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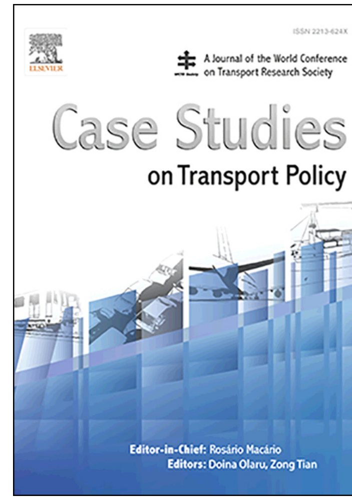

Tackling Urban Traffic Congestion: the experience of London, Stockholm and Singapore

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Tackling Urban Traffic Congestion: the experience of London, Stockholm and Singapore

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Abstract

It is generally supposed that the most credible approach to mitigating urban road traffic congestion is by charging for road use. Congestion charging has been in operation in three major cities for some years. The most extensive data is available for London, where the introduction of charging led to an immediate decrease in both traffic and delays; however, congestion returned to previous levels over subsequent years. A similar initial decrease in traffic and delays was observed in Stockholm. In Singapore, where the cost of car ownership is substantial, charging has enabled acceptable traffic speeds to be maintained. Evidence from these cities provides little support for the general use of congestion charging to limit demand for car use in urban areas. Congestion is therefore difficult to mitigate, but is also self-limiting, given the time constraints on travel behaviour. While delays arising from congestion are not easy to alleviate, there is scope for reducing journey time uncertainty.

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1. Introduction

Road traffic congestion is arguably the main problem of the transport system. It results in journeys that are both slower and less reliable than they would be in the absence of congestion. While there are considerable technological and policy opportunities for tackling detriments associated with pollution from vehicle emissions and road traffic accidents, congestion seems a more intractable challenge.

Congestion mainly arises in or near densely populated areas with high levels of car ownership, such that road capacity is insufficient to accommodate all the trips that might be made, particularly during morning and evening travel to and from work. Measures to tackle congestion, whether by increasing capacity or managing demand, need to allow for the possibility that faster journeys lead to more and/or longer trips being made by road users previously deterred by the expectation of time delays.

The approach to tackling road traffic congestion that is generally supposed to have greatest credibility is to charge vehicle users according to the level of congestion. The purpose of this paper is to assess the policy approaches to mitigating urban road traffic congestion in the light of the available evidence from the three major cities in which congestion charging has been implemented – London, Stockholm and Singapore.

2. Responding to congestion

In the second half of the twentieth century, growth of car ownership prompted extensive road construction programmes in the developed economies generally. New urban motorways and freeways in many cities accommodated traffic growth, but without relieving congestion on account of the 'induced traffic' – the new trips made possible by the increased road capacity. However, such high capacity roads proved to be detrimental to the urban environment, severing communities and generating air pollution, as well as incurring substantial construction costs. Construction of new roads in existing urban areas is therefore now less common in developed economies. Accordingly, to tackle congestion, attention has focused on measures involving demand management. In practice, managing parking capacity has been widely used, quite successfully in medium sized cities, given the need to be able to park at both ends if a car trip is to be made. However, the approach most attractive to economists is road user charging, also known as road pricing or congestion charging, implemented in certain cities, the largest being London, Stockholm and Singapore.

The basic economic argument for congestion charging is well established (ITF, 2010). In essence, since journey times increase with traffic volumes, an additional car on the road slows down all other cars, increasing time costs for all the occupants. The decision to travel made by the occupants of an additional car is based on their own travel costs (their private or internal costs). They ignore any increase in travel costs for all other car users (the external costs). This is inefficient when private costs are below the full social cost of the decision to travel. When decisions are made on the basis of underestimated costs, too much of a good (in this case, travel) will be consumed. A congestion charge is intended to confront users with costs imposed on other users, so as to align private costs with social costs. The charge will suppress part of demand, reducing congestion and generating net revenues.

Glaister (2014), in a recent review, observed that road user charging has been advocated by many of the greatest economists and wondered whether the scepticism held by most others, including many in the transport planning profession, comes from a distrust of economists or a lack of understanding of the underlying principle. As discussed below, scepticism is a reasonable response to the limited evidence for the efficacy of congestion charging in practice.

