London Congestion Charging

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TRAFFIC CONGESTION IS A textbook example of an externality and therefore calls for some government intervention if efficiency is to be achieved. Simple as road pricing may sound, it has seldom been adopted as a real world policy. With the exception of Singapore, which in 1975 implemented the first such measure, no other examples were to be found until February 2003, when London introduced a congestion charge for the privilege of driving in the central area. Many towns and cities around the world have been observing the case with interest. Stockholm implemented its own version of road pricing in 2007, and San Francisco is currently entertaining the idea. The New York State Assembly was considering congestion pricing for New York City but rejected it in April 2008.

The main reason why there are so few examples of road pricing is lack of public and therefore political acceptability, although London has proved that neither is an insurmountable obstacle to achieving the goal of reducing congestion. However, conditions in London before congestion charging took effect were very special: average speeds were extremely low, the transit use rate was unusually high, laws were already in place, and five years of technical analysis of different options for congestion charging had been completed.

This paper discusses the reasons why London's government thought that charging for congestion made sense, the basic goal of the congestion charging project, and policymakers' intentions and expectations when they established it. It describes the project and how it works, exploring costs, revenues, and economic benefits, and focuses on the different impacts that congestion charging has had in London, including impacts on traffic, transit use, land use, and prop-

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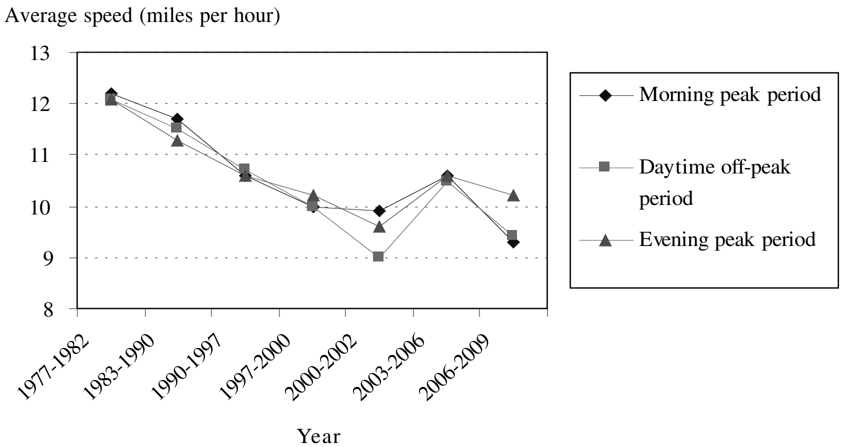
Figure 1. Central London Average Traffic Speeds, 1977–2009



Source: TfL (2007a, table 4.2.1, p. 46).

erty prices. It also includes an assessment of the political aspects of the project, followed by an analysis of its basic goals and a theoretical assessment of the scheme as an instrument for achieving those goals. New plans to link the congestion charge to emissions also are discussed.

Policy Background

Surveys of attitudes toward transport in London in the late 1990s revealed "public and business concerns over transport, in particular road traffic congestion, public transport and air quality."[1] The average speed in central London had been decreasing consistently since 1977, as figure 1 shows; indeed, drivers in central London spent 50 percent of their trip time traveling at less than 5 miles per hour.[2]

The Greater London Authority Act 1999 created an authority for Greater London consisting of the mayor of London and the London Assembly, and it gave the mayor powers to implement road user charges or workplace parking levies or both.[3] The introduction of congestion charging was a central part of Ken Livingstone's platform for election to the office of mayor in May 2000. After being

1. ROCOL (2000, p. i).
2. Department of the Environment, Transport, and the Regions (1998, p. 2); TfL (2003b, p. 52).
3. Acts of Parliament (1999).

elected, Livingstone decided to go forward with the idea of road pricing. He had the legal power to do so, and by that time a fair amount of technical research had already been conducted and published in two reports, *London Congestion Charging Research Programme* in 2000[4] and *Road Charging Options for London*,[5] both commissioned by the Government Office for London.

Livingstone went ahead with a flat charge throughout the day in the centermost area of London, as recommended by the ROCOL report on road charging options and some public and stakeholder feedback that helped to shape the final design of the project. The primary aim of London congestion charging (LCC) was to reduce traffic congestion in and around the charging zone (CZ). The project, which used a fairly unsophisticated technology, was intended to contribute directly to four of the mayor's ten priorities for transport set out in his transport strategy in July 2001:

—to reduce congestion

—to make radical improvements in bus service

—to improve trip time reliability for car users

—to make the distribution of goods and services more reliable, sustainable, and efficient.[6]

Policymakers, relying on the results in ROCOL (2000) and some further modeling conducted by Transport for London (TfL), expected that the LCC project would cause changes in traffic mode shares and average speeds, summarized as follows:

—During the morning peak period, there would be up to 15,000 additional bus users and 5,000 additional Underground users traveling in central London.

—Inside the zone, traffic would be reduced by 10 to 15 percent, queues would be reduced by 20 to 30 percent, and average speeds would be increased by 10 to 15 percent.

—Outside the zone, traffic might increase on orbital routes by up to 5 percent and decrease on radial routes by 5 to 10 percent, causing an overall reduction in traffic of 1 to 2 percent.

Policymakers also were expecting annual net revenues of £130 million, all of which would be invested in transport in London. The priorities were tran-

4. MVA Consultancy (1995) examined a range of technical options, including electronic road pricing, for congestion charging in London, varying the charging zone and the level of the charge by area and time of day.

5. ROCOL (2000) reviewed the available options for charging in London, conducted and discussed public attitude surveys, and assessed the impact of illustrative charging projects. It specifically considered a paper-based system, electronic road pricing, and a system based on vehicle registration numbers and enforced by cameras. The last option was deemed to be feasible and enforceable.

6. Greater London Authority (2001).

sit, roads, safety, and cycling and walking facilities. As discussed below, traffic reductions were greater and net revenues were lower than expected. A positive effect of that result was that because the average speed increase was at the upper end, the time savings were greater.

