a road to make it impractical to pass directly through the area in order to by-pass traffic queues on the major roads.

**Regulatory measures** control who has access to an area, using signing and increasingly backed up by electronic access controls. Such measures are usually introduced to control access to a defined area (e.g. a residential neighbourhood or city centre), but can also apply to particular streets (e.g. a major shopping street). They are often limited to certain times of day, such as during shopping hours, or at night to reduce noise nuisance in high density residential areas.

Regulated access can be based on different criteria, in particular:

- The type of vehicle (e.g. buses and cycles only); in the extreme case, this might be limited to pedestrians only.
- The type of person (e.g. residents only).
- The purpose of the trip (e.g. loading, or local access only).
- The emissions of the vehicle (e.g. Low Emission Zones – see box on next page).

Enforcement sufficient to achieve the required levels of compliance is crucial to success, unlike with physical measures which are largely self-policing.

**Pricing measures** targeted at moving traffic are considered more fully in the next few Chapters. This approach involves the charging of motor vehicles for using parts of the urban road network. Charging can vary by type of vehicle, time of day, etc. and may be based on several principles.

In particular:

- **Point charging**: for passing particular points on the network (e.g. crossing a bridge or using a major junction).
- **Cordon charging**: a charge for crossing a cordon line (e.g. the Oslo toll ring).
- **Area charging**: a charge for accessing and moving within a defined area (e.g. the London congestion charge).
- **Congestion-based charging**: a variable charge designed to maintain a certain level of network performance (e.g. the Singapore charging scheme).

**Information/marketing measures** are being increasingly used to encourage behaviour change, in particular modal shift from cars to other modes of transport. Such initiatives may be targeted at major destinations (workplaces, schools, hospitals, sports events, etc.), or more generally at daily travel patterns in households. In several Western Countries, household-based marketing campaigns have often been successful in reducing urban car use by 10%-15%, and workplace initiatives (in conjunction with improved public transport provision and local parking restrictions) may achieve a much higher modal shift.

### Assessment

Directly targeting moving traffic can be a very effective way of influencing car use and traffic patterns more generally; but the role that pricing can play in the policy mix has not been recognised in most cities.

In general, the strategies that have been applied to control moving traffic in urban areas are less sophisticated than those which have been adopted to control parking, where authorities consciously combine physical, regulatory, pricing measures and information/marketing to achieve their policy objectives. In most cases city authorities tend to introduce moving traffic controls in a less co-ordinated way, using only one, or possibly two, of the four available categories of measures. And with little attempt to link these explicitly with a parking strategy.

## Low Emission Zones

More than 200 cities and towns in ten countries around Europe already have in place, or are preparing to launch, 'Low Emission Zones' (LEZ) – areas within which the most polluting vehicles (in terms of NOX and particulates) are regulated in some way. Polluting vehicles may be banned or they may be charged in order to enter the LEZ. Details of European schemes can be found at: http://urbanaccessregulations.eu/; this also includes details of congestion charging and urban access regulation schemes in European cities.

**Berlin**

Berlin introduced a LEZ in January 2008 in the central and inner city, covering an area of 85km$^2$ and a residential population of over 1 million; standards were tightened in January 2010 and currently vehicles that do not meet at least the following minimum standards are banned from the area:

- Petrol: Euro 1, with a catalytic converter
- Diesel: Euro 4, or Euro 3 with a particulate trap

While the scheme does not seem to have reduced traffic flows inside the LEZ, it has resulted in a much cleaner vehicle fleet than would otherwise have been expected.

**London**

The London LEZ covers virtually the whole of the Greater London Authority area, and operates at all times. It was introduced in February 2008 and has extended the scope and tightened the standards since then. Cars and motorcycles are currently exempt, but diesel lorries, buses and coaches need to meet Euro IV standard or pay a charge of between £100 and £200 per day.

Transport for London is currently consulting on introducing an Ultra-Low Emission Zone covering the same area as the Central London congestion charge. If approved, this would be introduced in 2020 and require vehicles accessing the zone to be a minimum of Euro 4 (petrol) or Euro VI diesel), or pay a daily access charge of £12.50 (cars and vans) or £100 (lorries and buses).

**Milan**

Milan combines a LEZ with a congestion charging zone. Vehicles entering the Milan municipality during working hours on weekdays are required to pay a daily charge (5 euro) AND have to comply with minimum air quality standards. These standards are the same as those required in Berlin, as set out above. Free access is provided to electric vehicles, motorcycles and mopeds, hybrid vehicles, bi-fuel, CNG and LPG powered vehicles.

NOTE that London is the exception among these three cities, in allowing non-compliant polluting vehicles to enter the LEZ on payment of a daily charge.

## CONGESTION CHARGING

# 7. An Overview of Road Pricing Measures

As noted in Chapter 6, pricing is one of four broad policy measures which can be introduced to reduce traffic flows at peak times. In this chapter we first consider the different terms used to describe the pricing of moving traffic and the various reasons that are given for proposing such a scheme. Next we briefly address the important issue of public attitudes, then discuss the kinds of 'complementary measures' that need to be introduced to maximise the benefits of a charging scheme, and finally consider ways of measuring congestion.

## 7.1 Terminology and rationale

There are several terms commonly used to describe loosely related concepts, but these are not always clearly differentiated in the academic or policy literatures. These terms include: Road pricing, Road user charging, Value pricing, Road tolling, Congestion charging/pricing and Environmental charging.

The more generic terms, such as 'road pricing' and 'road user charging', are widely used by economists and are intended to apply to circumstances where drivers are being charged for the full range of costs which they impose, from road maintenance to externalities such as pollution and environmental costs. The term 'road tolling' more normally applies to the imposition of a charge to pay for a new piece of road infrastructure, although the 'urban tolls' introduced in Norwegian cities were collected to pay for new roads in the region that were not used by the majority of those paying, and to fund some public transport schemes.

'Environmental' charging is relatively self-explanatory, and usually applies to schemes that charge for local pollution caused by motor vehicles. 'Congestion charging' and 'value pricing' are both concerned with using prices to reduce congestion levels, although in the former case – unlike the latter - there is no link to a guaranteed level of service, or to new road construction. In some countries, national legislation has mandated the use of the terms 'congestion charging' or 'congestion tax' - which as we shall see, is not always helpful in maximising public support.

Similarly, the reasons advanced for introducing 'road pricing' differ considerably, and may include one – or more – of the following:

- To reduce road traffic congestion
- To reduce air pollution levels
- To use road space efficiently
- To fund new road investment
- To fund non-road investment

The stated policy rationale can get muddled too. In London, for example:

- Drivers are charged for congestion which they contribute to, in order to reduce network time losses to an acceptable level

- Authorities then take advantage of reduced traffic flows to take out general road capacity for other purposes (e.g. cycle lanes, more pedestrian crossings)
- So, traffic congestion is now back at same level as before the scheme was introduced (due to 30% capacity losses in Central London)

But is this consistent, in policy terms? We consider such issues further later in the chapter, in relation to public acceptability.

More generally, there are two contrasting rationales which are commonly used to justify pricing for urban roads at the point of use:

i. The **user pays**: the beneficiary pays for the benefits which they are enjoying from (new) road construction, or for a guaranteed level of service – a 'positive' message. Or
ii. The **polluter pays**: the 'bad guy' pays for the damage caused to other road users, or more widely among the population (e.g. congestion and pollution) – a 'negative' message.

The **user pays** is viewed as a charge for a service provided, taking one of two forms:

- **C1**: A **fixed**, average charge, designed to repay (part of) the cost of road construction and maintenance – charges may vary according to damage inflicted (e.g. toll on a new road with heavier charges for HGVs). This is particularly applicable while peak demand is well below the road capacity.
- **C2**: A **variable** charge, adjusted in order to maintain a predetermined level of service: given a fixed supply, charges increase (non-linearly) in line with demand, to maintain a level of usage which is below capacity (e.g. USA 'value pricing').

Conversely, the **polluter pays** is viewed more as a 'penalty' for a behaviour that is to be discouraged. Again, the charge may be based on two principles:

- **C3**: A **fixed** rate (per vehicle type), in cases such as emissions which can be directly related to time spent travelling or kms of travel in an area.
- **C4**: A **variable** rate, particularly for traffic congestion, where the externality is non-linear and depends on overall traffic volumes.

## 7.2 Public acceptability

While many people resist the idea of paying at all for road use at the point of use, since traditionally it has been seen as a free public good, public acceptability is generally higher under conditions **C1** to **C3** for a variety of reasons:

- **C1** (toll): the user is paying for a new service and so is obtaining an additional benefit, above what they previously experienced
- **C2** (value pricing): the user has the choice of using a free route or paying for a higher quality, guaranteed level of service
- **C3** (pollution charge): there is a general perception that pollution from motor vehicles is a bad, and so it is reasonable that it should be charged for

But charging for congestion (**C4**) is much more contentious, for several reasons:

- It appears that people are being made to pay for something they don't want!
- Generally, motorists see themselves as victims of congestion, not causers of congestion
- While similar vehicles might contribute equally to air pollution, this is not the case with congestion – which only starts to occur above a given traffic level. So debates about 'who' causes congestion (e.g. car commuters, parents driving children to school, etc.) are common and heated
- Economists advise that drivers should be charged the marginal cost – but this is the cost contributed by the 'last' vehicle – so people question why should all users pay this charge? It does not seem 'logical', or fair
- Equity concerns – the intention is that some people will be 'priced off', but the economically marginal trips are often not perceived to be the same ones as the socially marginal trips

There are also public concerns about how the money raised is spent:

- **C1**: Goes directly into paying for the infrastructure, so there is a clear link – at least until the investment has been paid off (then it can become more contentious)
- **C2**: This may also be paying for investment, where additional lanes have been added onto an existing road, but otherwise this can also be contentious
- **C3**: The concern here is to ensure that the money raised is being used to address the problem, through research, subsidies for purchasing low polluting vehicles, or mitigation measures – then it is broadly acceptable
- **C4**: this is rarely linked to proposals to fund increases in road capacity, enhancements, or maintenance – but funding improved public transport or subsidising fares is often seen as an acceptable use of the net income by motorists.

What is NOT considered acceptable by the public under **C4** is the economists' notion that the use of charges raised does not have to relate to the reason for which they were incurred. While this is the norm in the case of general taxation, in this case the evidence shows that hypothecation (i.e. reserving net funds for specific purposes) is essential to gain majority public support for congestion charging schemes.

Several studies have shown that the public is doubtful about the fairness or effectiveness of using pricing to substantially reduce urban congestion, but they are supportive of improvements to public transport, and in some situations are willing to support additional charges on motorists to pay for these improvements. This can be seen in Figures 7.1 and 7.2, taken from an opinion survey of a sample of all London residents prior to the introduction of congestion charging in London. Just over half (51%) think that better and cheaper public transport is the most effective means of reducing congestion, compared to only 5% who believe that road user charges would be best. But 41% favour road congestion charging, or higher parking charges, as the preferred means of funding the desired public transport improvements.

The legislation in the UK, and in Sweden, specifies that road user charges should be introduced to combat traffic congestion – hence the term 'congestion charging, or 'congestion tax'' – and not to raise money for transport improvements. But, as we can see below, this line of argument does not necessary assist in gaining public support.