3. Road user charging in practice

3.1 London

Congestion charging was implemented in a zone in Central London in February 2003 (Glaister and Graham, 2006; Richards, 2006). The initial charge of £5 per day was raised to £8 in July 2005, to £10 in January 2011, and in June 2014 to the current charge of £11.50 per day for driving a vehicle within the designated zone between 07.00 and 18.00 hours, Monday to Friday. A range of discounts and exemptions are available for certain groups and in respect of certain vehicles, including exemptions for taxis, private hire vehicles and low carbon emission vehicles, and a 90 per cent discount for residents of the charging zone. Analysis of camera data indicated that in the charging zone around half of cars pay the full charge, some 30-40 per cent are exempt and around 10 per cent receive residents' discounts (Evans, 2008).

The scheme was extended to a Western zone in 2007 but this extension was withdrawn in 2011, following a change in political leadership. The charging scheme is operated by Transport for London (TfL) the public body responsible for public transport and major roads. Six detailed annual reports were published up to 2008, after which reporting was included in the main annual report series 'Travel in London'.

The final annual report on congestion charging provides a perspective on five years' experience of operations in the central zone (TfL, 2008). The initial introduction of charges in 2003 led to a reduction of car traffic entering and leaving the zone of 33 per cent, following which entering/leaving traffic of all kinds has remained at broadly stable levels. For all four-wheeled vehicles, including cars, vans, lorries, buses and taxis, the initial reduction was 18 per cent, followed by relative stability. The increase in the charge in 2005 had virtually no further impact on traffic levels, which suggests that those car users more sensitive to price had largely been deterred by the initial £5 charge and that the remaining car users are less sensitive to additional charges (Evans, 2008). Such relative price inelasticity may be due to factors such as the congestion charge being a relatively smaller proportion of the overall running costs of more expensive cars or to the charge being treated as a business expense.

TfL estimates congestion by reference to the 'excess travel rate' - minutes per kilometre (the inverse of speed), comparing travel rates in the early hours of the morning with those during charging hours. Immediately prior to the introduction of charging, the mean excess travel rate was 2.3 min/km. With charging in place there was an initial 30 per cent reduction to 1.6 min/km. However, this parameter steadily increased in subsequent years, returning to 2.3 min/km by 2007, as shown in Figure 1, despite the increase in charge in 2005.

Vehicle-km driven within the charging zone decreased a little between 2003 and 2006 (from 1.45m to 1.41m, TfL, 2007), while delays due to congestion were increasing. Subsequently, traffic in the charging zone has continued to decrease, being 25 per cent lower in 2016 than in 2007 (TfL, 2016a).

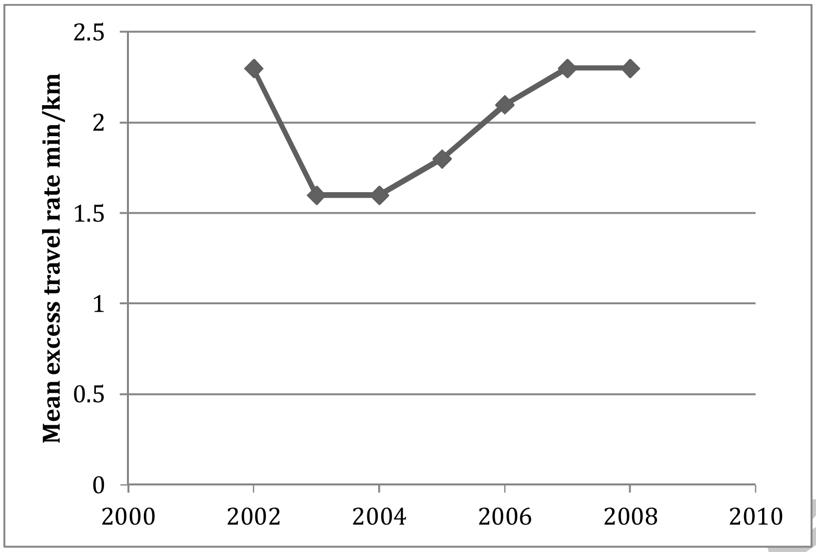

Figure 1. Mean excess travel rate in congestion charging zone.
Source: Table 4.1 of TfL (2008).

Although introduction of congestion charging led to a significant and sustained reduction in traffic entering the zone, the initial impact on congestion proved short-lived. TfL accepts that congestion within the zone has returned to its previous level, despite there continuing to be less traffic: this is attributed to providing more road space for walking and cycling, and improvements to public transport, urban realm and road safety (TfL, 2017). Other factors cited include reduction in effective capacity of the road network due to street works and major building works; and changed timings of traffic signals for reasons of traffic management and pedestrian safety (TfL, 2008).