LCC Project Background and Basic Provisions

The original LCC project was implemented on February 17, 2003. The project was designed and is managed by Transport for London, which is responsible for London's entire transport system. TfL is controlled by a board whose members are appointed by the mayor, who also chairs the board.

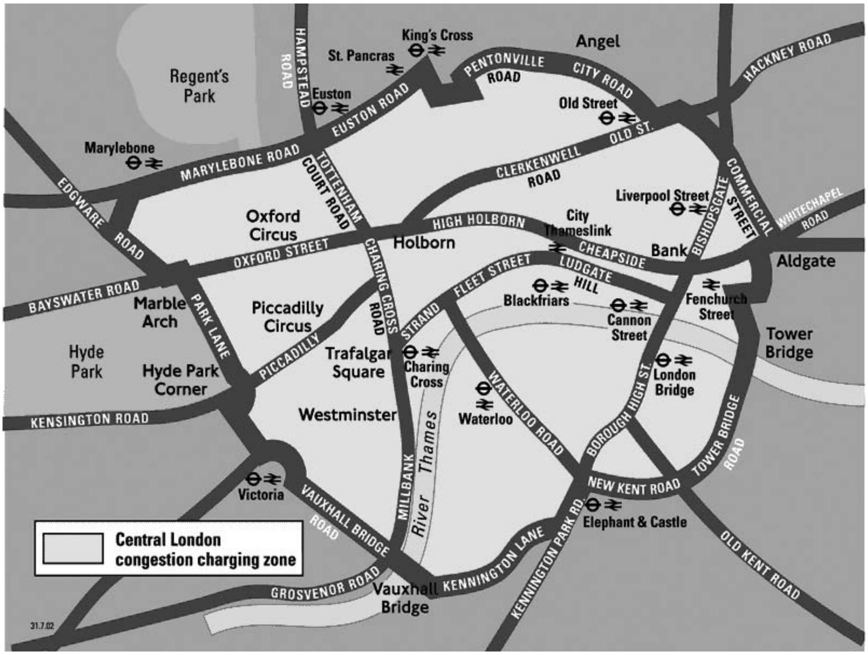
From the beginning, the congestion charge was an area license. All vehicles entering, leaving, driving, or parking on a public road inside the charging zone between 7:00 a.m. and 6:30 p.m., Monday through Friday, excluding public holidays, had to pay the charge, initially £5 ($10). Traffic signs clearly indicated the limits of the CZ. Figure 2 shows the limit of the original CZ, the Inner Ring Road. No charge was made for driving on the Inner Ring Road itself. The charging area was relatively small, covering 21 square kilometers (8 square miles), which represents just 1.3 percent of the total 1,579 square kilometers (617 square miles) of Greater London.

The charge could be paid in advance of using a road in the charging zone, on the day of use itself, or on the day after. If the charge was paid between 10:00 p.m. and midnight on the following day, it increased to £10. A number of options were available: the charge could be paid for a day, a week, a month, or a year, up to 90 days in advance of the charging day.

A number of exemptions and 100 percent discounts were in place, which applied to two-wheelers, emergency vehicles, vehicles used by or for disabled people, public buses, licensed London taxis and minicabs, some military vehicles, and roadside assistance and recovery vehicles. Also, vehicles registered to residents within the CZ were entitled to a 90 percent discount when residents paid at least a week's worth of congestion charges. Finally, although reducing environmental externalities was not an objective of LCC, alternative fuel vehicles (with stringent emission savings) were given a 100 percent discount, "intended as an added environmental benefit, possible within the structure of LCC."[7]

7. Malcolm Murray-Clark (director of congestion charging for TfL), speaking at the Congestion Charging Seminar, organized by the Institution of Highways and Transportation, Imperial College, London, March 19, 2003. Planned changes on this front are discussed later in the paper.

Figure 2. Map of the Original Congestion Charging Zone



Source: Transport for London. Reprinted with permission.

Alterations to the Original LCC Project

There have been a number of major changes to LCC since it began in February 2003. On July 4, 2005, the charge was increased to £8 ($16), with an equivalent increase in the weekly resident charge, from £2.50 to £4; at the same time, a new discount of 15 percent was introduced for annual and monthly payments.[8] On June 19, 2006, the Pay Next Day facility was introduced, giving drivers an extra day to pay the charge. Thus, the £8 charge can be paid until midnight on the charging day or a £10 charge can be paid until midnight on the following charging day.[9]

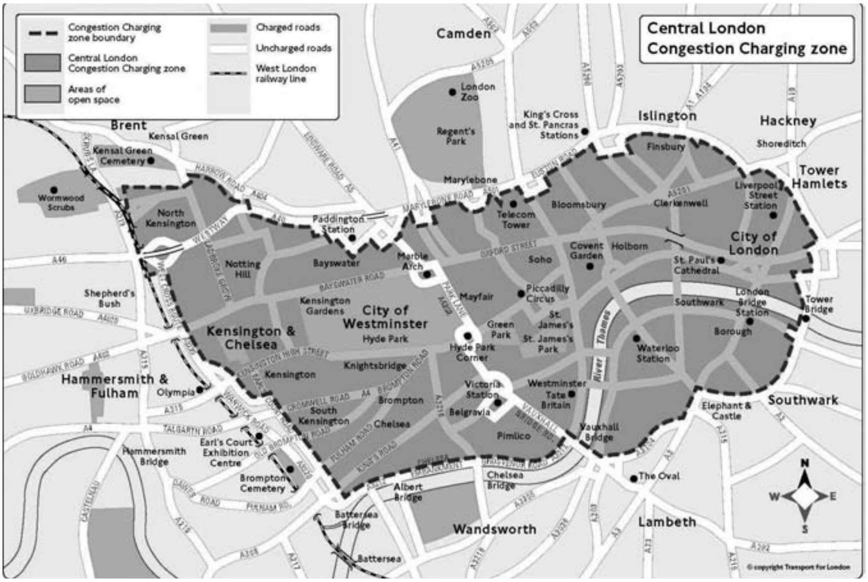
The draft transport strategy revision, which outlined the plans for an extension of the zone, was sent to public consultation between February and April 2004. In response, a number of residents in buffer areas just outside the original zone and the then-proposed extension put in representations[10] arguing that