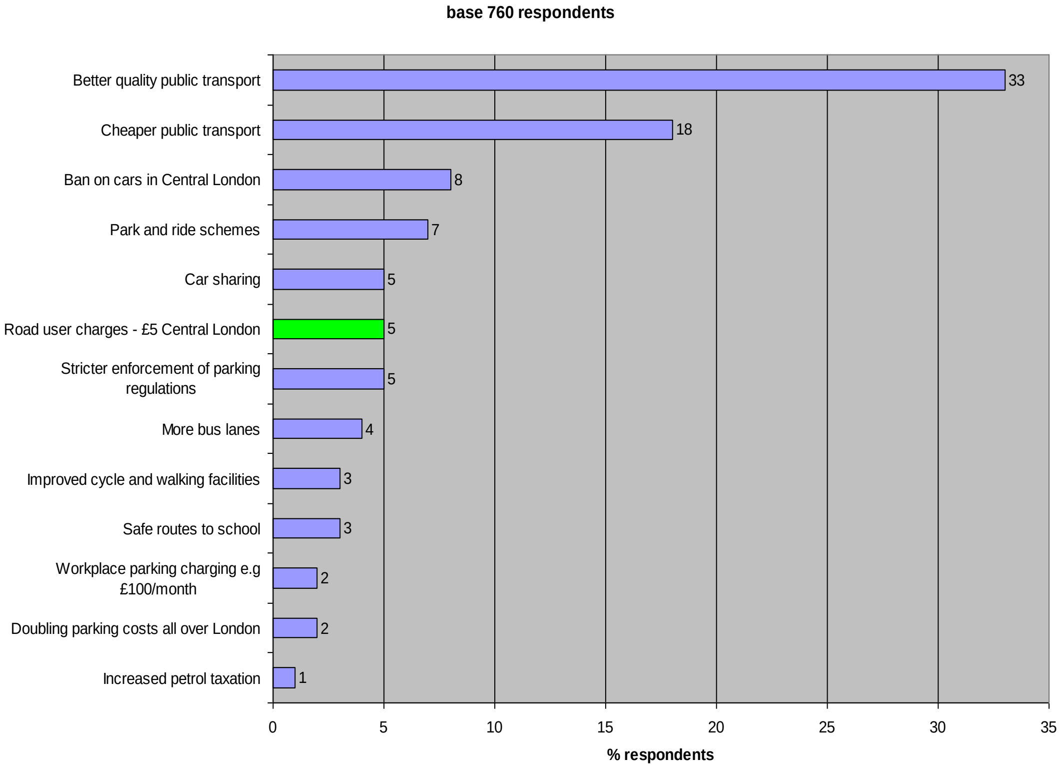



Figure 7.1: London resident views on the most effective measures to reduce urban traffic congestion

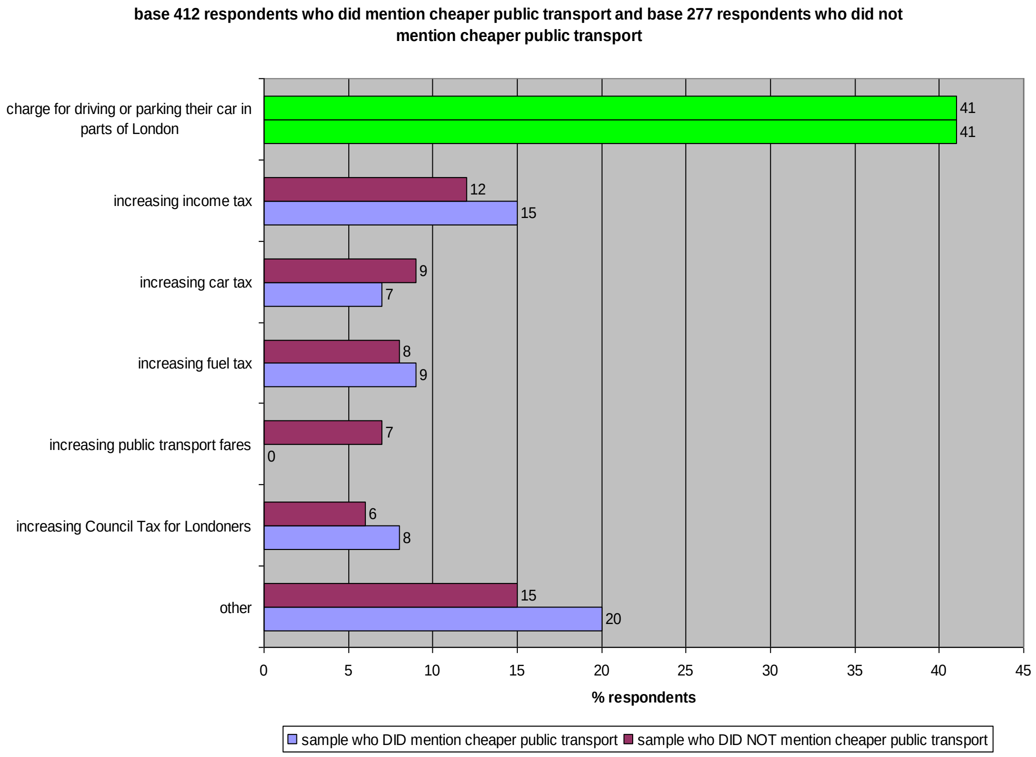



Figure 7.2: London resident views on how public transport improvements should be paid for

### 7.3 Complementary measures

A wider package of complementary policy measures is usually introduced at the same time as – or, in advance of - the operation of a congestion charging scheme, for two main reasons, as:

- Mitigation measures, particularly to reduce boundary problems, and
- Supporting measures, to encourage switch of trips from car

**Mitigation measures**

Most congestion charging schemes introduce charges within a fixed area, and there are particular concerns about negative impacts occurring just outside the boundary of the scheme. This can take two forms: (i) increased pressure on parking provision outside the boundary (i.e. drivers park and walk, cycle or take public transport into the charged area), and (ii) traffic diversion to roads just outside the charged area causing congestion there.

Parking issues can be dealt with by introducing on-street controls in areas surrounding the charging zone – either limiting parking by regulation (e.g. limited time or residents only), or by introducing or increasing hourly parking charges. This needs to be backed up by high levels of parking control enforcement.

Traffic diversion can be addressed by:

- Signing appropriate diversionary routes
- Introducing measures to discourage ‘rat running’ on residential streets just outside the charging zone, for example, through introducing lower speed limits or introducing physical traffic calming measures.
- Increasing traffic capacity on the boundary orbital ring road.

In the case of London, traffic signal controls were adjusted on the Inner Ring Road, which was just outside the charged area. This reduced capacity for traffic crossing the cordon (which was expected to decrease) and switched it to provide extra capacity (i.e. longer green time) for traffic using the ring road. As a result of this policy, travel times did not increase on the Inner Rind Road following congestion charging, despite some increases in traffic flows.

**Supporting measures**

These measures are designed to increase the capacity and attractiveness of modal alternatives to the private car, for example, by improving public transport services and enhancing the provision of facilities for cycling.

Supporting measures are crucial for several reasons:

- To provide car drivers with acceptable alternatives
- To increase public acceptability
- To achieve the desired reduction in car use at a lower charge than would have been required in the absence of such enhancements.

Such measures typically include:

- New vehicles (e.g. buses and coaches)
- More frequent services on existing routes
- New public transport routes
- New major public transport construction projects (e.g. tram lines)

Two of the proposed congestion charging schemes in the UK (Edinburgh and Manchester) involved an agreement to build new tram lines before the scheme was introduced. In each case, the tram lines were built, but the congestion charges were subsequently not introduced, due to strong public opposition in local referenda.

In the case of London, it was not feasible to greatly increase rail capacity, in the short term, so the main enhancements were to bus services (new routes, higher frequencies, etc.). Buses are generally less attractive to motorists contemplating a modal shift than travel by train, so the aim was to achieve a 'cascade' effect. Some existing short-distance underground and suburban rail users living in Inner London would be encouraged to switch to the improved bus services, thereby freeing up rail capacity for motorists. This was successfully achieved.

## 7.4 Measuring congestion reduction benefits

If the primary aim of a pricing scheme is to reduce congestion, then it is important to be clear about what is meant by congestion and how any improvement is to be measured. However, the phrase 'urban traffic congestion' is widely used but poorly understood and inconsistently measured.

There are several issues here which need to be considered when judging the 'success' of a proposed congestion charging scheme:

- Measures of road traffic congestion typically compare observed day-time speeds, or travel times, on different parts of the road network with those which prevail at times of free flow (e.g. during the night). But, given the much greater use of the urban road network during the day (e.g. by delivery vehicles, by buses and by pedestrians and cyclists), then it would not be feasible, on a multi-modal transport network, to attempt to 'eliminate' congestion measured in that way. Hence conventional measures of congestion overstate the problem and so are not very useful from a policy perspective - and do not encourage informed public debate.
- Furthermore, while such measures are objective, at the same time they are also partly arbitrary and subject to policy influence. For example, if legal urban speed limits are reduced on large parts of the road network (e.g. from a default value of 50kph to large areas with 30kph zones), in order to improve air quality or reduce noise levels or traffic collision severity, then measured congestion would suddenly 'appear' to have reduced - since the baseline night time speeds then become lower and so the observed differences in speeds between daytime and night time conditions automatically reduce.
- Most traffic congestion measures deal with average values (e.g. mean speeds), whereas, particularly for the freight and logistics sector, it is reliability (i.e. reducing variation and unpredictability) which is more important commercially

than increasing average speeds. Private motorists also prefer to ‘keep moving’ rather than experience frequent start/stop driving – even if door-to-door journey times are less in the latter case. This has implications both for selecting the ‘best’ performance indicators and for the appropriate policy measures to best manage the network to best meet user needs. For example, a combination of charging levels and area traffic signal controls could be used to keep some ‘reserve’ capacity in the network which could be released when incidents arise; this would lead to longer average travel times but significantly reduced variability.

- Measures of congestion are often reported on a ‘per vehicle’ basis, rather than taking into account differences in vehicle occupancy. A city might report a growth in vehicle congestion over time, resulting from the reservation of more parts of the carriageway space for bus and tram lanes; yet, if looked at from a person movement perspective, given different average vehicle occupancies between buses/trams and private cars, then overall speeds may have been increasing and door-to-door journey times decreasing. This suggests the need to take a more comprehensive view and adopt broader measures of urban road network performance.

It might also be useful to consider rather different measures of network performance and efficiency. For example, on high capacity parts of urban road networks it might be more appropriate, rather than using speed or delay as a comparator, to consider performance in terms of maximum rates of flow.

Another possibility would be to take a more holistic view of the entire urban transport system and develop indicators which reflect conditions for travellers using all modes of transport, including walking and cycling (for example, in terms of average door-to-door travel times, or average journey speeds). This might show, for example, that slight increases in road traffic congestion due to increased provision of surface pedestrian crossing facilities are being more than offset by reductions in door-to-door travel times for pedestrians and public transport users, when taking account of the walk stages in their trips. Again, this might lead to net reductions in travel times, when averaged across all road users.

# 8. Congestion Charging Schemes

As noted in Chapter7, ‘Congestion Charging’ is often used as a generic phrase to cover a number of quite different types of scheme with differing objectives. The phrase first came into widespread use following its association with the Central London Congestion Charging scheme which was successfully brought into operation in 2003. The phrase has also been associated with the Stockholm City Congestion Tax and to a lesser extent the Singapore Electronic Road Pricing Scheme.

The aim of the London and Stockholm schemes, when introduced, was very much to reduce congestion in the centre of these cities, hopefully without increasing it in the surrounding area and without producing any other adverse impacts. In Singapore, however, it could be argued that the intention, in addition to providing a higher level of service on main routes, was also to raise net revenues as the current scheme replaces a paper based supplementary licensing system.

This chapter is in two main parts. It first considers three successful schemes which have been introduced in London, Stockholm and Singapore. These have been successfully operated in all three cities for a number of years: congestion has remained under control, there is little evidence of substantial adverse impacts and the schemes are now operating with significant surpluses having covered their initial implementation costs many times over. Part two reviews three proposed schemes that were not introduced, in Edinburgh, Manchester and New York, and discusses the main reasons why they were not implemented.