London congestion charging has been successful in many respects: its implementation was the result of skilful political leadership; there is good public acceptability, with no pressure to withdraw or reduce the charge; and the technology, which uses number plate recognition cameras to enforce compliance, has proved reliable. Moreover, there is a useful net financial surplus used to support public transport provision: in 2015/16 gross income was £258m, less £90m of operating costs, yielding net income of £168m (TfL, 2016b).

However, the main purpose of the London congestion charging zone was to reduce congestion and journey times, and in this respect it has not succeeded. What has been observed is an immediate reduction in time delays following introduction of the charge, followed by a rebound over time to previous congestion levels, as previously noted by Givoni (2012). There is no evidence as to whether journey time reliability has changed, as discussed below.

3.2. Stockholm

Congestion charges were introduced in Stockholm in 2006 as a seven-month trial, followed by a referendum where a majority voted in favour of the charges. This led to the permanent reintroduction of congestion charges in August 2007. Eliasson (2014) has summarised the experience.

The charging system consists of a cordon around the inner city, with a time-differentiated toll being charged in each direction. The peak charge is rate is 35 SEK (about £3). Traffic across the cordon was reduced by around 20 per cent, a reduction that has remained stable over time.

Congestion in Stockholm is measured by a congestion index where 0 per cent corresponds to free-flow travel time, while 100 per cent corresponds to twice the free-flow travel time. Significant reductions in congestion were observed, comparing a period before introduction of the charge with the period immediately after, the magnitude depending on the class of road and the time of day and of year. For example, for arterial roads in the evening peak, a congestion index of 100 per cent was observed in October 2006 in the absence of charges, which fell to 50 per cent a year later when the charges were operative. However, there appear to have been no measurements of congestion beyond the short-term impact, so it is not possible to assess whether congestion reduction has been permanent, or whether temporary, as in London.

As for London, the Stockholm charging scheme reflects effective political leadership; the technology based on number plate recognition has worked well; and useful revenues have been generated. But the impact on traffic congestion in the medium term is unproven.

Congestion charges were introduced in Gothenburg in 2013, similar to the Stockholm scheme. Reduction in traffic volume across the cordon stabilised at 12 per cent after 8 months. However, only minor reductions in congestion were observed on roads within the cordon (Borjesson and Kristoffersson, 2015; Andersson and Nassen, 2016).

3.3. Singapore

Singapore introduced a congestion charge based on a paper licence in 1975, which was replaced in 1998 with Electronic Road Pricing (ERP), utilising a payment card inserted into an on-board unit that interacts with an exterior system of radio beacons mounted on gantries (Santos, 2005). The scheme covers a central restricted zone plus lower charges on four further zones. The aim is for vehicles to travel at a consistent speed in the restricted zone – between 20 and 30 km/h on urban roads and between 45 and 65 km/h on expressways. Accordingly, charges are assessed quarterly by measuring average speeds: if speeds fall below a threshold, charges are increased to reduce the volume of traffic, whereas if speeds are above the threshold, charges are reduced. Charges also vary by vehicle class, time of day and location. Traffic is quite sensitive to ERP even though the charges are relatively low (Olszewski and Xie, 2005).

Traffic volumes in the central business district were reduced by about 10-15 per cent following the introduction of ERP (Chin, 2010). Data on traffic speeds published by the Singapore Land Transport Authority show that average speeds at peak hours on expressways have been consistently in excess of 60 km/h in recent years, and for central arterial roads around 28 km/h, in line with the objectives (end note 1).

Private car ownership in Singapore is limited through a licence bidding system aimed at restraining growth of the car stock to match planned increase in available road space. Vehicles are consequently expensive to purchase: a Certificate of Entitlement to own a car for 10 years may cost S$80,000 (about £40,000), and car ownership is only about 100 cars per 1000 population, compared for instance to 450 cars per 1000 for the UK population. Revenues from licences are far greater than from congestion charges, so the latter are no of policy concern.

In effect, road user charging in Singapore comprises two elements: a high fixed charge for access to the network; and a low variable charge reflecting the use made as a function of congestion.

4. Lessons from three cities

The common experience of congestion charging in London, Stockholm and Singapore includes: effective political leadership to implement the scheme and secure general public acceptability; a satisfactory technology for charging and enforcement; and generation of useful net revenues to support the transport system.

However, in the case of London, while a permanent reduction in traffic was achieved, the reduction in congestion was short-lived - delays reverted to pre-charging levels five years after charging was introduced. Likewise, in Stockholm, a reduction in both traffic and congestion were observed immediately after charging was introduced; however, congestion was not monitored thereafter, so whether or not congestion reverted to previous levels is unclear.