8. TfL (2006b, p.147).

9. TfL (2007b, pp. 98–99).

10. Any person or group of persons affected by a project sent to public consultation in the United Kingdom may lodge a representation or objection. There usually is a set period of time

Figure 3. Map of the Extended Congestion Charging Zone



Source: Transport for London. Reprinted with permission.

they were more exposed to adverse impacts because their local services, shops, and amenities—such as libraries, medical offices, hospitals, and leisure centers—were located inside the CZ. Some representations also related to parking problems; in some cases designated resident parking was inside the extension area and residents had no practical alternatives outside the zone.[11] Consequently, from October 2006 residents in a number of buffer zones became eligible for the 90 percent resident discount.[12]

On February 19, 2007, the charging zone was extended to the west, to include Westminster and parts of Kensington and Chelsea. Also on that day, the charging hours, which originally extended until 6:30 p.m., were shortened by 30 minutes.[13] Figure 3 shows the limits of the extended CZ. No charge is made for driving on the roads that limit the CZ, and there are two free corridors: one runs north to south along Edgware Road, Park Lane, Grosvenor Place, Bressenden Place, and Vauxhall Bridge Road, and the other, located northwest

during which representations can be made. Typically a representation must state the full name and address of the person or group making the representation and the reasons for making the representation or objecting to all or some aspects of the project.

11. TfL (2005a, chapter 7).

12. TfL (2005a, point 7.3.8, p. 94); TfL (2007b, p.248).

13. TfL (2007b, pp. 4, 9, and 144).

of the zone, runs east to west, as the diversion route would have been too long for drivers who wanted only to cross that segment of Westway A40. The dark-colored roads in figure 3 are all free of charge. The extended CZ covers roughly 39 square kilometers (15 square miles). A few other alterations also took place, but they are not described here as they were minor and did not really change the essence of LCC.

Payment

Various methods of paying are available: online, in person at retail outlets, by post, by telephone, and by mobile phone text messaging; payment for the previous charging day, however, can be made only through TfL's call center or website.[14] Businesses and other organizations operating more than ten vehicles can use the fleet scheme. After the vehicles are registered and an annual administration charge of £10 per vehicle is paid, the license plates of the registered vehicles are photographed and the charges corresponding to them are calculated automatically. A prepayment for the forthcoming month is drawn by direct debit from the fleet account. The daily charge for registered fleet vehicles is £7 rather than £8.

As before, a number of exemptions and discounts are in place for two-wheelers, emergency vehicles, public buses, alternative fuel vehicles and so forth, and vehicles registered to residents of the CZ are entitled to a 90 percent discount when residents pay for at least a week's worth of congestion charges.

Enforcement

Rules are enforced through automatic number plate recognition (ANPR). Traffic cameras record the license plate numbers of virtually all the vehicles making use of the zone and send them to a processing center, where they are matched against the numbers of vehicles that have paid, are exempt, are entitled to a 100 percent discount, or are registered with the fleet scheme. The photos of the matched numbers are then automatically deleted. After a manual check, violators are tracked through the Driver and Vehicle Licensing Agency and issued a penalty charge notice (PCN) for £100. The charge is reduced to £50 if paid within 14 days and increased to £150 if not paid within 28 days. Unpaid penalties are pursued through civil courts. Once a penalty has increased to £150, a charge certificate is sent to the person who registered or hired the vehicle to inform the person that the penalty has increased and that action will be taken to recover the outstanding amount. Failure to pay can lead to registration of the

14. TfL (2003a, point 6.7); TfL (2007b, p.105).

debt with the county court and the eventual appointment of a bailiff to recover the debt.

Vehicles with three or more outstanding PCNs may be clamped or removed anywhere in Greater London. The clamp fee is £65, and the removal fee is £150. Vehicle storage costs £25 a day. If a vehicle is clamped or removed, then all of the outstanding charges must be paid before it is released. If the release fee is not paid, then the vehicle may be disposed of at auction or by scrapping. In that case, the registered keeper remains liable for all outstanding charges, including a £60 disposal fee.

Upon receiving the PCN the registered keeper is entitled to challenge it by making a representation in writing, which may be accepted or rejected by TfL. If it is rejected, the registered keeper has the right to appeal to the Parking and Traffic Appeals Service, an independent body that serves as a tribunal; its decision is final and binding. In 2006 more than 74 percent of all PCNs issued were paid; the remaining 26 percent were canceled because a representation was accepted or the debt was not recoverable—for example, because the registered keeper of the vehicle could not be traced or was bankrupt.[15]

Practical Administrative Problems

If everyone had refused to pay the charge, the system simply would not have worked. Sending PCNs to all the drivers of all the chargeable vehicles entering the CZ and subsequently chasing them through the system as described above would have created administrative chaos. That did not happen.

Although LCC was never in disarray, there were (and in some cases still are) a number of practical problems with its administration, relating mainly to the enforcement process. For example, in the first three months an unacceptable number of PCNs were issued in error and representations and appeals were incorrectly processed.[16] However, by July 2007, the percentage of error-free payments by charge payers had reached 99.8 percent.

License plate theft is a problem in the United Kingdom, and it has had some impact on PCNs, which occasionally have been issued to the victims of theft. IAM Motoring Trust (2005) estimates that one in 250 vehicles entering the CZ may be using stolen number plates. It reported, for example, that one man who traveled into London by train had received bills amounting to £8,000 for congestion charges and speeding offenses. A car carrying his vehicle's number plate had entered the CZ at least twenty-eight times.