When drawing conclusions and making recommendations, in Chapters 9 and 10, we also draw on the authors’ wider experience and knowledge of the topic and the various attempts, some successful, some not, of introducing similar scheme in other international cities such as Auckland, New Zealand and Melbourne City Link in Australia. Use has been made of, and material has been drawn from, study reports and other published and unpublished material.

## SUCCESSFUL SCHEMES

## 8.1 London

### The scheme

While there has been a history of suggestions for introducing charging in Central London, going back to the 1960s, these did not materialise due to a combination of lack of perceived necessity (i.e. a belief that conditions were not bad enough to warrant such an ‘extreme’ measure, since the problem could be solved in other ways), and a lack of suitable governance arrangements, with London’s strategic decisions being taken by a national government regional office between 1986 and 2000, following the abolition of the Greater London Council.

The opportunity to introduce congestion charging was created by the establishment of the post of a directly elected executive Mayor, whose main responsibility was the Capital’s transport system. The National Government recognised that the new Mayor may wish to introduce a charging scheme and so undertook a preliminary study

(‘Review of Charging Options for London’), in order that appropriate primary enabling legislation would be in place on the election of the Mayor in May 2000 to enable a charging scheme to be introduced - should the Mayor so wish to do so. This was necessary because UK legislation did not permit a charge to be introduced for the use of the existing highways. In the event, London’s first elected mayor indicated while a candidate that he would introduce the charge, if elected, and proceeded to do so.

The charged area covers 22km$^2$ of Central London, as shown in Figure 8.1. The charging zone has a clear boundary road, the inner ring road, travel on which is free of charge at all times. Alongside this, the charging zone is served by a good public transport network including buses, underground trains and some suburban train services. Together, these provide a range of options in place of driving in the charging zone including change of mode to public transport, walk or cycle, or for those with both origin and destination lying outside the zone, avoiding entry by diverting to the boundary road or roads in the network beyond that.

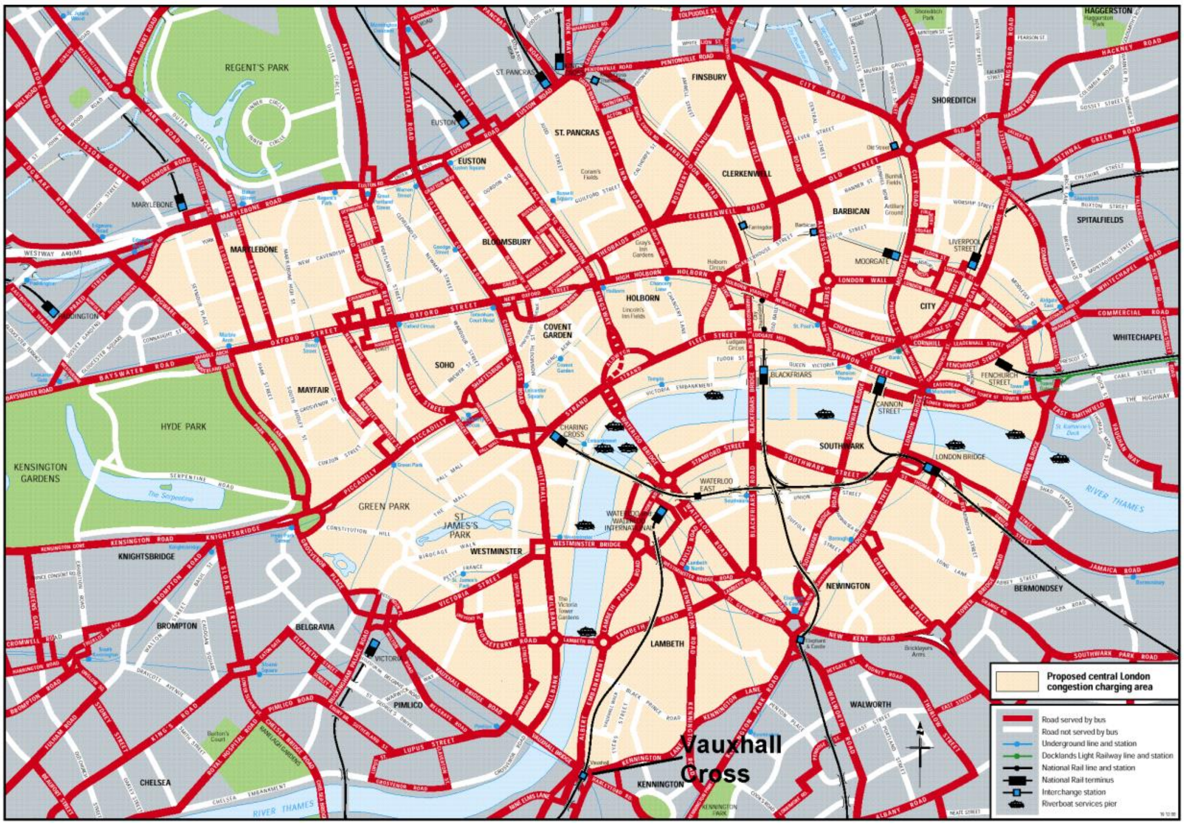



Figure 8.1: Are covered by the Central London congestion charging scheme
Source: Transport for London

The Central London Congestion Charging Scheme is a simple, single zone operating as a charged area. The charge is payable by drivers of standard fuelled (i.e. petrol or diesel) motor vehicles for use of any part of the public road network within the designated boundary during the working day, between the hours of 07.00 and 18.00 on weekdays. Payment of the charge licences a specified vehicle for unlimited travel within the Central Charging Zone (CCZ) on the nominated day. The charge is not payable on weekend days (Saturday and Sunday) or on public holidays. Identification (for payment and enforcement) is by cameras which are located at 180 boundary points and 25 locations within the Zone. There is no form of electronic tagging.

The scheme went live in 2003 and cost £162m to introduce; it now costs £90m per annum to operate, producing a net revenue of £132m annually. The cost of collection is assessed at 40%. The charge was set at £5 in 2003 (an amount equivalent to a return tube fare from Zone 3) to drive modal shift and reduce congestion in central London. (The daily Casual User Charge is now £11.50 and £10.50 for account holders). Around 170,000 vehicles are identified and processed each day of which 67,000 currently pay the charge. The funds raised by the charge are hypothecated for use in the London transport system as a whole.

Concessions are made for various kinds of vehicles and individuals, in the form of discounted charges or exemptions. These include:

- Residents who have an address within the congestion charging zone, or in a designated area adjacent to the zone, may be entitled to a 90 per cent discount.
- Blue Badge holders who are registered as disabled drivers or passengers are entitled to 100 per cent discount.
- Accredited breakdown vehicles and roadside recovery vehicles.
- Ultra Low Emission vehicles (ULED): cars or vans (not exceeding 3.5 tonnes gross vehicle weight) that emit 75g/km or less of $CO_2$ and that meet the Euro 5 standard for emissions qualify for a 100 per cent discount on the Congestion Charge. This applies to vehicles of fuel type 'electric' and also to some plug-in hybrid vehicles.
- Vehicles with nine or more seats.
- Motor tricycles.
- Two-wheeled vehicles.
- Taxis and registered private hire vehicles.

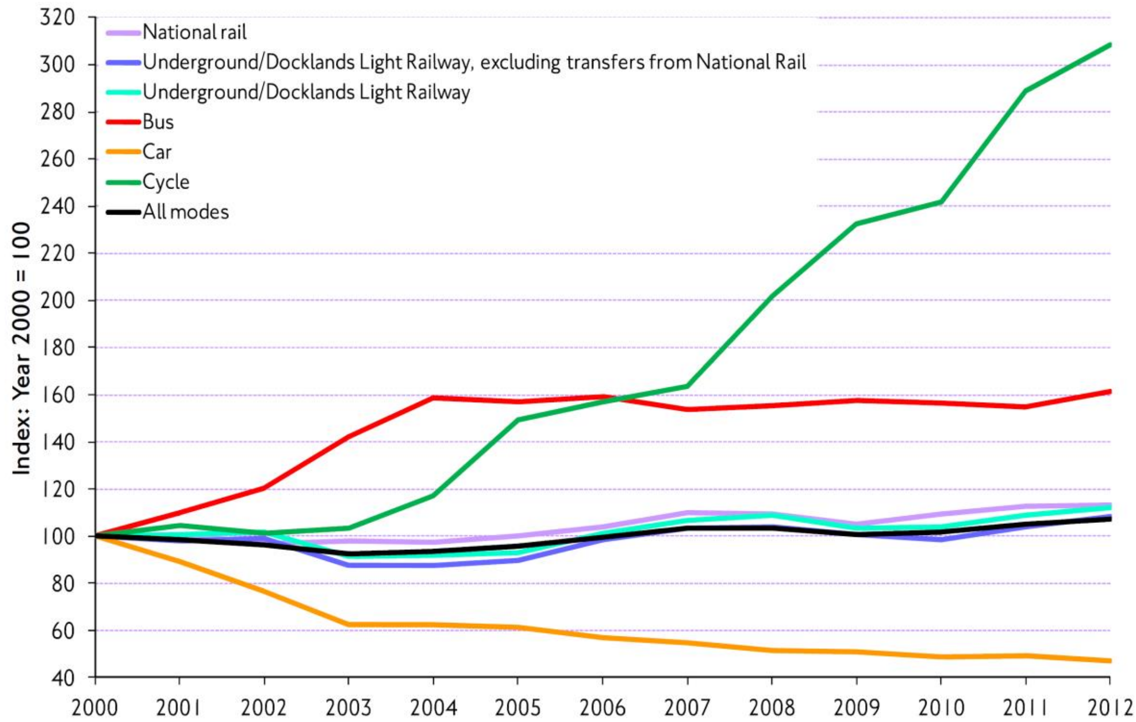
Though the scheme was simple to understand, because Londoners were generally not used to paying a charge for use of the road, a substantial publicity and education exercise was needed. In addition, the customer contact channels needed to be able to service a high and relatively unpredictable volume of calls before and during go-live. Additional provision for customer contact resources was made to handle a “bow-wave” of customer events at go-live. Retail channels for cash payment were provided – although they have since been phased out.

For casual users the scheme has evolved from requiring payment in advance of travel, with a dispensation to pay by midnight on the day of travel, to the dispensation now extending to the day after the day of travel. Users can now also register for an account which is paid monthly in arrears.

**Scheme impacts**

The congestion charge was introduced at a time when private vehicle use for travel into central London during the morning peak period was already in decline (although this was not matched by a corresponding decline in congestion). Figure 8.2 shows that this decline in morning peak mode share started well before the introduction of the congestion charge in 2003, which therefore had the effect of reinforcing it.

TfL (2008) estimated that by, 2007, there had been a reduction of motor traffic entering the central charging zone during charging hours of about 16 per cent by comparison with 2002. The entering flow of cars and minicabs over the whole charging period fell from about 180,000 vehicles (07.00 – 18.00) to about 120,000 on introduction of the congestion charge, and has remained more or less at that level since. There has been relatively little change in entering flow of other kinds of traffic. During the same period, cycling has increased by a factor of about 3 (i.e. 200 per cent increase). This is due to a combination of several influences, including reduced traffic and more orderly traffic flow (despite elevated traffic speeds) that arise from the congestion charge, but also explicit promotion of cycling alongside other active modes of travel and the introduction of public bicycle hire.




Source: TfL Group Planning, Strategic Analysis.

Figure 8.2: Trends in modal use for morning peak travellers into the charging zone

The effects of the charge on levels of congestion was initially substantial, with a 30 per cent reduction in excess travel time per km reported during the first year of operation. However, the size of this reduction has diminished over time, through a 21 per cent reduction in year 3 of operation, an 8 per cent reduction in year 4 and no discernible reduction in years 5 and 6. This reduction in “benefits” has mainly been due to road space reallocation – in favour of pedestrians, cyclists, and street activities – and some increase in road works due to utilities (replacing water mains, laying new fibre optical cable, etc.) resulting in an effective reduction in road traffic capacity of 30%.

