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To What Extent Has Congestion Charging Contributed to Sustainable Urban Environmental Governance? Evidence from London and Stockholm

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Abstract. This paper examines the progress of congestion charging in promoting sustainable urban environmental governance in London and Stockholm. A comparative case study of traffic demand, environmental results, equity and acceptance, and long-term institutions. Both schemes reduced the amount of traffic entering the paid area significantly and permanently altered people's travel behaviour. A drop in demand did not result in a reduction of long-term congestion or air pollution because both were also influenced by capacity, growth, fleet structure, weather and traffic diversion. The schemes achieved stability through different paths: London was led by politics and administration; Stockholm was a trial run by the public and a referendum. Equity effects were determined by car dependence, alternatives and revenue utilisation. Congestion charging will thus have a relatively small and uneven effect. It is recommended that one of the first devices to be used for demand-fluctuation regulation is selected to reduce congestion and pollution.

Keywords: Congestion charging, Sustainable urban environmental governance, Traffic demand management, Public acceptance, London and Stockholm

1. Introduction

Urbanisation has led to congestion, air pollution and high-carbon transport emissions in governance. Road expansion and administrative control cannot fully meet the demand for development, so market-oriented policies have been introduced [1]. According to Pigou's theory, drivers do not bear the full social cost of travel, and thus road use exceeds the social optimum [2]. Congestion charging internalises some of these costs and reduces excessive demand [3].

London and Stockholm are wealthy European cities with well-developed public transport and central-area congestion, but they have taken different implementation paths. London introduced a direct charge in 2003; Stockholm used a 2006 trial, referendum and permanent scheme [4, 5]. The above similarities and differences support a most-similar systems comparison of how design and institutions shape outcomes.

Based on official monitoring and academic data, this paper will compare traffic and congestion, emissions and air quality, equity and acceptance, and long-term governance. Contribution refers to

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the size, longevity and attribution of the effect, as well as its reliance on supporting policies. The framework will offer support for the Pricing Design and Implementation.

2. Congestion charging as an economic instrument for urban environmental governance

2.1. The theoretical foundation of congestion charging

Road transport has caused various problems of congestion and emission externalities. Near capacity, an additional car will delay both the driver and others. Drivers consider fuel, vehicle and personal time costs, but not all delays imposed on other road users. Marginal social cost (MSC) therefore exceeds marginal private cost (MPC).

Emissions costs are related to distance, fuel, vehicle type and technology. Drivers do not fully bear the climate and health costs of CO2, NOx and particulate matter. Indirectly reduce emissions by lowering driving costs and thus reducing trips, distance or fuel consumption. Diversion will shift the traffic and pollution to the surrounding roads.

Pigouvian Taxation is a way. When MPC is less than MSC, trips whose private benefits do not cover their social costs still occur. A tax or charge will make travellers feel some of the external costs [2] and thus choose not to take a low-value trip.

Walters [6] and Vickrey [7] have shown that congestion costs are relatively large near the road's capacity. Small and Verhoef add that costs vary with flow, capacity, location and time [3]. Therefore, effective charging should be spatially and temporally scarce. Figure 1 shows that a negative externality separates market and social optima, and a Pigouvian tax reduces this gap.

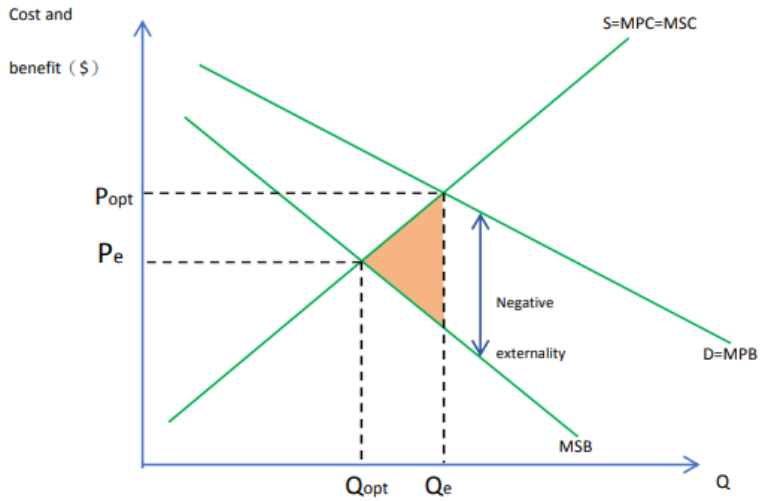


Figure 1. Negative externality and Pigouvian congestion charging

Source: Author's own elaboration based on references [2, 3, 6, 7].