15. TfL (2007b, pp. 109–10).
16. TfL (2007b, p. 101).

Table 1. Annual Costs and Revenues of the LCC Project[a]
2005 pounds (millions)

Costs and revenues	*2002–03*	*2003–04*	*2004–05*	*2005–06*	*2006–07*
Total operating costs	18	98	92	88	88
Total revenues	20	179	197	210	208
Charge revenues	19	122	120	144	154
Enforcement revenues	1	58	77	66	54
Net revenues	2	82	105	122	120

Sources: Columns 1 through 4: TfL (2006a, table A, p. 5); column 5: TfL (2007b, table 6.2, p.114), converted to 2005 values and prices using the GDP deflator from the U.K. Treasury website (http://www.hm-treasury.gov.uk/economic_data_and_tools/gdp_deflators/data_gdp_fig.cfm)

a. For the financial year 2006–07, figures for the extended zone are provided and therefore include an element of contribution from the Western extension, both in terms of discounted resident payments from October 2006 and charges from February 19, 2007. In a full financial year, it is expected that net revenues will increase by up to £40 million per year more than the amount of pre-extension revenues (TfL, 2007b, p. 113).

Also, the media have reported on gadgets to fool the cameras that appear to be available on the black market. One such device is the liquid crystal display license plate, which works by attaching a fake number to a vehicle's plate. The fake number can be activated from inside the vehicle, through a switch that sends a signal to the false plate, which frosts over, obscuring the actual license number.[17] Neither of these problems has been widespread enough to have a significant effect on functioning or enforcement of LCC.

Costs, Revenues, and Benefits

The capital costs of the original LCC project were approximately £200 million at 2002 prices (roughly £220 million at 2005 values and prices), most of which were funded by the central government.[18] The capital costs of the extension were projected to be between £113 and £118 million at 2005 values and prices; they were paid from TfL's general fund.[19] Table 1 presents costs and revenues for the 2002–06 period. Except during financial year 2002–03, which is different because LCC was introduced toward the end of it, the ratio of costs to revenues has always been around 50 percent.

Use of Revenues

The Greater London Authority Act 1999 requires net revenues from road charging projects introduced during the first ten years of the legislation

17. *The Observer* (2003).
18. Information provided by TfL.
19. TfL (2005a, table 7.8, p.113); TfL (2006a, table A, pp. 5 and 7). This is the latest and only published information on the matter.

Table 2. Use of Net Revenues from LCC
2005 pounds (millions)

Revenue source	*2003–04*	*2004–05*	*2005–06*	*2006–07*
Bus network operations	66	84	100	99
Roads and bridges	13	11	14	14
Road safety	0	2	4	5
Walking and cycling	6	6	4	3
Distribution of freight	2	1	0	0

Sources: Column 1: Greater London Authority (2004, table 12, p. 51); column 2: TfL (2005b, figure 94, p. 139); column 3: TfL (2006b, table 9.4, p. 174); column 4: TfL (2007b, table 6.3, p. 114). All values were converted to 2005 values and prices using the GDP deflator from the U.K. Treasury.

(1999–2009) to be earmarked for at least ten years from their implementation for projects included in the mayor's transport strategy.[20] Indeed, any road pricing project in London must include a plan of how revenues will be used during the first ten years. Table 2 presents the allocation of net revenues since LCC started.

LCC raised £78 million in 2003–04, less than the £120 million expected for the first year. Transport improvements in London in that year totaled £82.8 million. The difference was covered with funds from other sources, such as increased revenues from public transport.[21] TfL (2003a) gives the following reasons for the lower revenues:

—The actual number of individual chargeable vehicles going into the CZ after LCC was introduced was below the modeled range because the reduction in traffic was greater than predicted and the baseline number of vehicles, against which the reduction was measured, was overestimated.

—The number of exempt and discounted vehicles was higher than expected.

—Fewer commercial vehicles used the fleet scheme than expected.

—Evasion was higher than expected.

In 2006, TfL published a four-year plan giving some indication of how revenues would be used in the 2006–10 period. It expected to raise £620 million during that time. Although TfL did not give any figures on how the net revenues would be allocated to different uses, it mentioned a number of programs, all of which support the objectives of the mayor's transport strategy, as required by law. The programs include the improvement of bus service and accessibility, so that "all Londoners, regardless of their mobility" have access to public transport networks, especially buses; enhancement of transport mode inter-

20. In the case of LCC, this period would have been 2003–13. However, the clock was turned back with the extension, and the new period is 2007–17.

21. Information provided by the Greater London Authority on request.

changes; development of trams and segregated bus lanes; and improvement of safety and security on streets and in transit, among other concerns.[22]

The fact that net revenues are earmarked for the local transport plan has helped increase the political acceptability of congestion charging somewhat. LCC is not popular, but the public response probably would have been worse if net revenues had gone into the London general budget. Surveys carried out between March and August 1999 found that people's attitude toward the idea of congestion charging changed when they were told that revenues would be ring-fenced to transport. Sixty-seven percent of the general public thought that road user charges in central London would be a good idea if net revenues were spent on transport improvements, and the proportion increased to 73 percent if respondents' suggestions on how road pricing revenues should be spent were introduced in the proposed package.[23] Earmarking has the obvious disadvantage of limiting the government's freedom to decide how tax revenues are spent each year. Newbery and Santos (1999) argues that with few exceptions, the British Treasury has always resisted hypothecating or earmarking taxes to particular purposes. The Treasury's view is that hypothecation of revenues should be limited to a few specific instances for which there is a very good case. The London charge, however, is not classified as a tax. According to the *System of National Accounts 1993,*

> [t]axes are compulsory, unrequited payments . . . to government units; they are described as unrequited because the government provides nothing in return to the individual unit making the payment, although governments may use the funds raised in taxes to provide goods or services to other units, either individually or collectively, or to the community as a whole.[24]

The London congestion charge does not fulfill that definition at all. Nevertheless, staff at the U.S. and German embassies have refused to pay the congestion charge in London, arguing that under the 1961 Vienna Convention, they are exempt from paying taxes.[25] These embassies have lately been joined by the French, Russian, and Belgian embassies and some African embassies as well.[26]

22. TfL (2006a).
23. ROCOL (2000, p. 57).
24. Commission of the European Communities–Eurostat (1993, point 7.48).
25. *The Londoner* (2006); BBC News Online (2006a and 2005a). Ken Livingstone has publicly expressed, on several occasions, his frustration with the U.S. ambassador for not paying the congestion charge (BBC News Online 2006b).
26. The Times Online (2007).