## 8.2 Stockholm

### The scheme

The Stockholm scheme emerged from a long history of discussions about the need to deal with air pollution and traffic congestion in the capital city, and to improve public transport provision and provide some new road capacity. Several proposals had included congestion charging as one element of a comprehensive package (e.g. the Dennis Plan), but none were successfully implemented. In the end the scheme was introduced by a Swedish national coalition government, with pressure from the Green party. In this case there were no proposals to change the machinery of regional, local or city government, and it was decided that the Stockholm scheme should in fact be designated as a Tax. This had significant implications for how the scheme was developed, introduced and operates.

The Stockholm Congestion Tax (so-called because of the requirements of Swedish law) is implemented in a 35km$^2$ area in central Stockholm. It was initially introduced on a time-limited trial basis for the seven months between January and July 2006. Following the success of this trial, a local referendum and subsequent national elections, it was adopted indefinitely, with its reintroduction in August 2007. Alongside this, the charging zone is served by a good public transport network including buses, a metro rail system and some suburban train services. Together, these provide a range of options in place of driving in the charging zone, including change of mode.

The scheme cost 1.9bn SEK to introduce and cost 220m SEK per annum to operate and produces a net revenue of 660m SKE annually. The cost of collection is assessed at 22% of revenues – less than in London due in part to the much smaller number of crossing points. During the pilot phase, vehicle identification was via an electronic tag attached to the vehicle windscreen, but this was withdrawn and the implemented scheme uses number plate recognition technology and roadside cameras, both for vehicle identification and enforcement.

It is a relatively complex scheme:

- It is a cordon scheme operating on weekdays 06:30 – 18:30;
- Charges are paid per crossing and vary by time of day, but not by direction of travel;
- Charges vary (SEK 10, 15, 20) according to time of day, but are capped at a maximum amount of SEK 60 for the day (equivalent to the cost of about 4 litres of petrol);
- Some users are not charged if they transit the city within a given time.

The charge is not payable on weekend days (Saturday and Sunday), on public holidays or during July – the main holiday period. The funds raised by the charge are invested in the transport system, including funding for major infrastructure investment in the Stockholm metro system and road network.

However, geographically it is very simple – the boundary is very well defined through the bridges and islands as indicated in Figure 8.3 below.


Figure 8.3: Stockholm Scheme Boundary and Example Detection Infrastructure
Source: Sweden National Roads Authority

The infrastructure used to detect vehicles is also very visible and imposing – there is little likelihood that a driver will not see they are approaching a cordon point. Because of the islands, there are only 18 cordon points which are located on areas where there is lots of space for equipment and there are large gaps between the premises inside and outside the cordon. The scheme processes 350,000 - 400,000 vehicles per day.

Payment of the Stockholm Congestion Tax is made by monthly invoice to the address/account of the registered vehicle keeper, according to the charges accumulated during the month. Concessions were made originally for various kinds of vehicles and individuals in the form of discounted charges or exemptions. These were found to be effective in promoting the uptake of alternative-fuel vehicles. These exemptions were, however, abolished in 2012 when they were judged to have fulfilled their intended role.

**Scheme impacts**

The traffic effects of the Stockholm Congestion Tax were judged to be highly significant. Traffic congestion had built to a level where peak-period travel times on arterials within the city were typically three times the free-flow times. Traffic levels had remained stable over about 15 years, most likely because of limited road capacity. Public transport mode share into the central area was consequently high at around 60-65% of all motorised person trips, with up to 80% during peak periods (Eliasson, 2014).

On introduction of the congestion tax, traffic flow crossing the charging cordon levels fell by about 22%, with consequent reductions in congestion of between 30-50%. These reductions were observed during the trial period, were largely reversed after the end of the trial, and then recovered after full implementation of the congestion tax. Public transport mode share increased by 4-5%. Traffic levels (measured in vehicle-km) within the inner city decreased by about 16%, and outside the cordon by about 5%, showing some reductions but also some timing and routing choices to avoid crossing the cordon during the charging period. Consequent reductions in queues helped reduce congestion in these areas.

Vehicular emissions of pollutants were reduced, with greatest reduction of 10-15% in the inner city. The reductions varied among different kinds of pollutant, with reduction of 10-14% in particulates and about 8% in $NO_x$, carbon dioxide ($CO_2$) emissions across the whole of the Stockholm area were reduced by 2-3%.

## 8.3 Singapore

The Singapore Electronic Road Pricing (ERP) (Santos, 2005) system was implemented in about 7 $km^2$ of central Singapore in September 1998, and is much more complex in nature than the London or Stockholm schemes – although this does not seem to have caused difficulties for users. The charging zone corresponds to the central business district of Singapore, expressways leading into the city and the outer ring road. The central business district is served by a good public transport network. ERP replaced a simple manual, paper-based cordon charge (the Area License Scheme) introduced in 1975.

The charge is levied each time a vehicle passes a fixed gantry, of which there are currently 80. Gantries have been added incrementally according to need as assessed by the pattern of road congestion, with scope for further additions when required. The charge is presented as a toll payable by drivers of motor vehicles who pass any one of the 80 charging points within the city. The toll is payable on each passage (in either direction) past a charging point during the charging period. The charge varies by location and time of day, according to a level of congestion that is estimated in advance. Charges are levied between 07.00 and 19.00 in the CBD area, and from 07.30 to 09.30 on the expressways and outer ring roads. The range of charges is from about $0.50 to $3, and a typical journey will be charged between $2 (mid-day off-peak) and $15 (peak period), corresponding to the price of about 1.7 litres of petrol. The funds raised by the charge go into general taxation, but are associated with substantial investment in the transport system, including construction and maintenance of roads and extensions to the metro system.

Vehicles passing any of the charging gantries are required to be equipped with an in-vehicle transponder, carrying a stored-value card. The card can be removed and its value topped-up externally. The charge is enforced by video cameras mounted on the gantries that use automatic number plate recognition (ANPR) technology.

Exemptions were made originally for various kinds of vehicles, including carpools, taxis, motorcycles, buses and commercial vehicles. Most of these exemptions have now been withdrawn, with only emergency vehicles currently exempt.

### Scheme impacts

Before introduction of the ALS in 1975, traffic congestion had reduced travel speeds to 12 mph. On introduction of the ALS, traffic levels in the CBD fell by about 45% (Willoughby, 2000), with a further reduction of about 20% following introduction of the ERP and consequent increase in travel speeds to 18 mph (Phang and Toh, 1977).

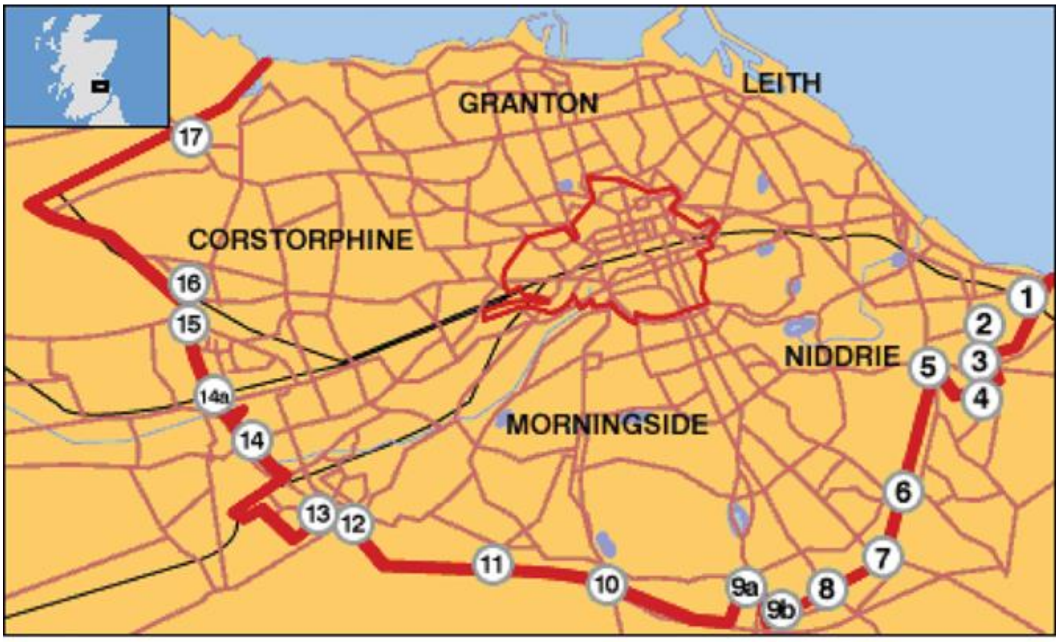
Public transport mode share increased by about 20%, to 65% of commuters to the central area.

Vehicular emissions of pollutants were reduced, with greatest reduction of 10-15% in the inner city. The reductions varied among different kinds of pollutant, with reduction of about 10 kg pa in particulates. Carbon dioxide ($CO_2$) emissions across the whole of the Singapore area were reduced by about 80 tonnes pa.

## SOME UNSUCCESSFUL ATTEMPTS AT IMPLEMENTATION

### 8.4 Edinburgh

The city of Edinburgh (city population 450,000 with a catchment of about 1 million and an area of 264 km$^2$) developed plans for a charging system with two cordons, as illustrated in Figure 8.4. In the final proposal, the outer cordon would be active during the morning peak period and the inner one throughout the working day, both on weekdays. Passing either cordon when active would incur a charge of £2, with all further travel on that day then permitted without further charge. Alongside this, proposals were developed for traffic calming, public transport improvements (including park and ride, bus and train improvements), and the promotion of cycling and walking, as well as the construction of a tram from the airport west of the city through the city centre to Leith, a redevelopment area formerly comprising docks.




**Source:** www.edinburgh.gov.uk (2004a and 2004b)

Figure 8.4: Proposals for a double cordon charging scheme in Edinburgh

Edinburgh City Council undertook a series of consultations of residents' views between 1999 and 2005, culminating in a referendum. Support declined over this period from about 60 per cent support against 30 per cent opposition in 1999 (Cain and Jones, 2003) to the referendum result of 74 per cent opposition in 2005 (Saunders, 2005). As a consequence of this, the proposal was not taken forward – although the main part of the tram line has been constructed.

Saunders (2005) and Rye et al (2008) assessed reasons for the negative result of the 2005 referendum on congestion charging in Edinburgh as including:

- The lack of a non-political champion
- Public and other stakeholder mistrust of Council motives
- Misunderstanding of the charging proposals
- Major opposition to some elements of the proposals
- Insufficient connection between up-front investments and charging
- Lack of definition of the investment proposals
- Inadequate clear benefit for motorists
- Belief that government should pay for transport investment
- Belief that improvement of public transport on its own would reduce car use.

Other factors also played a part:

- Agreement to construct the tram line was reached in advance of the referendum, so those in favour of the tram did not need to support charging
- There were political and personal differences between the city council and the surrounding authorities.
- One part of the Edinburgh city council area lay outside the outer cordon; in order to avoid political defeat at local elections, the leading political party agreed to exempt these residents from the outer charge – which triggered a negative reaction among others living outside the ring road.
- There was no clear by-pass route for traffic wishing to avoid paying the inner cordon charge, and no plans to spend any funds on road improvements.

## 8.5 Manchester

The Greater Manchester metropolitan county (combined population 2.7 million in an area of 1277 km$^2$) comprises 10 local councils. The Greater Manchester Council (2008) developed plans for a cordon charging system with the two cordons illustrated in Figure 8.5. In the final proposal, inbound passage during the morning peak period would be charged at £2 for the outer cordon, with a further £1 for those passing the inner cordon. In the evening, a further £1 would be charged for outbound passage through each cordon.