Congestion charging aims to allocate limited road space and will not prohibit driving altogether. It will not be used to cover the social costs of a trip, and high-value trips will not be allowed after payment. Keep the option to differentiate prices instead of directly banning the cars, and provide a foundation for market-based regulation.

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2.2. Expected impacts and evaluation framework for urban environmental governance

The first expected result is a drop in car demand for charging services. If the cost is too high, some travellers will not be able to travel and will have to choose other ways. Therefore, the first index is traffic volume, and the response depends on price elasticity and the availability of alternatives. Both cities would need to decline simultaneously in order to lower prices.

Traffic will be reduced, so fuel consumption and emissions will fall, but air quality may not improve. Other reasons for the change in concentration are technology, fleet composition, weather and background pollution, etc. Kelly et al. [8] found no London air-quality change clearly matching the traffic decline. Thus, the modelled emissions are separated from the measured ambient concentrations.

Charging expands governance from administrative restrictions to economic incentives and preserves choice [1]. Durability also depends on the mode of transport, enforcement, fairness and acceptance. Burden varies by income, place of residence and car-dependency; revenue-use shapes benefits. Stockholm shows that perceived outcomes can change public acceptance after implementation [9].

The four expectations for the analysis are: reduce traffic demand by pricing; lower traffic may lead to environmental benefits, but attribution of the final outcome is weak; equity depends on car-reliance, alternatives and revenue-use; and institutionalisation requires effective design, enforcement and legitimacy. Sections 3-5 test the above expectations, explore limitations and explain cross-case differences.

3. Empirical evidence from London and Stockholm

3.1. Traffic impacts and behavioural change

The first is that higher driving costs will reduce the number of cars in the charging area. Both cities have introduced this system, but their long-term outcomes have been different.

In February 2003, London introduced a weekday central-area fee. Transport for London reported that the amount of traffic in the area dropped by 18%, internal traffic fell by 15%, and congestion initially decreased [10]. Leape [4] and Santos and Fraser [11] have found a clear demand response. Table 1 shows the changes in early traffic, emissions and fuel.

Table 1. Impacts of London congestion charging after implementation

Indicator	Change after introduction(2003 compared with 2002)
Traffic entering charging zone	↓18%
Traffic circulating within charging zone	↓15%
Congestion level	↓around 30%
NOx and PM10 emissions	↓16%
CO2 emissions	↓20%
Fossil fuel consumption	↓19%

Source: Transport for London [10].

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As both entering and internal traffic decreased, the cause was not only boundary diversion. Congestion first decreased the number of vehicles, which was in line with the non-linear effect of reducing vehicles near-capacity roads. Therefore, the early evidence supports the deletion of the lower-value trip.

Stockholm also had a long-term effect. Traffic crossing the cordon dropped by about 20-25 per cent during the 2006 trial and exceeded the 10-15 per cent goal [5, 12]. Five- and ten-year studies show that the effect persisted after residents adapted [13, 14].

Although they had different designs, the central-area car demand in both cities fell by about one-fifth and thus provided strong support for demand management. This does not ensure the same long-term congestion reduction; capacity, urban development, road-space reallocation and other policies will also affect travel time. Therefore, the demand effect is relatively more credible than the congestion effect.

3.2. Environmental outcomes and emission reduction

The second is that a lower car population will help the environment. Both cases show some reduction in emissions, but the connection to measured air quality is more complicated.

London's monitoring showed that lower traffic reduced emissions of CO2, NOx and PM10. Figure 2 shows the traffic and modelled emissions moving in the same direction. Indirectly reduce pollution by changing car-use and fuel-consumption behaviour, rather than reducing emissions directly.