Net Economic Benefits

LCC's main benefits, as opposed to revenues, which are just a transfer from road users to the London government, are the time savings and reliability experienced by road users, including those using chargeable and nonchargeable modes of transport. TfL estimates the value of those benefits at £227 million a year for the original CZ.[27] There are additional minor advantages, such as savings on vehicle fuel and maintenance, accident reduction, and environmental benefits. There also are some disbenefits, such as compliance costs for those paying charges (the time incurred in paying the charge) and deterred trips. When all of these are taken into account, the annual total gross benefit amounts to £200 million, which, combined with the total cost of £88 million, presented in table 1, yields an annual net benefit of £122 million, or a benefit-cost ratio of 2.27.

TfL (2007b) does not provide data on costs, revenues, and benefits for the Western extension separately. However, before the extension went ahead, it conducted a cost-benefit analysis and arrived at benefit-cost ratios of 0.8 and 1.15 for assumptions of low and high sensitivity of response respectively, which are not too different from those estimated by Santos and Fraser, who conducted an independent cost-benefit analysis.[28] Newbery argues that "although the original scheme had positive net benefits, the extension appears not only socially unprofitable, but also costly to the London budget."[29]

A consolidated cost-benefit analysis, in which the enlarged CZ is treated as a single entity, would undoubtedly hide the fact that the extension is not economically worthwhile. That is because the benefit-cost ratio of the original CZ was very high.

Impacts on Traffic

The impacts on traffic must be analyzed separately for the original CZ and for the extension, which went into effect only in February 2007. The extension is the area to the west of the north-south free route, highlighted with a bold line cutting across the whole CZ in figure 3.

27. TfL (2007b, table 7.2, p. 136).
28. TfL (2005a, table 7.9, p.108); Santos and Fraser (2006, table 12, p. 294).
29. Newbery (2006, p. 307)

Table 3. Traffic Counts by Vehicle Type Entering the CZ during Charging Hours for an Annualized Weekday[a]

Vehicle type	*2002*	*2003*	*2004*	*2005*	*2006*
Cars and minicabs	195,000	130,000	129,000	125,000	125,000
Vans	55,000	49,000	49,000	47,000	48,000
Lorries and others	15,000	13,000	13,000	12,000	13,000
Licensed taxis	56,000	66,000	65,000	65,000	63,000
Buses and coaches	13,000	16,000	17,000	16,000	16,000
Powered two-wheelers	28,000	31,000	30,000	28,000	28,000
Pedal cycles	16,000	18,000	20,000	22,000	24,000

Source: Information provided to the author by Transport for London.
a. An annualized estimate is an average of spring and autumn counts in each year.

Original CZ

The total volume of traffic entering the CZ during charging hours in 2003 and 2004 was 18 percent lower than in 2002. Table 3 gives traffic counts per year by vehicle type. As expected, there was a reduction in the number of potentially chargeable vehicles and an increase in exempt vehicles.

While the number of certain vehicle types will decrease in response to a congestion charge, the distance that they are driven may increase. Depending on the relative magnitude of the changes, the total vehicle-kilometers driven may increase or decrease. Vehicle-kilometers for all chargeable vehicles in London, however, have decreased, indicating that the reduction in the number of vehicles was not compensated for by the potentially longer distances driven. TfL reports a decrease of 19 percent in vehicle-kilometers driven by vehicles with four or more wheels between 2002 and 2006. Table 4 gives the changes in vehicle-kilometers by vehicle type. TfL warns that although most of the indicated year-on-year changes are not statistically significant, there was a small increase in vehicle-kilometers driven by chargeable vehicles between 2005 and 2006.[30]

The aim of LCC was to reduce traffic congestion in and around the CZ, and it succeeded in doing so during the first two years. Even in the third year congestion was less than before LCC was introduced, although the difference was not as big as in the first two years. During 2003 and 2004, congestion—defined by TfL as "the difference between the average network travel rate and the uncongested [free-flow] network travel rate in minutes per vehicle-kilometre"—was 30 percent lower, on average, than before LCC.[31] If one uses an uncongested net-

30. TfL (2007b, p. 26).
31. TfL (2003b, table 3.1, p. 46); TfL (2005b, p. 14).

Table 4. Year-on-Year Percent Change in Vehicle-Kilometers Driven within the Original CZ during Charging Hours[a]
Percent change

Vehicle type	*2002–03*	*2003–04*	*2004–05*	*2005–06*	*2002–06*
All vehicles	-12	-5	+1	+1	-14
Four or more wheels	-15	-6	0	+1	-19
Potentially chargeable	-25	-6	-1	+3	-28
Cars	-34	-7	-1	+4	-37
Vans	-5	-4	-4	+3	-9
Trucks and other	-7	-8	+8	+2	-7
Licensed taxis	+22	-7	+5	-5	+12
Buses and coaches	+21	+5	-1	+3	+25
Powered two-wheelers[b]	+6	-2	0	-3	0
Pedal cycles	+28	+4	+14	-2	+43

Source: TfL (2007b, table 2.4, p. 26).
a. Annualized weekday for 2002, 2003, 2004, 2005, and 2006.
b. Powered two-wheeler trends are relatively volatile, reflecting weather and fashion.