The primary reason for proposing the congestion charging scheme was to support a central government initiative to trial congestion charging in UK cities, and so attract grant and loan funding from central government of around £2.7bn for a wide range of transport infrastructure improvements, covering both road and public transport (in particular, major tram extensions). However, the national regulations prohibited the introduction of a charge for using existing public roads with the primary aim of raising revenue, so that the local authority had to promote it as congestion reduction scheme (i.e. 'polluter pays'), rather than as a more attractive investment (i.e. 'user benefits') scheme.

This set a very negative tone, which was picked up by the media (Vigar et al, 2011). A public referendum was held in 2008, with the requirement that there should be a majority in favour in at least 7 out of the 10 local council areas for implementation. In the event, voters in each of the 10 local councils showed a clear majority against the proposal, with an average vote of 78 per cent of voters opposing it. As a consequence of this, the proposal was not taken forward. The local newspaper carried out its own poll and found that support would have been much higher had the authorities been able to 'sell' it as a match-funded investment package.

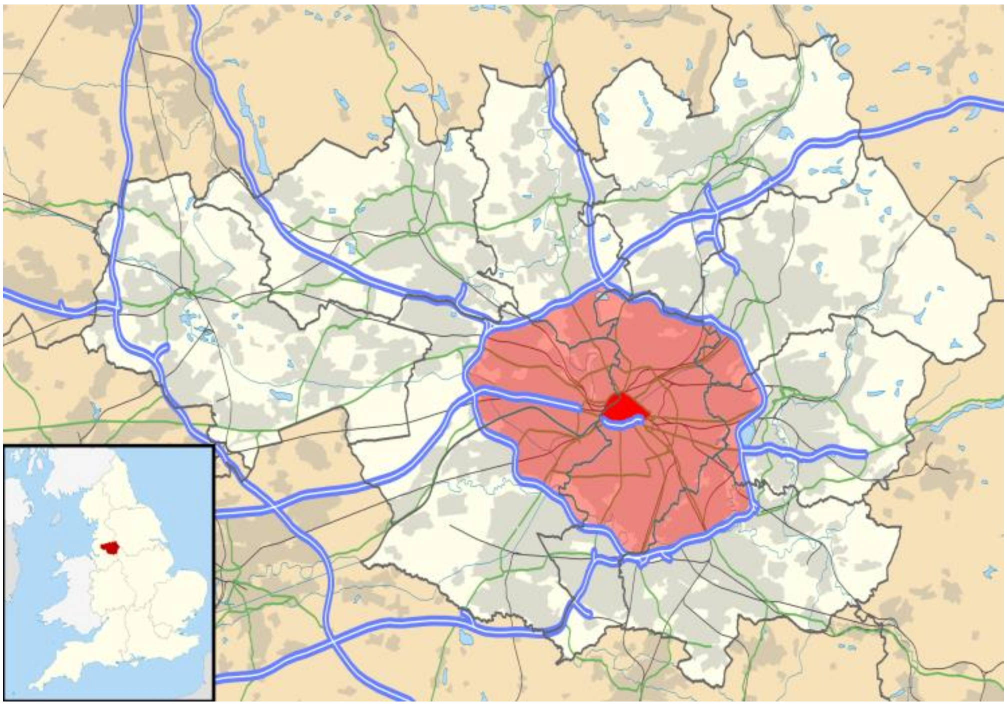


Figure 8.5: The proposed Manchester congestion charging areas
(Source: upload.wikimedia.org/wikipedia/commons/c/cb/Manchester_Congestion_Charge.png)

## 8.6 New York

Schaller (2010) summarises the main factors behind the unsuccessful attempt by Major Michael Bloomberg to introduce congestion pricing in the mid and lower part of Manhattan, New York in 2007/2008.

There was widespread agreement among supporters and opponents that problems of traffic congestion, poor air quality and additional funding for public transport in New York City needed to be addressed – particularly as population and employment were growing rapidly. The Major developed a comprehensive land use/transport sustainability plan to address these problems, and a poll of residents within New York City found 67% in favour and 27% opposed to the introduction of congestion charging between 6am and 6pm, Monday to Friday – provided the money raised was put into improved public transport. (Without certainty of full 'hypothecation' and 'additionality' of funds, support dropped to 40%.). There was also broad support from major businesses in the city and environmental and other advocacy groups.

However, the Republican City of New York had to get approval from the New York State legislature to introduce the scheme and Democrats in the State Assembly, championing the interests of a relatively small group of negatively affected car users (representing only 5% of employed New York City residents) were able to block the passage of the bill until after a deadline for receiving federal funding to introduce the scheme. Closer inspection shows this was associated with three underlying equity concerns:

- People living outside the charged area and driving in were generally much less wealthy than the residents inside the congestion charging area.
- Public transport alternatives were much poorer from some of the surrounding areas than others, and
- Drivers entering Manhattan from the west currently paid tolls, which would have been offset against the congestion charge – meaning that many would incur no increase in price, unlike those arriving from the east.

The author concludes that:

*"….gaining broad public acceptance and approval of congestion pricing [in a North American context] will require changing how motorists see pricing as affecting their own best interests. Given the ability of auto owners to thwart pricing through the political process, pricing programs need to be formulated such that drivers see fees or tolls as benefitting individual drivers".*

# 9. Assessment: Lessons learnt

## 9.1 Making the case for congestion charging

‘Congestion charging’ can be considered a short-hand description of a complicated concept founded upon Market Economy principles. As noted in Chapter 7, the term is often used - and mis-used - to describe various forms of road pricing and access charging, travel demand management, motoring taxation etc. It is important that such misunderstandings are addressed.

The three major successful schemes described in Chapter 8 have all had the explicit objective of reducing traffic congestion through reducing traffic levels. In London and Singapore, revenue raising was a by-product rather than an aim of the scheme, whereas in Stockholm is was implicitly a co-benefit.

That the Central London CCS raised substantial net revenues was largely incidental. It was ‘helpful’ that the scheme as a whole covered its operating cost and was able to relatively rapidly ‘payback’ its implementation cost and contribute to the overall costs of the operation of London’s transport system. The legislation stipulated that any net revenues were required to be hypothecated to London’s transport. That it generated any surplus was a by-product of the size of charge necessary to discourage traffic and the size of ‘fine’ necessary to achieve acceptable levels of compliance.

Fully appreciating and understanding the above is essential to enable the case for ‘Congestion Charging’ to be taken forward and developed in detail.

**Using pricing to tackle the problem of severe traffic congestion**

A congested transport system is an inefficient transport system. In principle, this issue can be overcome by changing/increasing supply or changing/reducing demand for transport. Figure 9.1 illustrates the case for charging, its relationship to Demand Management and various factors and consequences which need to be considered.

Supply side interventions to increase road capacity are in, general, expensive and in established cities are disruptive and can cause environmental problems. The exception tends to be public transport, where there may be some available ‘spare’ capacity, with scope to increase bus or rail frequencies. But at some point that mode too becomes congested and requires considerable investment.

Demand side interventions are in general less expensive than supply side ones. Care must, however, be taken to manage demand and avoid suppressing or destroying travel which is economically desirable. In essence, Congestion Charging is a travel demand management (TDM) tool.

Clearly, a combination of Supply side and Demand side measures as part of an integrated package approach to transport is likely to produce the ‘best’ solution. Political and public understanding and acceptance of this and change to these fundamental aspects of the transport system are not always widespread. This was discussed further in Chapter 3.

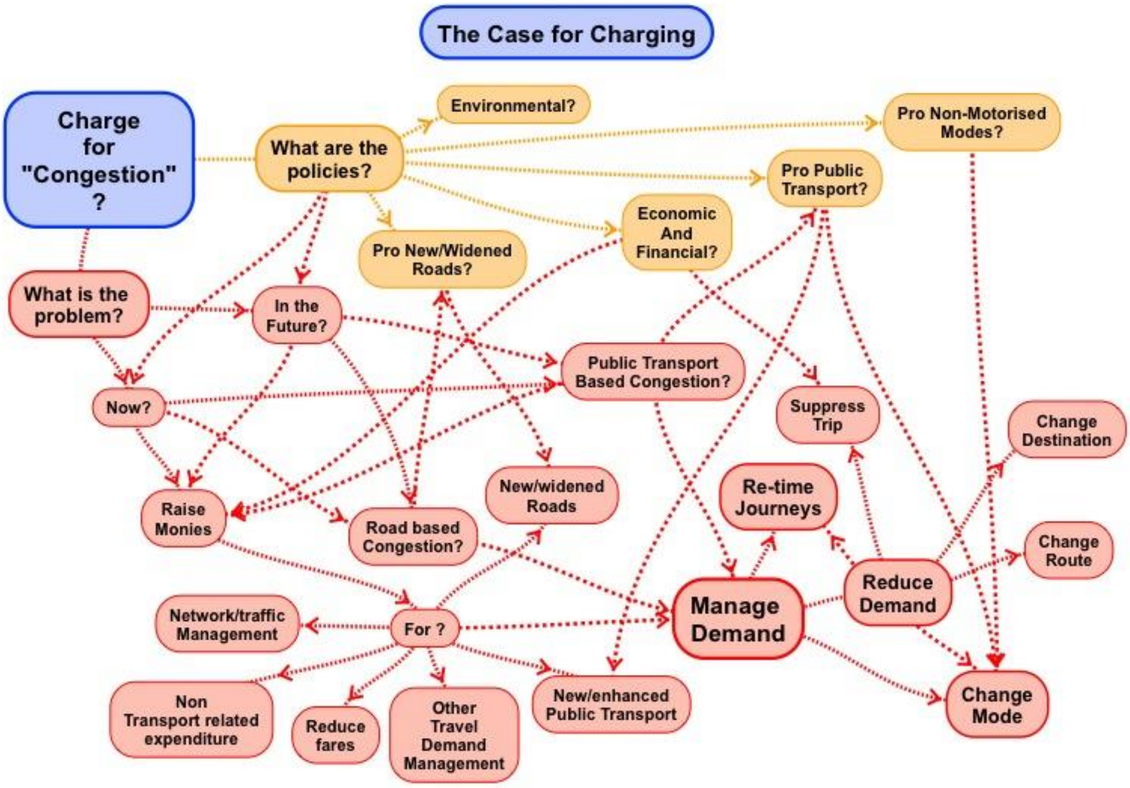



Figure 9.1: Factors affecting the case for introducing congestion charging

### Obtaining wider transport system benefits

Reducing road traffic congestion benefits a range of mode users and may help to make other modes more attractive at the same time as making car less attractive. As an example: buses in congested streets may not be used because they are unreliable despite being relatively cheap, clean etc. as their journeys are disrupted by parked and slowly moving vehicles. Reducing the amount of traffic in such circumstances generally has a disproportionate benefit on bus reliability. Similar benefits could be achieved for the buses by giving them priority over general traffic; however, the effect on the general traffic would then be to increase congestion and thus have an overall regressive impact.

### The economic case

In a market economy it is arguably unwise to continue to enable a scarce resource such as urban road space to remain ‘free’ at the point of use.

Transport congestion of any form is a huge and inefficient drain on the economy of a city. The increase in journey times, fuel costs and the large impact of uncertainty and unreliability all add significantly to the cost of business. Traffic congestion also completely undermines ‘just in time’ as a principle of efficient logistics, particularly impacting on day time postal and delivery services, and essential servicing trips (e.g. repairing a leaking pipe or a faulty computer system).

### The environmental case

Traffic delayed in congestion is a major cause of increased ‘greenhouse gases’, NOX emissions and particulates, as well as noise. Walking and cycling were perceived to be easier and more pleasant, and road safety also improved, following the introduction of the Central London CCS.

### Conclusion

The above provides a clear and strong case for a careful, comprehensive and detailed examination of urban congestion charging, especially when considered as part of an overall strategy of providing a package of TDM and public transport enhancements. It does not, however, necessarily preclude investment in new highway infrastructure; but, as with other TDM measures, it does provide an area-wide intervention and area-wide benefits with exceptional value for money – and also providing a revenue stream for other measures be they transport or non-transport ones.