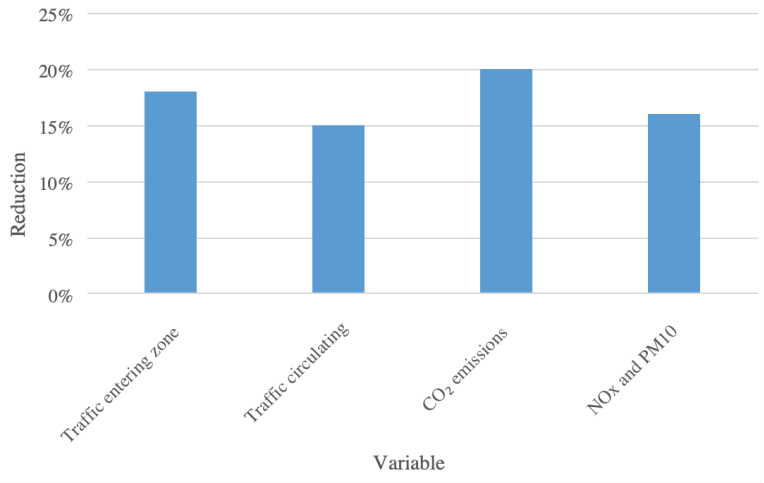


Figure 2. Reduction in traffic and emissions following the introduction of London congestion charging

Source: Adapted from Transport for London [10].

Figure 2 shows the modelled emissions based on traffic, fleet and emission factors, not concentrations measured at monitoring stations. Ambient Air Quality Reflects Technology, Weather and Background Pollution. Kelly and others [8] found no corresponding improvement clearly attributable to charging. London thus offers stronger evidence for reduced transport emissions than for cleaner ambient air.

Stockholm also had environmental and welfare benefits and lower demand [5, 15]. However, the evidence in this case is not detailed about emissions and pollutant concentrations, so the comparison

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is one-sided. Only the general mechanism is known; thus, no specific air quality data have been obtained.

Charging will reduce transport emissions by lowering traffic, but we do not know how much the air quality will improve. The environmental benefits are to be considered as demand-management co-benefits rather than the outcome of a single-pollution policy.

3.3. Public acceptance and policy institutionalisation

The third expectation is institutionalisation. The first is traffic congestion; enforcement and public acceptance are the others. Both schemes lasted, but via different governance paths.

London was a top-down type. Mayor Ken Livingstone, the Greater London Authority and Transport for London implemented the scheme despite the controversy. Leap [4] Studies administrative capacity and its effect on the revenue of public transport. London shows how leadership and institutions can sustain a contested cause.

Stockholm employed a trial-referendum-permanent implementation sequence. A trial would be held to inform the public of the new traffic regulations and solicit their opinions on the law.

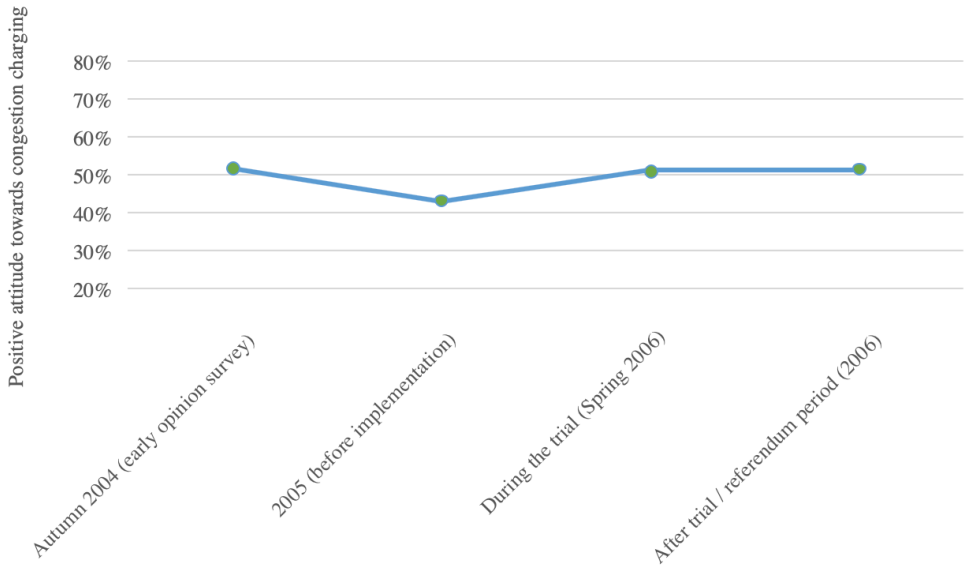


Figure 3. Changes in public support for Stockholm congestion charging before and after the 2006 trial

Source: Adapted from Winslott-Hiselius et al. [16] and Stockholm referendum data.