work travel rate of 1.9 minutes per kilometer (approximately 32 kilometers an hour) from TfL[32] and 2002 and 2003–04 average travel rates of 4.2 and 3.5 min per kilometer respectively, it can be seen that congestion decreased from 2.3 to 1.6 minutes per kilometer. Most of the reduction in travel time was the result of reduced queuing "time at junctions, rather than increases in driving speeds."[33]

However, TfL (2006b) reports that in 2005, average delays were 1.8 minutes per kilometer rather than 1.6 minutes per kilometer as in the previous two years. In other words, congestion was just under 22 percent less in 2005 than it was in 2002; in contrast, congestion was 30 percent less in 2003 and 2004 than it was in 2002. By 2006, two-thirds of the original gain had been lost: the average reduction in congestion was just 8 percent.[34] There are a number of reasons for the loss:

—a great deal of road work, particularly in the second half of 2006
—traffic management programs to reduce the number of traffic accidents
—improved bus service
—better environment for pedestrians and cyclists.[35]

Put simply, with less traffic and more effective network capacity, the additional capacity has been reallocated to other users, such as, for example, buses and pedestrians. This is not a new concept. In the 1970s, when the United Kingdom was not going beyond desk studies of road pricing, there already were proposals for redistributing network space by "providing better conditions for

32. TfL (2003b, p. 52).
33. TfL (2005b, pp. 15, 13).
34. TfL (2007b, p. 39).
35. TfL (2007b, point 3.2, p. 35; point 3.10, p. 45; p. 2).

bus operation and pedestrian movement at the expense of some restriction on the car."[36] Road work also reduces vehicle speed, and the reduction would probably be worse if there were no congestion charging.

Western Extension

The Western extension is different from the original CZ; the impacts of charging, therefore, were expected to be different, and indeed they have been different. For example, while the number of employees in the original CZ is more than 1 million (and that obviously has consequences for the number of commuters entering the CZ each morning), the number of employees in the extension is just 170,000.[37] As of January 2008, the data on traffic impacts in the Western extension were limited. TfL (2007b) reports the following:

—Traffic entering the extension zone is down by 10 to 15 percent of comparable pre-extension traffic, in line with TfL's expectations.

—Traffic on the free corridor north to south, which was the limit of the original CZ, is effectively unchanged in terms of aggregate volume.

—Traffic on the remainder of the Western extension boundary free route has increased in aggregate by 5 percent.

—There is some evidence that traffic entering the original CZ has increased by 4 percent. That may reflect in part an increase in discounted trips to and from the original CZ by Western extension residents.[38]

The first comprehensive survey of congestion in the Western extension reported a reduction of 20 to 25 percent of the amount of congestion in equivalent conditions before the extension. That is at the upper end of TfL's expected range of 17 to 24 percent.

The benefits in general are lower in the extension, because the reductions in traffic are smaller (as expected) than those experienced with the original LCC project. Indeed, almost two-thirds of the traffic that entered the extension before the extension actually took effect probably have not been affected by the charge because 9 percent of that traffic consists of vehicles that were exempt or discounted (for example, resident, disabled, and alternative fuel vehicles), 19 percent of taxis and buses, and 36 percent of vehicles that went through or came from the original CZ before the extension, having already paid the charge. Furthermore, since residents within the extension are entitled to a 90 percent discount, they may be attracted on to the roads.[39] By paying the discounted

36. May (1979, p.120).
37. TfL and GLA Economics (2005, p. 12).
38. TfL (2007b, pp. 247–48).
39. TfL (2005a, points 6.4.11 and 6.4.12, p. 72).

charge, they are able to drive not only in the extension but also in the original CZ. It also should be mentioned that there is a greater proportion of car travel by residents in the extension than there is in the original CZ and that therefore a higher proportion of households is able to take advantage of the resident discount.

Impact on Use of Mass Transit

Use of mass transit (especially buses) was a key element in the success of LCC. Many commuters who were priced out of driving switched to taking the bus, and bus passenger numbers increased by 18 percent and 12 percent during the first and second years after charging respectively. Since then passenger numbers have settled at around 116,000 in the weekday morning peak period (7:00 a.m. to 10:00 a.m.). The increase in the charge in July 2005 had only a limited impact on the number of cars entering the central zone (8 percent reduction) and no impact on bus ridership.[40]

LCC is not the only reason for the increase in bus passengers. Bus fares have been restructured over the last few years, leading to a real decrease in the average fare paid per individual trip. Bus service reliability improved on routes in and around the CZ following the introduction of LCC. Excess waiting time, used by TfL as a measure of the unreliability of service, fell by 30 percent in the first year and by a further 18 percent in the second year following the introduction of LCC. Reliability increased not just in the CZ but throughout the London bus network, reflecting changes in the new contracts between TfL and the different bus operators. In 2006 the reliability of bus service in and around the CZ deteriorated, with excess waiting time 2 percent greater than in 2005, although reliability still remains substantially better than at precharging levels.[41]

Contrary to TfL's expectations, during the first year of charging, the number of Underground passengers across London and especially in fare zone 1, which covers central London, including the CZ, decreased. The decrease obviously was not related to the congestion charge, which would have caused a marginal increase in demand, if anything. The decreased passenger levels on the London Underground in the first year of LCC probably were linked to the slowdown of the economy and the decrease in tourism in London, which in turn may have been linked to the war in Iraq. In addition to that, the Central

40. TfL (2007b, p. 58).
41. TfL (2007b, p. 55); TfL (2007b, p. 57).

Line was temporarily closed for almost three months following a derailment at Chancery Lane station in January 2003.

Over more recent years, the prevailing trend has been toward increasing patronage, with the London bombings of July 2005 not having an apparent long-term effect on aggregate patronage. In 2006, the number of passengers using the Underground was higher than in 2005.[42]

No significant changes in demand for trips by rail have resulted from the scheme, in line with TfL's expectations.[43]

Impacts on Land Use and Property Prices

In London, as in the rest of the United Kingdom, a land use planning system is in place. Not only new construction, but also substantial changes in use of a property usually require planning permission—for example, a shop cannot be changed into a family dwelling overnight. The main uses include shops, financial and professional services, restaurants and cafés, drinking establishments, hot food takeaways, businesses (offices, light industry facilities), general industrial plants, storage and distribution facilities, hotels, residential institutions, dwellings, nonresidential institutions (schools, libraries, medical offices), and public assembly and leisure facilities (cinemas, swimming pools, gymnasiums).