It is also clear that there has to be widespread professional, public and political agreement that traffic congestion, or another externality such as local air pollution, is bad enough to warrant serious attention – and override traditional rights to ‘free’ road use by motor traffic. Although in London and Singapore the issue of how the monies raised would be spent was not central to the decision to implement the schemes, in other situations this may well be the case.

## 9.2 Lessons from Edinburgh, Manchester and New York

These three unsuccessful initiatives show that there are many challenges to be overcome in developing and implementing a successful urban congestion charging system. This is notwithstanding that a proposal is technically satisfactory, and that there is a clear public view that congestion is a problem and that public transport is in need of improvement.

These case studies demonstrate that achieving adequate public support for a specific charging system is in itself a major hurdle – compounded, in the New York case, by political posturing between the different parties at different levels of government.

In the UK cases, the major obstacles seem to have been a lack of clarity about governmental commitments, and diminishing public support in the run up to the planned date of scheme introduction – possibly arising because the costs become known whilst the benefits remain intangible. This dip in public support before implementation is a common phenomenon, which was addressed in Stockholm by introducing the scheme experimentally and only asking for views once the trial had ended.

In the UK examples there seems also to have been a lack of leadership and an individual champion for this approach, both locally and nationally. And, under British legislation, a requirement to focus on the ‘negative (charging for congestion) rather than the positive (funding transport improvements), made it more difficult to secure majority public support. From a public perspective, at best this sounds like being asked the question:

> "Would you like in the future to pay for driving into parts of town that in the past have been free?"

Which is unlikely to elicit a positive response.

## 9.3 General conclusions and recommendations

Looking across all the congestion charging scheme proposals, both successful and unsuccessful, some general guidance can be given:

1. There needs to be general acceptance among a sufficiently broad group of professionals, the public and politicians that current traffic levels and congestion are unacceptable – due to delays and unreliability, local air quality problems, need for $CO_2$ reduction, or whatever – and that 'something needs to be done'.
2. There is a need for vision and top-level national or local leadership (e.g. the role of the Mayor of London)
3. Mitigation measures should be introduced to tackle any potential boundary problems
4. Congestion charging needs to be positioned as part of a wider policy package to address a range of urban problems
5. More generally, scheme design needs to anticipate and deal with any major social and spatial equity issues.
6. Good, attractive modal alternatives need to be provided:
    a. In USA-style car dominated cities, on corridors where public transport is not competitive, this implies some form of 'value pricing' (i.e. offering a free, congested road lane alternative)
    b. In European-style cities where public transport is competitive with the car in journey time and out-of-pocket cost terms, this implies providing better public transport and walking/cycling facilities
7. Where support is more marginal, there are advantages in introducing the scheme experimentally and then inviting citizens to vote on whether to reintroduce the scheme (as in Stockholm); the evidence is that public support drops off just before implementation and then rises steadily after introduction
8. Local political support can be increased if central government offers matched funding – to the point where politicians might support a scheme without majority public support (e.g. as in Oslo, where it did not become an election issuer as all parties supported the scheme).
9. Where they are generated, net revenues should be hypothecated for transport investment and operating purposes

## 9.4 Taking a fresh approach

Although several cities have been able to introduce successful congestion charging schemes, the number is quite small in global terms. This section suggests and illustrates two strategies for gaining broader political and public support for charging-based measures, by:

- Framing the proposal in terms of paying for an improved service, rather than being penalised for causing congestion, and
- Considering schemes which explicitly link moving traffic and parking pricing

### 9.4.1 Dynamic charging for a guaranteed level of service

Cities could make use of new technology to provide a guaranteed service level for vehicle drivers, in real time:

- An on-board system calculates the optimum route for that journey, based on current or short-term predictions of traffic conditions
- Key corridors are kept ‘free flowing’ by limiting use through an appropriate level of dynamic charging
- Drivers are given a cost estimate to approve for obtaining an estimated travel time.

This could also be linked to dynamic booking and payment for a parking space close to the intended destination while making the journey, eliminating any parking search time.

### 9.4.2 Linking road use charging with provision of parking

There is scope for offering a new type of paid for product, which would reduce traffic levels in a selected area, by combining parking and road use pricing, taking into account the following considerations:

- Nottingham has successfully introduced a ‘workplace parking levy’, which charges larger employers a fixed annual fee for each parking space they provide for an employee, but:
    - Some employers have absorbed the charge, so there has been no influence on driver behaviour
    - In other cases where the charge has been passed on, some staff have stopped using an employer provided space, but there has been a big increase in on-street parking in residential streets, to avoid incurring the charge
- 25% - 30% of traffic in city centres is passing through, not stopping, so is unaffected by local parking charges; at the same time, cutting this out would have a major impact on congestion and pollution in that area

One solution might be to introduce an ‘Area Parking Charge’, in which vehicles entering the designated area pay a fixed fee:

- This entitles them to a period of free (e.g. 2 hour) public parking, so they get something for their money
- Even a low charge is likely to deter virtually all the through traffic – leading to a noticeable reduction in traffic levels
- It is no deterrent to shoppers etc. who contribute to the local business economy, since they already pay for parking and so would have a ‘neutral’ effect on this group
- But those with free workplace parking would pay some charge – so some car drivers may be encouraged to switch to other modes

# 10. Implications for Hangzhou and other Chinese cities

Each Congestion Charging scheme should be developed in response to the particular circumstances and policies in and governing that city. The size and general nature of Hangzhou tend to suggest that there are likely to be potential similarities with London, from which a significant amount of subsequent material informing this chapter has been drawn.

## 10.1 Strategic considerations

There are a large range of interrelated factors which would influence the development of a Congestion Charging scheme for Hangzhou: Policy, Detailed Design, Implementation and Operation. These are summarised in the Mind - Map in Figure 10.1 below.

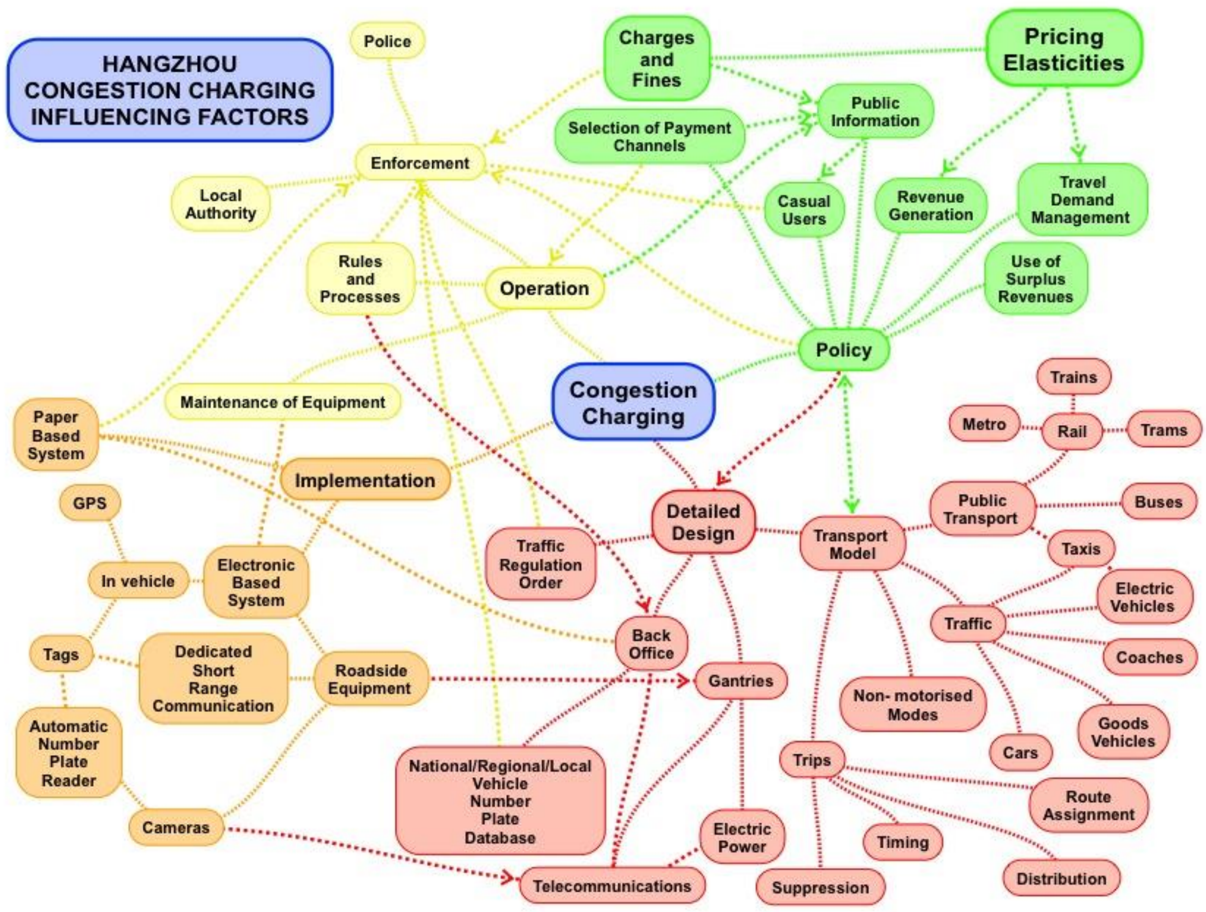



Figure 10.1: Mind map of factors to take into account in developing a congestion charging scheme for Hangzhou

Many of these factors are driven, or indeed decided, by Policy considerations. Key among these is whether the aim is to reduce congestion, raise surplus revenues, reduce pollution, or manage the transport system optimally as whole. Ideally, these decisions are informed by carrying out computer simulations in a Transport Model of the way all the various factors and assumptions interact.

### 10.2 Detailed design considerations

There are a number of important enablers for the development of a successful scheme. First and foremost is a reliable, robust and substantially complete vehicle register data base of the vehicles, their registration numbers (number plates) and the details of the 'keeper' or owner of the vehicles who are likely to incur charges. Without this any system would be unwieldy, subject to extreme abuse and be virtually unworkable.

Assuming that Policy decisions and guidance is obtained, the Detailed Design process, when it commences, should also use the Transport Model to assess the impact of the charges on trip making patterns, diversionary routes, etc. It may also prove necessary to iterate various parameters and assumptions with the Policy makers as the implications of the entire scheme become clearer. The Mind - Map in Figure 10.2 below summarises the Detailed Design considerations which will need to be decided upon during the design of the scheme.