Congestion arises in densely populated urban areas with high levels of car ownership, particularly at times of maximum demand when people travel to and from work. There are therefore many more trips by car that could be made but are not (suppressed trips), due to anticipated time delays arising from congestion. Alternatives chosen include adopting a different mode of travel, time or destination, or not making the trip at all. An important determinant of such choices is the time available to the individual for travel.

Travel time has been monitored in national travel surveys and has generally been found to be invariant at about an hour a day (Schafer and Victor, 2000; Schafer, 2000; Mokhtarian and Chen, 2004; Metz, 2008). This implies that there is a time constraint on daily travel, reflecting the many other activities that have to be fitted in to the 24-hour day. The prospect of congestion delays exceeding the individual's travel time availability is a deterrent to car use. Accordingly, congestion is generally self-limiting – as traffic increases, delays increase, and the incentive to make other choices increases for those who are flexible. Gridlock is generally avoided, aided by urban traffic management systems that micro-manage traffic flows.

For the same reason, road traffic congestion is difficult to mitigate. The introduction of congestion charging in London and Stockholm reduced traffic as those road users who were cost-sensitive vacated the charging zone. However, the resulting reduction in congestion would tend to lead to a rebound, as those who were more time-sensitive but less cost-sensitive would make more and/or longer trips, until congestion reverted to its previous level.

As noted earlier, the explanation offered by Transport for London, that the rebound was due largely to changed use of road space, implies that without such changes, the reduction in congestion would have been permanent. It is of course hard to substantiate such a counter-factual. In any case possible explanations are not mutually exclusive in that the traffic reduction resulting from introduction of the charge is likely to have facilitated the changed use of road space.

The experience of Singapore is quite different from that of London and Stockholm. The very high charge to own a car restrains ownership to a far lower level that would be the case for a city with similar personal incomes and usual costs of ownership. This, coupled with dynamic road charging, allows congestion to be largely mitigated. However, such high ownership charges are unique to Singapore, a constrained island state with no areas of low population density.

Dynamic road pricing has been applied elsewhere, for instance the long established I-15 Express Lanes that provide 20 miles of travel in San Diego free for carpools and buses. Solo drivers can use the Express Lanes for a fee, paying electronically, which may vary from 50 cents to a maximum of US$8 depending on trip length and traffic in the lanes. Toll charges are adjusted to ensure free flow, with charges displayed on signs to allow driver to decide whether to pay the toll to use the Express Lanes or to use the uncharged but congested lanes (end note 2).

Express Lanes open only to multi-occupancy vehicles incentivise shared use. Dynamic road pricing allows spare capacity on the Express Lanes to be used by solo drivers for a charge, reducing congestion somewhat on the other lanes. The Express Lanes illustrate how buses can achieve speed and reliability if protected from general traffic. However, Express Lanes on multi-lane highways are feasible only in limited circumstances.

5. Other measures for mitigating congestion

There are a range of interventions that may affect the level and composition of traffic and that are commonly supposed to mitigate congestion. Constraints on parking provision at destinations, including a Workplace Parking Levy (Dale et al 2017), may reduce car traffic, given that a trip will not be made without reasonable assurance of parking availability. In high-density cities, constraints on residential parking limit car ownership, as for example in inner London boroughs where only 25-45 per cent of households have access to a car, compared with 50-75 per cent of outer boroughs (TfL, 2013). Parking location apps may reduce traffic cruising to find a space. Dynamic pricing of parking, as in San Francisco, can improve parking availability and thus reduce cruising (Pierce and Shoup, 2013; Ng, 2016). Promotion of active modes of travel may get some drivers out of their cars. Freight consolidation may reduce the number of urban delivery vehicles. Shared use of taxis may reduce taxi use; shared use of cars likewise. It is claimed that all these approaches could lessen congestion. Nevertheless, it is to be expected that suppressed trips will emerge to take advantage of the road space freed up by such measures.

New road transport technologies are attracting much interest and development effort. The question for policy is whether new technologies are likely to reduce congestion (in which case they should be encouraged), worsen congestion (discouraged), or have little impact, in which case the market could be allowed to operate. Electric vehicles seem unlikely to impact on congestion levels. For autonomous vehicles (AVs) the position is unclear: they might operate with reduced headway, making more efficient use of road space; but demand might be greater since no driving licence would be required; taxis without drivers would reduce costs and attract more demand; parking space might be saved, but mainly off-street and in suburbs; but empty AVs would add to traffic.