In addition, there are listed buildings, which are registered as having specific architectural or historic importance. They cannot be demolished or have their external and, in some cases, internal appearance altered without special permission from the local listed buildings official and, in some cases, from English Heritage, a public body concerned with the preservation of the historic environment.

There are around 250 listed buildings in London, many of which are inside the CZ. With the number of listed buildings and the restrictions imposed by the planning system, even for nonlisted buildings, it is no surprise that land use has not changed as a result of LCC.

In order to identify the impact of LCC on property prices, TfL commissioned two studies, one on residential and the other on commercial property prices. The residential property study compared property values and volume of property transactions over time, by property type (detached, semi-detached, terraced, or apartment) and location (inside the CZ, in the boundary area, or in the remainder of Greater London). The main finding at the time was that LCC had

42. TfL (2007b, p. 57).
43. TfL (2003a, 2007b).

had no statistically significant effect on residential property prices, a conclusion that is counterintuitive.[44] After all, given the benefits of reduced congestion and the very substantial resident discount, prices inside the CZ could have been expected to increase relatively more than those in the boundary area and the rest of London.

There are a number of problems with the study. First, although the period of analysis went back as far as 1995, it covered only up to the first quarter of 2004, including barely a year of congestion charging. Second, only average, not individual, prices per property type per postcode per quarter were used. Third, there was no control for characteristics likely to influence the value of a property. A proper hedonic property pricing study would deal with all those shortcomings.

The commercial property study analyzed the performance trends of retail and office buildings in the CZ. The main findings were that before LCC was implemented, rental growth on retail properties inside what was going to become the CZ was slower than that in the rest of Inner London and in three competing retail locations, Bromley, Kingston, and Richmond. However, after LCC was introduced, rents grew faster inside the CZ than in the rest of Inner London and the competing locations. The conclusion for office space was that just inside the edges of the CZ, demand was weaker than in the 2-kilometer (1.25-mile) ring around it, with firms preferring to locate just outside rather than within the CZ. That result, however, may have been caused by the stronger performance of the West End, because part of this area was outside the CZ before the extension took place.[45]

Political Aspects of LCC

Lindsey (2006) reviews the published literature on road pricing to assess whether economists agree that it is a good idea. The author finds that economists "do agree that highway congestion should be solved by pricing."[46] The problem is that politicians traditionally have avoided road pricing because gaining public support remains a challenge. Ken Livingstone took the risk, and it paid off: he not only reduced congestion in central London, he also was reelected a year after implementing LCC. His victory, however, does not mean that LCC

44. Steer Davies Gleave (2004, p. 20).

45. Steer Davies Gleave (2006).

46. Lindsey (2006, p. 296). He also finds that despite the general agreement on that point, there is a fair amount of disagreement on how to set tolls, how to cover costs, how to use net revenues, if and how to compensate those who lose, and whether to privatize highways.

is popular, nor does it mean that Londoners voted for LCC when they reelected him. Indeed, it is not clear what would have happened if a referendum on the congestion charge had been held or what the result would be if a referendum were held today.[47] As explained below, there was and still is a fair amount of opposition to LCC.

After being elected with congestion charging as part of his manifesto, Livingstone decided to go forward with the ROCOL proposals. A number of documents and public consultations followed his decision. The first document was a Greater London Authority discussion paper, *Hearing London's Views*, published in July 2000. This paper was aimed at getting feedback from key stakeholders—such as local councils, businesses, and road user representatives—on the boundary of the CZ, level and structure of charges, hours of operation, exemptions and discounts, penalty charges, and possible uses of net revenues. More than 85 percent of stakeholders who responded showed support for the idea of a central London congestion charge.[48] After initial comments were received, the mayor's draft transport strategy, which included proposals for a congestion charge in central London, was published in January 2001 and remained open for public comment until March 2001. More than 87 percent of the ninety-six organizations that responded supported the concept of LCC.[49] According to MORI and Greater London Authority (2001), around half of the members of the public who responded mentioned congestion charging; of those, 60 percent opposed and 40 percent supported LCC. MORI also conducted a telephone opinion poll with 2,003 Londoners, half of whom supported LCC. Support was significantly higher among CZ residents (57 percent were in favor); opposition was higher among those who had access to a car or van.[50]

The mayor's final transport strategy was published in July 2001. In the same month, TfL published "The Greater London (Central Zone) Congestion Charging Order 2001," which was then sent out for public consultation until September 2001. Table 5 reports the results of the consultation.

Although virtually all stakeholders were contacted and therefore their views can be considered fairly representative, the other organizations and members

47. The city of Edinburgh, Scotland, had been contemplating the possibility of introducing road pricing since 2001, when the Transport (Scotland) Act 2001 (Acts of the Scottish Parliament, 2001) was passed. The city eventually decided to introduce pricing, subject to the results of a referendum. About 74 percent of residents who participated in the referendum, which was held in February 2005, voted against congestion pricing, and the plans were abandoned as a result. More than 60 percent of eligible voters participated in the referendum, making it a success in terms of turnout (BBC News Online, 2005b).