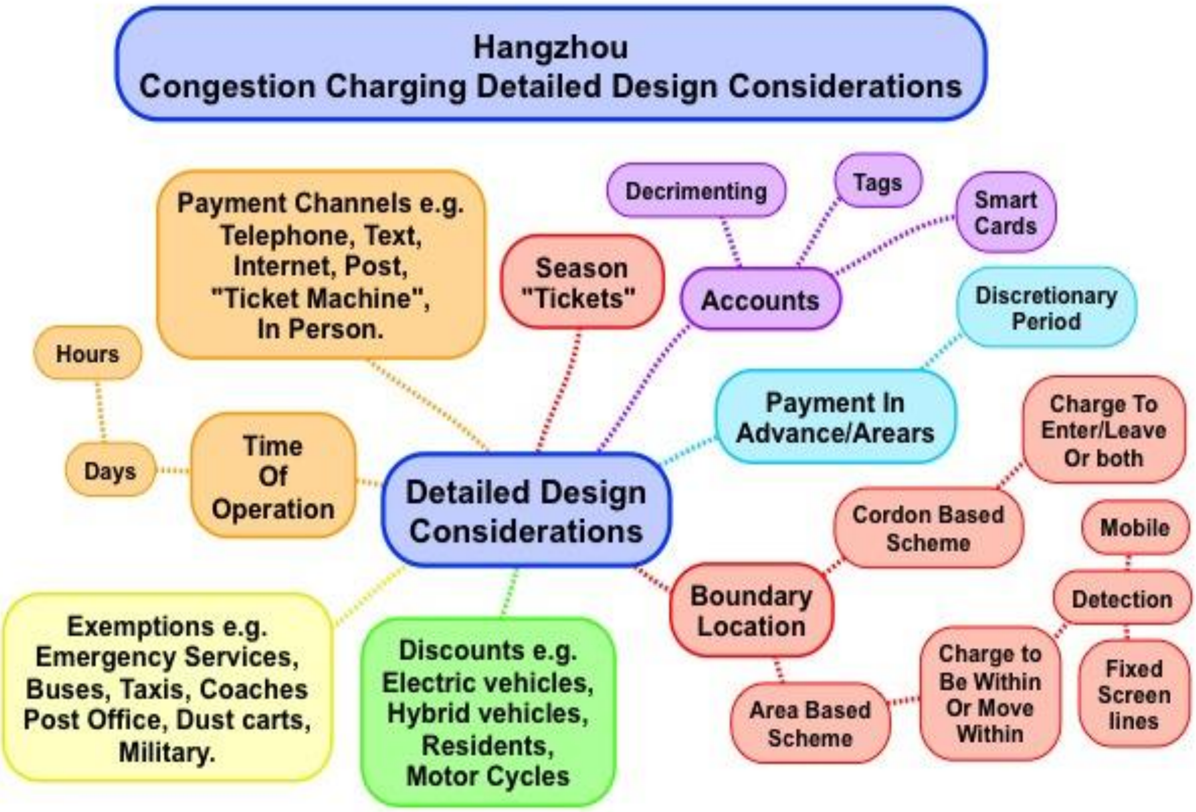



Figure 10.2: Mind map of detailed design considerations for Hangzhou

There are a large number of activities which are required to be undertaken to operate the scheme successfully, once implemented. The High Level Processes for a Western scheme are summarised in Table 10.1 below.

## 10.3 Operational and technical issues

A number of operational and technical “lessons” can be applied from other schemes to a potential Congestion Charging scheme for Hangzhou, as summarised in table 10.1 below:

| 1. Customer Channels | 2. Vehicle Detection |
|---|---|
| • Contact channels<br>• Payment channels<br>• Cash collection<br>• Account management<br>• Marketing and communications | • Vehicle passage records<br>• Tag transactions<br>• Manage detection data quality<br>• Manage on-street infrastructure<br>• Store evidence |
| **3. Back Office** | **4. Enforcement** |
| • Reconcile vehicle transactions and payments/accounts<br>• Manage exemptions and discounts<br>• Process customer accounts and registrations<br>• Manage customer data quality<br>• Reconcile interoperable accounts<br>• Verification of vehicle detection records<br>• Refer non-payers to enforcement<br>• Process top-ups/billing of post-pay accounts | • Validate violation data/evidence<br>• Gather owner records from Vehicle Registrar<br>• Issue violation/penalty notices<br>• Receive penalty payments<br>• Manage enforcement data quality<br>• Register debts<br>• Manage input to court process<br>• Manage appeals<br>• Identify persistent non-payers<br>• Initiate debt collection/bailiff action<br>• On-street enforcement<br>• International debt collection |

Table 10.1: High level processes that contribute to successful congestion charging scheme operation

a) The scheme needs to be made easy for drivers to understand and use; collecting payments through customer accounts and the internet are the preferred and lowest cost methods for the majority of schemes elsewhere. Cash/retail and telephone Call Centre channels may also be required but have a high processing cost. Casual users – those without accounts - need to have an easy means to pay that is also cost effective.

b) Once drivers have become used to the operation of a scheme, early provisions for excess customer channel capacity can be fine-tuned to optimise customer service and operating costs. Lower cost channels should have incentives to increase their use.

c) The majority of area or cordon schemes use cameras for vehicle detection. Tag and beacon is primarily used as an addition to cameras where there is strong business case for improved detection rates, offsetting the additional cost of issuing and managing tags; this is usually where there are multiple detection events needed to calculate the charge due. There are currently no urban schemes that use GPS devices for road pricing.

d) Data quality is a key driver of scheme operating cost and efficiency in collecting revenue, including enforcement evidence, customer data and transaction data.
e) The quality of vehicle registration data held is a key determinant of the approach to enforcement.
f) The on-street detection infrastructure can be intrusive and needs to be carefully considered. The detection equipment can also impact nearby parking, driveways and access which can make it hard to locate.
g) Enforcement processes should build on existing proven processes that drivers already understand primarily to make them acceptable and increase compliance.
h) The categories of exemptions and discounts should be minimised as there can be significant costs in processing them in addition to the revenue foregone. For example, in London over 60% of vehicles driving in the city are exempt or discounted.
i) The costs of other schemes are generally not a reliable benchmark for planning a new scheme as there are so many factors that make the schemes different. Cost of collection as a proportion of the revenue collected can range from 15-70% depending on many local factors. Unit costs, are however, more comparable e.g. per camera, call centre payment, card payment. Therefore, it is generally more useful to model the costs and revenue of a specific scheme based on the intended charging parameters, a high level design, traffic data and unit costs for the transactions involved. Most charging scheme projects initially under-estimate the costs of operation and interacting with 'customers' and take some time to fine tune their operations.

One of the key challenges for charging schemes has been whether users can easily understand how the scheme operates and therefore the actions they must take to use it efficiently. The high cost of compliance for end users often stems from users not being able to easily understand the scheme. This can then impose additional loading and costs on the operation of 'customer' channels and also feed stakeholder objections if service levels are not met under high loading conditions. It is likely that these behaviours and the resultant cost and inefficiencies would be seen with a Congestion Charging scheme in Hangzhou, unless an extensive programme of public information and education was undertaken.

Concern about these issues in the London scheme led from the outset to the development and use of a large range of Payment Channels – Retail, Web, Mobile Text, Telephone and Interactive Voice Recognition (IVR). The initial percentage use of each channel is shown in the Figure 10.3 below:

The optimal use of the various payment channels continues to be important up to today. What is noticeable in Figure 10.4 below is the steady move towards more technology-based payment channels. This probably reflects both the public becoming more comfortable and confident with technology in general and the way the London Congestion Charging scheme operates. (Note, the 'Fleet Usage' is in essence a Web based application). The use of Retail and the Telephone Call Centres played a vital part in gaining the public's confidence in and understanding of the scheme as they would be very likely to in the early days of any Congestion Charging Scheme for Hangzhou.

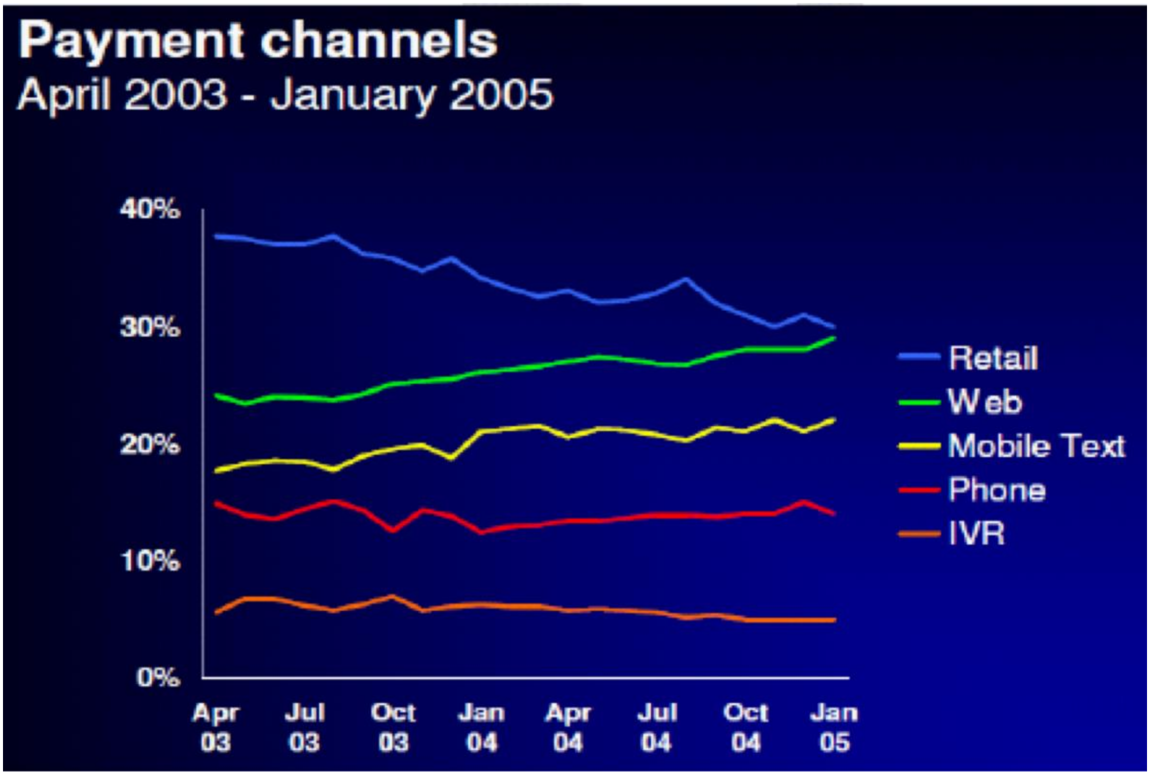



Figure 10.3: Payment channels in the early years of the London charging scheme
Source: Transport for London

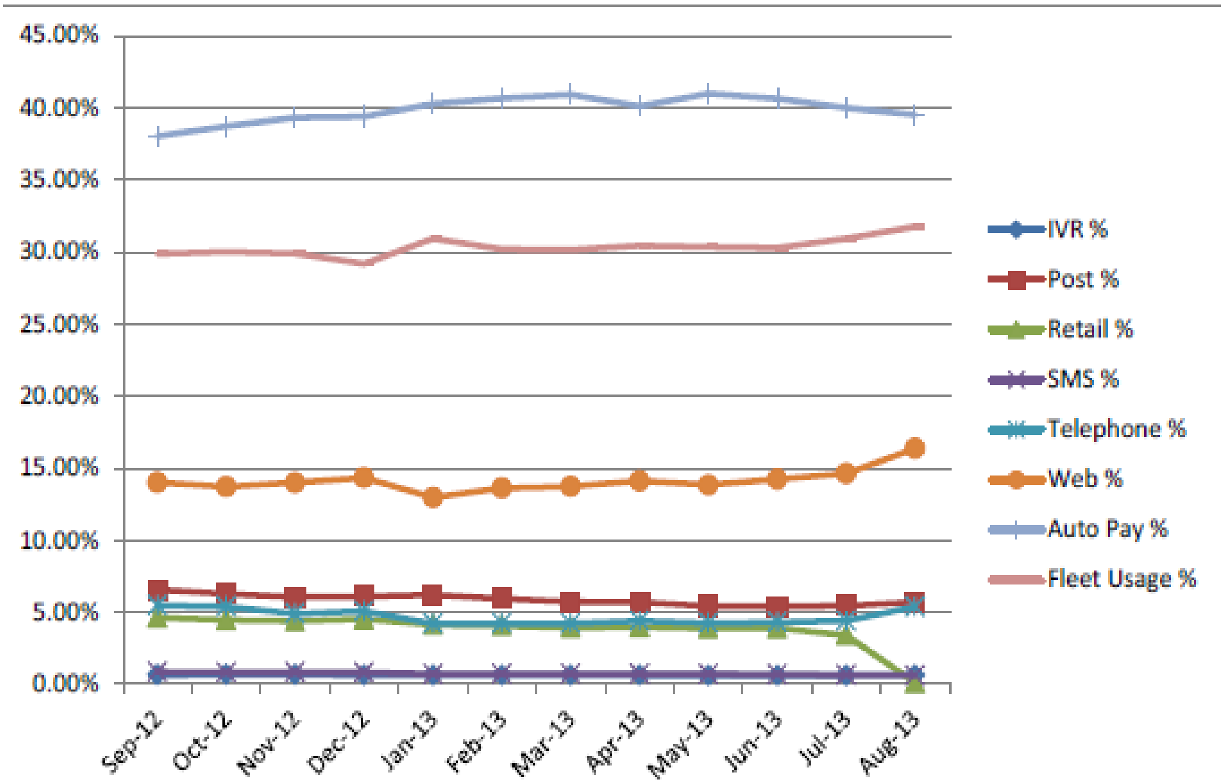



Figure 10.4: Payment channels now used in the London charging scheme
Source: Transport for London

### 10.4 Equipment, Roadside Infrastructure and Implementation.

On Board Units are not necessary to implement a successful charging system. It is sometimes argued that such devices are needed to reduce the cost of operating the system. Against this, however, must be weighed the matter of how the Occasional or Casual User will be charged and the fact that, to achieve compliance with the regulations, enforcement will be necessary and to be practical it is necessary to install roadside cameras and automatic number plate readers. Such equipment clearly relies on the chargeable vehicles to display a readable number plate and for that number plate to be held on a central vehicle register along with the details of the owner/keeper of the vehicle.