Figure 3 shows that the positive view rate fell from 52% in 2004 to 43% in 2005 and then rose to 54% after the trial [16]. Opposition increased as costs were apparent but benefits had not yet been realised. Schuitema and others [9] believe that the perceived outcome is responsible for alterations in acceptance.

The later 51.3 per cent referendum result cannot be directly compared with the surveys and should be considered a separate political authorisation. The trial has shown that it can help alleviate traffic congestion and has been adopted permanently.

London was led and carried out by others; Stockholm, however, gained legitimacy through experience and a vote. Together, they show that acceptance is formed through implementation and

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observed results, not determined in advance before the policy starts. Section 5 uses these paths to explain cross-case differences.

4. Challenges and limitations of congestion charging

4.1. Limitations as a standalone environmental policy

Charging will reduce car demand in the area but will not address urban transport and environmental issues independently. Population, employment, land-use and infrastructure shape the structure of car dependency, and pricing affects only marginal trips.

Feasibility needs feasible options. Mature bus, rail, walking and cycling networks reduce the cost of behaviour change. Both cities expanded public transport around implementation. London added buses [4], and Stockholm increased capacity; however, neither accounted for the full drop in traffic [12]. If the alternative is weak, then charging will increase the burden without changing the mode.

Another is the area covered. Area or cordon schemes do not cover all the city's traffic, and drivers may change routes, parking or destinations. Lower traffic inside the zone therefore need not produce an equivalent city-wide decline in activity or pollution.

Charging destinations based on road-demand instead of vehicle-emission performance. Fewer cars do not guarantee a cleaner remaining fleet. Low-emission zones instead restrict vehicles according to emissions [17]. The two instruments will reduce demand and change the fleet composition.

These limits define the function of the instrument, they are not failures. Wider environmental improvements will also require public transport, emission control and planning to reduce structural car dependence. Thus, charging will be included in the general plan.

4.2. Equity concerns and political challenges

Congestion charging raises distribution concerns because efficiency does not guarantee equitable costs and benefits. A single fee will affect people of different incomes, residences, car-ownership statuses and transport needs differently.

Low-income residents who need to drive and do not have other transportation options will be more negatively impacted by high fees, given their already limited funds. People able to change mode, time or workplace can avoid it more easily. Therefore, the burden will be adjusted according to demand and price.

Charging is not necessarily backward-looking. Stockholm research finds weaker regressivity than simple income comparison suggests [18]. High-income groups are more likely to own and use cars, and will pay more; low-income public-transport users will be less directly affected. Equity must consider actual travel and alternatives.

Table 2. Potential winners and losers of congestion charging

Group affected	Impact	Explanation
High-income car users	Mixed	They bear the financial cost of the charge, but may benefit from shorter travel times and more reliable journeys.
Low-income car users	Potential losers	The charge may represent a larger proportion of their income, especially when affordable transport alternatives are limited.

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Table 2. (continued)

Public transport users	Winners	Reduced congestion can improve bus reliability, while charging revenue can support public transport investment.
Residents in charging zones	Winners	Lower traffic volumes can improve local air quality, reduce noise pollution and increase urban liveability.
Businesses in charging zones	Mixed	Some businesses may experience reduced car accessibility, while others may benefit from a cleaner and less congested urban environment.

Source: Author's own compilation based primarily on reference [18], with wider policy context from references [1, 17].

Table 2 shows that the winners and losers are not clearly divided by income. Low-income, car-dependent people with no other choices are most at risk; public-transport users may enjoy reduced traffic or better services. Equity concerns: Who can adapt and who benefits, not only who pays.

Revenue Use Change Distribution. Open investment in public transport offers more choices and benefits for non-drivers, and an ambiguous connection between fees and improvements makes it seem like a fee-for-service model. Recycling is thus both unfair and illegitimate.

Distribution is jointly determined by income, car-dependency, alternatives and revenue-use. Perceived unfairness will also reduce the scheme's effect. Equity is thus a way to link design, adoption and long-term institutional life.

5. Comparative evaluation

5.1. Governance conditions explaining different outcomes

Both schemes reduced demand but had different long-term congestion and legitimacy. Given that the cities had higher incomes, more developed public transportation systems and less central congestion, pricing design, implementation and institutional support are better explanations for the variation than the mere existence of a charge.