While reducing congestion is difficult, and looks likely to remain so, the experience of London and Stockholm suggests that, nevertheless, it is possible to reduce traffic levels through a combination of congestion charging and measures that reduce road space available for cars. Generally, the evidence is that traffic levels are determined by road capacity. Interventions that increase road capacity lead to previously suppressed trips now taking place, resulting in 'induced traffic' (Goodwin, 1996; Small, 1999; Noland and Lem, 2002) – hence the experience that we can't build our way out of congestion (Duranton and Turner, 2011). The composition of traffic can also be varied, for example by allocating carriageway to bus or cycle lanes. Congestion charging would favour road users having higher values of time and of income, including users for whom the charge is a business expense, such as taxis and private hire vehicles.

6. Reliability of journey times

Although congestion is difficult to reduce, there is nevertheless scope for mitigating its impact on road users. Congestion results in both slower journeys and lessened journey time reliability. When road users are asked in surveys why congestion is a problem, their response is that journey time uncertainty is of more concern that time delays compared to free flow (Costley and Gray, 2013). Journey time uncertainty can be reduced by providing predictive journey time information at the outset of the trip, as offered by route guidance apps. Road users taking advantage of such information would reduce their exposure to congestion if they were able to travel outside peak times. Those constrained to travel during peak congestion may be able to take advantage of less busy routes. The benefits of digital route guidance technologies do not depend on the implementation of congestion charging.

Other means of improving journey time reliability for urban residents include investment in rail routes, and insulating buses from general traffic, as with Bus Rapid Transit. Where a city is experiencing population growth in circumstances where the full use of road capacity effectively prevents growth of traffic, the share of car journeys declines, thus exposing a smaller proportion of the travelling population to road traffic congestion. For instance, in London, which has been experiencing quite rapid population growth, the share of car use has declined from 50 per cent of all trips in 1993, to 36 per cent currently, with further decline projected (Metz, 2015).

7. Conclusion

Traffic congestion arises in areas of high population density with high levels of car ownership. Many potential car trips do not take place (are suppressed) by the expectation of time delays that would exceed the individual's daily time availability (which on average is about an hour a day). Congestion therefore tends to be self-regulating: if traffic increases, delays increase and the more flexible road users make other choices, whether to travel at a different time, by an alternative mode, to another destination, or not to travel at all.

The same logic argues, consistent with the available evidence, that measures aimed at reducing congestion, such as London's congestion charge, would fail in this aim on account of previously suppressed car trips now being made: initial reductions in congestion reduce time delays and make car trips more attractive, a conclusion earlier reached by Givoni (2012).

There would be a level of the congestion charge at which sufficient road users would be price-sensitive for demand to be permanently reduced, but the failure to achieve such reduction with the charging regime in London suggests that this might be substantially higher than the present charge. It is noteworthy that the increase in the charge in 2005 had virtually no further impact on traffic levels, suggesting that those more sensitive to price had largely been deterred by the initial charge and that the remaining car users are less sensitive to additional charges. It would be possible in principle to explore such sensitivity by raising the charge in stages, allowing each time for the initial relief of congestion to abate, until a long term impact was established – but this would likely be a contentious policy.

Another approach would be to relate congestion charging to distance travelled (rather than to presence in the charging zone as in London and Stockholm), as in Singapore, an approach suggested for London in the future (Mayor, 2017). However, there is little evidence of the magnitude of the charges that would be required to achieve a permanent reduction in congestion. The experience of Singapore, with a high fixed charge for entitlement to operate a vehicle in the road network, indicates the magnitude of charging that might be needed to effect a sustained reduction in urban traffic congestion. Capital cities with many resident having relatively high incomes may not be the best places to implement congestion charging, the impact of which may be greater when the range of incomes is narrower.

The experience of London and Stockholm does not provide evidence to support the introduction of congestion charging as a means of demand management in cities of developed countries with high levels of car ownership. In contrast, the experience of Singapore suggests a possible approach for cities where car ownership is still relatively low.

While it is difficult to mitigate congestion by means of congestion charging, it is possible to raise revenue. Road user charging may be of increasing importance for this purpose as use of electric vehicles grows - vehicles which do not contribute to the costs of operating and maintaining the road network through taxation of road fuels. Road user charging is also a means of discouraging more polluting vehicles from entering urban centres where air pollution from transport sources exceeds permissible limits. Accordingly, if road user charging becomes generally employed for revenue raising and to counter air pollution, the mechanism will exist by which the possibilities of demand management may be explored.

End notes

1. Information in this and the following paragraph is from the website of the Singapore Land Transport Authority.
2. Information from the website of the San Diego Association of Governments.

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