Figure 10.5 indicates a typical layout of this type of equipment for a two-way road, and the following photograph shows an example of an installation which is part of the Central London Congestion Charging scheme. It shows that the equipment and roadside infrastructure, here in the centre of the photograph, can be relatively unobtrusive especially compared with the earlier photograph (Figure 8.2) of an example of the Stockholm Congestion Tax which at the pilot stage used cameras, automatic number plate readers and tag and beacon readers all supported on a series of gantries.

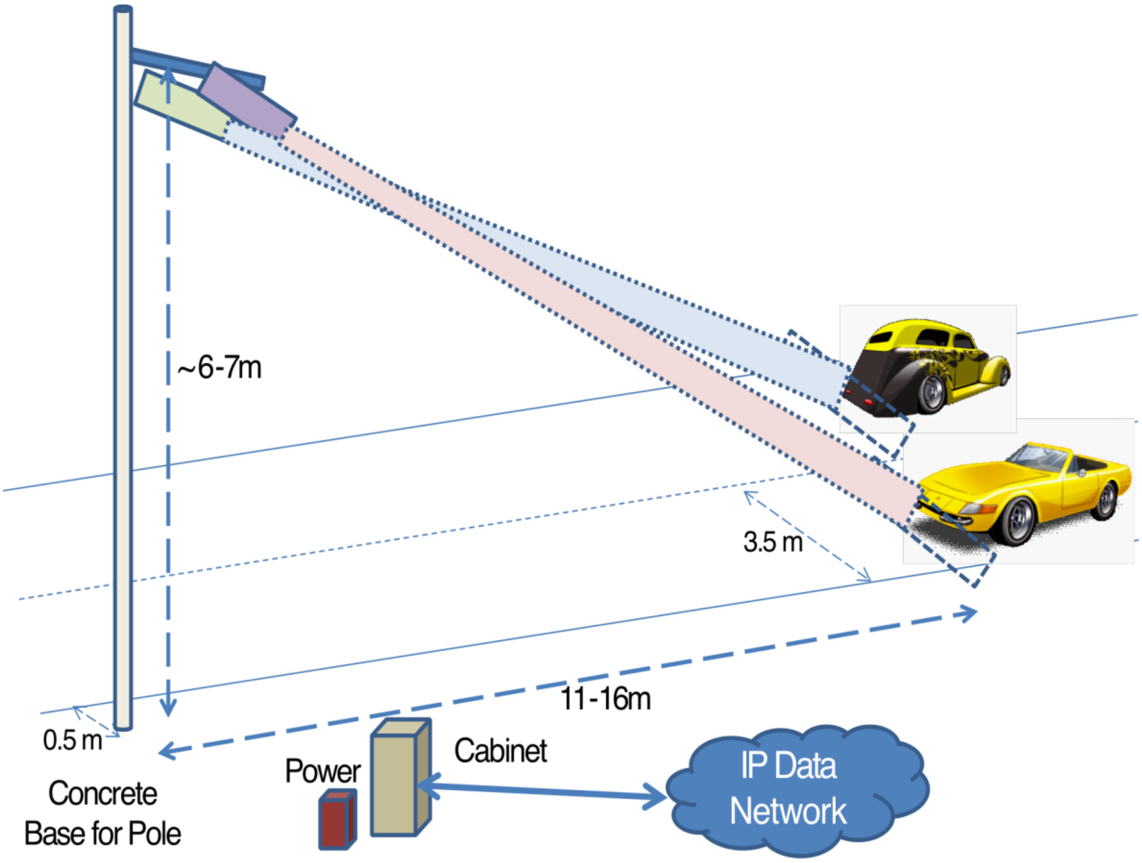



Figure 10.5: Typical layout of number plate reader and enforcement cameras in London (above) and example of implementation (below)
Photograph source: Transport for London

Roadside Dedicated Short Range Communication (DSRC) equipment, or beacons, which are necessary to accompany a Tag based scheme can also be pole mounted as is shown in a typical arrangement below (Figure 10.6). The Tag and Beacon schemes do also have the added issue of how to deal with the supply, installation and maintenance of the Tags.

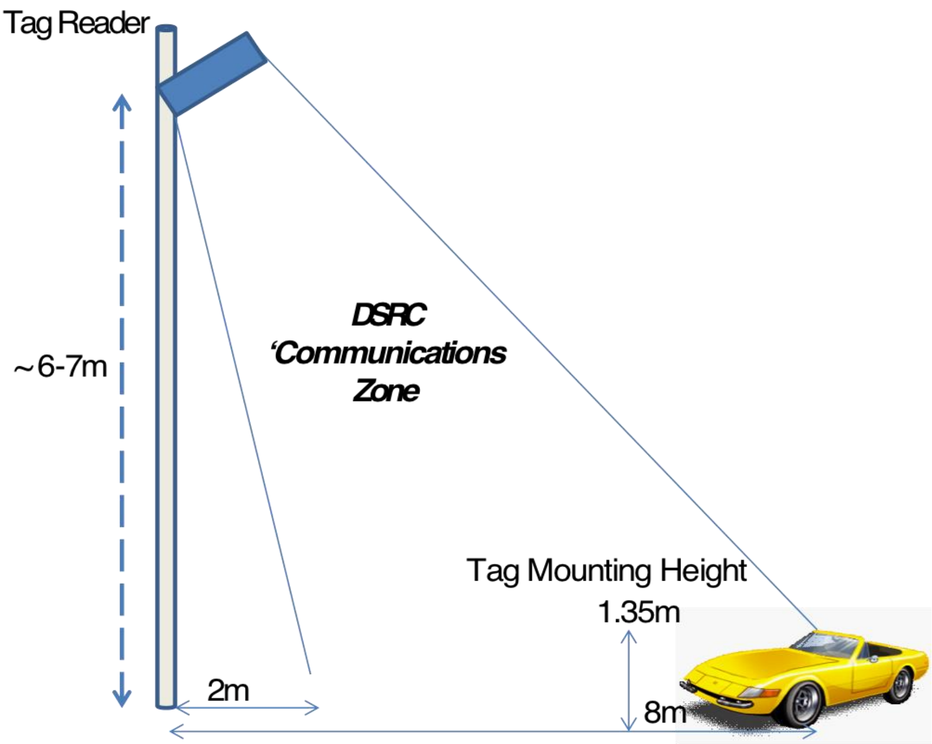



Figure 10.6: typical layout of camera and tag reader system

### 10.5 Conclusions

The implementation of any Congestion Charging scheme first involves detailed consideration of a wide range of differing aspects. These are summarised in Figure 10.7 below. These aspects can be tackled as discrete packages of work or often combined into larger ones of related packages with the possibility of their delivery being contracted out. It should be noted, however, that few companies are able to cover all, or indeed most, of the wide range of disciplines involved.

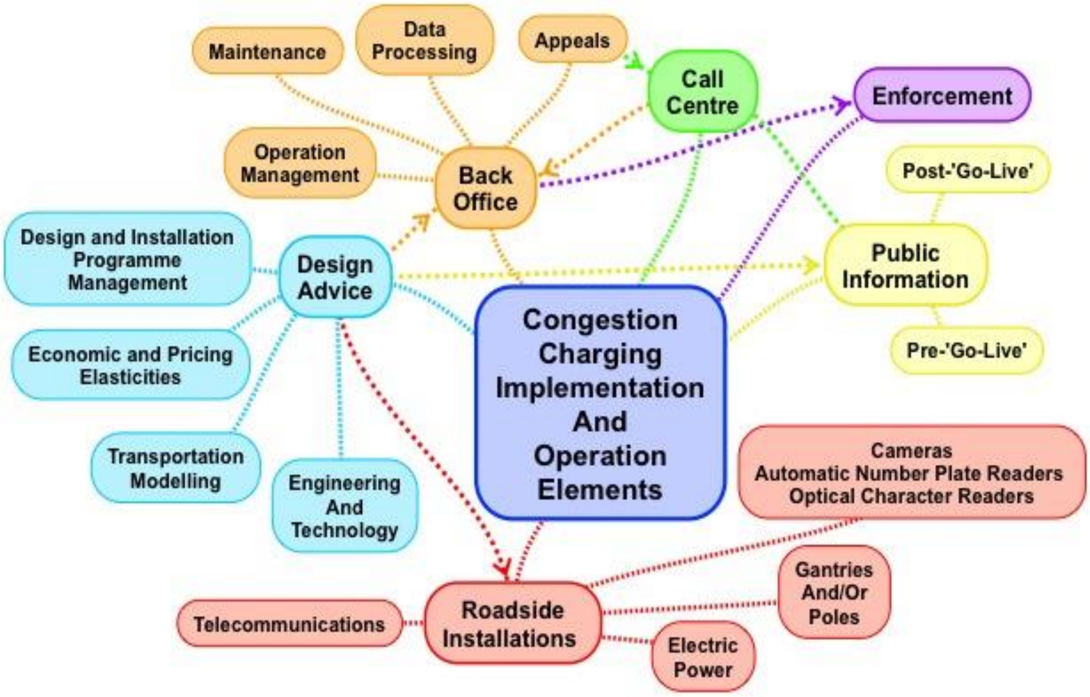



Figure 10.7: Range of technical and operational issues to take into account

The three successful city schemes reviewed in Chapter 8 demonstrate that charging schemes can be successfully introduced. They also show that many of the commonly held views and fears about Congestion Charging are totally unfounded. What is striking is that the literature does not provide any evidence of Congestion Charging schemes having been withdrawn - modified yes, but totally removed, no.

It is also clear that it is not the technology which is the controlling or limiting factor regarding the successful implementation of Congestion Charging schemes, but the need for clear firm and long-term strategic leadership.

From this strategic review it can be concluded that:

1. There is no fundamental reason why a congestion charging scheme cannot be successfully developed for Hanghzou and similar size Chinese cities
2. Technology is not the constraining factor in the development of the scheme
3. An integrated approach to the City and its transport problems should be adopted; one that includes the further investigation of Congestion Charging

To make progress in cities such as Hangzhou, it will be necessary to address a number of questions, such as:

1. Why is the possible introduction of Congestion Charging being examined?
2. What are the city's and region's current transportation policies and aims?
3. What are the fundamental demographic, economic and transport trends and traffic predictions facing the region and the city?
4. What are the current institutional arrangements for transportation in the region and city?

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