Design provides the basis for congestion price setting. London's first fixed daily area fee did not charge extra for extra travel after payment. Stockholm varied charges by crossing times and had higher peak fees. Therefore, the structure better reflects temporal road scarcity [3], although alternatives and enforcement also matter.

Second, forms of political survival. London used mayoral power and administrative capacity to implement the scheme before the benefits were realised [4], so there was no pre-implementation veto, but it required strong leadership. Stockholm used a trial and referendum to show the uncertain benefits before the final decision [5].

Third, long-term living needs institutions and legitimacy. Alternatives, revenue uses and tangible benefits all affect the feeling of fairness. Stockholm's trial increased the acceptance rate after trials [9]; London depended more on strong local institutions. Table 3 shows the differences in Design, Implementation, Traffic Effects and Legitimacy.

Table 3. Comparison between London and Stockholm congestion charging systems

Dimension	London	Stockholm
Policy objective	Reduce congestion and improve traffic management	Reduce congestion and evaluate public acceptance through a trial

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Table 3. (continued)

Charging design	Fixed daily charge for vehicles entering the central zone	Time-dependent charges with higher fees during peak hours
Public acceptance	Initially controversial; acceptance improved after implementation	Opposition decreased significantly after successful trial
Environmental outcomes	Reduced traffic and emissions in central London	Reduced traffic and improved air quality in Stockholm
Institutional support	Supported by Transport for London with revenue reinvestment	Strong government support and continuous policy evaluation

Source: Adapted from references [4, 5, 13, 14].

Outcomes are not solely determined by price. Design Shapes demand response; implementation affects entry and survival; institutional support transforms behaviour change into stable governance. Pricing is the foundation, but long-term effectiveness remains conditional.

5.2. To what extent has congestion charging contributed to sustainable urban environmental governance

Congestion charging is relatively small and unevenly distributed. Evidence for traffic demand is relatively strong and close to the price mechanism. Supporting policies and institutions are gradually providing support for long-term congestion, environmental quality and governance.

First, the strongest contribution is traffic-demand management. Traffic entering London fell by about 18%, and Stockholm cordon traffic dropped 20-25% and has been lower since then [13, 14]. Both cases show that higher private road costs reduce some car journeys. The effect of excessive central-area demand is relatively small and independent.

Second, extended congestion relief is unavailable and context-specific. Reduce traffic to improve flow, but also increase capacity, development and street-space allocation. Some of the early London gains were later offset, and Stockholm's response was relatively stable. Charging reduces excess demand but cannot determine long-term road conditions alone.

Third, the self-regulating environment is not feasible. London's lower traffic was associated with reduced modelled CO2, NOx and PM10, but not with an equally clear measured air-quality improvement due to charging [8]. As the policy targets road use and not all emission sources, its environmental effect will be indirect and supplementary.

Fourth, equity has no fixed direction. A flat-rate fee will be relatively burdensome for low-income drivers without other options, and high-mileage drivers will pay more. Public-transport investment can distribute benefits. Equity refers to the adjustment capacity, benefit distribution and revenue utilisation, and thus determines legitimacy.

Fifth, the contribution of governance is relatively small. London is the most organised, and Stockholm shows that a trial and a referendum can alter public opinion. Charging supports market-based governance and policy learning only when institutions, alternatives, fair design and public legitimacy are available.

The total is relatively small and unevenly distributed. Demand management is relatively strong; long-term congestion relief is moderate; the independent ambient-air effect is weak; distribution shapes political durability; and governance gains depend on institutions. Therefore, congestion

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charging is a good tool that can be used in conjunction with public transport, emissions control and fairness in design and implementation.

6. Conclusion

Based on the above analysis, congestion charging has achieved some results in promoting sustainable urban environmental governance. It will reduce the number of cars in the city centre. Prolonged traffic jams are also related to capacity, development and street-space allocation; therefore, even if transport emissions are reduced, there may be little change in ambient air pollution. Durable governance needs alternatives, suitable design, administrative capacity, transparent revenue use, equity and legitimacy. Equity is required for efficacy because cost and benefit distribution affect acceptance. Therefore, congestion charging should be added to an all-encompassing policy package and not introduced as a standalone measure. Other cities can adapt according to their own transport, distribution and institutional circumstances and are not obliged to copy London or Stockholm.

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