48. Note that the general public had not been involved at that stage.

49. TfL (2002, point 1.3.7, p. 6).

50. MORI and Greater London Authority (2001, pp. 91, 67).

Table 5. Public Review Results on the Congestion Charging Order
Percent

Opinion	*Stakeholders*	*Other organizations*	*General public*
Support	56	25	36
Oppose	13	39	47
Not stated	31	36	17

Source: TfL (2002, point 4.2.3, p. 32).

of the general public that responded were those that probably held strong views.[51]

The results of the public consultation, especially in the area of exemptions and discounts, crystallized in a number of changes in the proposals. The proposed modifications were published in November 2001 and again submitted for public comment. On February 26, 2002, the mayor finally confirmed the "scheme order," which was subsequently modified several times before February 2003. After LCC was implemented, there were a number of public consultations through July 2005 on different modifications, including the charge increase and zone extension. Seventy percent of the members of the public, 80 percent of the businesses, 61 percent of the stakeholders, and 84 percent of other organizations that responded during the public consultation opposed the extension. Seventy-six percent of the members of the public, 56 percent of other organizations, 89 percent of the businesses, and 75 percent of the stakeholders that responded opposed the charge increase from £5 to £8.[52]

It might be argued that those who responded were those who were most strongly opposed to the proposals and that for that reason, the responses may not have been representative. Following the public consultation on the Western extension, TfL commissioned Accent to conduct an attitudinal survey that would "provide a representative sample of Londoners' views, including those within the proposed western extension" in order to "assess how representative the consultation findings are." As suspected, the responses differed somewhat, with 41 percent of Londoners as a whole supporting the extension and 43 percent opposing it.[53]

51. "Stakeholders" are defined as key organizations such as the London boroughs, groups of disabled people and those representing their interests, health authorities, environmental and transport pressure groups, trade unions, taxi and minicab organizations, organizations representing pedestrians and cyclists, London members of Parliament, and members of the European Parliament, among others. "Other organizations" are those that responded to the public consultation on behalf of the interests of a group, for example, businesses, residents' associations, voluntary and nonprofit organizations, educational establishments, and so forth.

52. TfL (2005a, point 1.4.12, p. 5); TfL (2005c, point 3.2, p. 5).

53. Accent (2005, pp. 167, 194).

The different responses simply reflected the way in which the charge and the subsequent modifications would have affected the various respondents or the principles for which they stood. Not surprisingly, residents of the CZ were prone to support the idea of LCC but also to ask for a full exemption (not happy enough with a 90 percent discount) and boundary residents were likely to ask for buffer resident discounts.[54] Business group representatives, freight groups, and motoring organizations, among others, felt that all vehicles using alternative fuels (including bi-fuel and clean diesel) as well as all commercial and delivery vehicles should be entitled to a 100 percent discount, while environmental groups felt that those vehicles should pay a higher charge than cars and disagreed with the exemption for two-wheelers. Walking and cycling groups, on the other hand, felt the charge was not high enough and that the zone should be extended to the whole of Greater London. Some emergency service providers were concerned that increased traffic congestion on the boundary would reduce their operational efficiency. A number of representatives of disabled people, London boroughs, environmental and transport lobby groups, and government departments argued that the 100 percent discount for disabled people should apply to all disabled people irrespective of their home address.[55] Voluntary, community, and nonprofit organizations and groups representing disabled people argued for an exemption or discount for care providers and charity workers. Many members of the public opposed the original plans and referred to the congestion charge as another tax on the motorist, arguing that road taxes were high enough in England and that the London government was just trying to raise money.

Despite a fair amount of opposition, LCC was implemented and the charge increase and extension of the CZ were confirmed and adopted. The point of the public consultation apparently never was to arrive at a yes or no decision on those issues but to engage the public, stakeholders, and other organizations in the debate and to take into account some of their suggestions. Santos and Fraser (2006) argues that decisions such as the level of the charge, whether it was going to differ by vehicle type or time of the day, the times when the scheme was to operate, and the exact limits of the CZ all were influenced by the responses received. The mayor was not prepared to abort his plans for LCC, the increase in the charge, or the Western extension, but he was prepared to let trucks pay the same charge as cars, rather than a higher charge, in response to the concerns of the freight industry. He also was happy to change the end time from 7:00 p.m.

54. After more than three years, this suggestion was eventually introduced.

55. This representation was taken into account, and the final scheme order contained the 100 percent discount for all disabled people.

to 6:30 p.m.—and again from 6:30 p.m. to 6:00 p.m.—in response to concerns of the entertainment industry and West End establishments. These were only small compromises in relation to the magnitude of the project.

Both the mayor's strong will (no doubts were ever expressed publicly, and there was no stalling or U turns) and the special conditions that existed in London at the time contributed to the success of the project. In 2002, prior to the start of LCC, 87 percent of people entering central London during the morning peak did so by transit.[56] Another 3 percent used two-wheelers and taxis; only 10 percent used a car. In 2003, after LCC was introduced, the share of people entering by car dropped from 10 percent to 8 percent.

In addition to the special precharging conditions, bus service was improved before LCC began. Thus, bigger buses and more frequent service ensured that commuters who were priced out of driving had an alternative mode of transport. Note that success in this context does not mean full public support but achievement of the project's basic aims: reduction of the level of traffic, change in travel behavior (many drivers have switched to transit), and generation of revenues for the transport plan in London.

TfL Business Surveys

About 18 months after the implementation of LCC, TfL conducted a survey of businesses on the impact of LCC. The views of the businesses that responded (the response rate was 39 percent) are summarized in table 6.[57] TfL reports that in aggregate, LCC has had no significant impact on business activity in the CZ since its introduction, a conclusion that it presented in previous reports. Ernst & Young (2006) reviews the TfL assessment and finds that TfL's conclusion is reasonable. Businesses, however, do not seem to share that view: 43 percent of retail establishments, 39 percent of restaurants and cafés, 20 percent of hotel and leisure businesses, and 27 percent of distribution businesses reported a decrease in their performance.[58] The reasons behind the decrease were perceived to include economic conditions, a reduction in tourism, and LCC, among others.[59]

However, in 2002, before LCC was introduced, 52 percent of businesses surveyed thought that the level of congestion in central London during peak hours was very bad or critical, while only 25 percent thought so in 2004.[60] In

56. Department for Transport (2007, table 1.6).
57. TfL (2005b, p. 89).
58. TfL (2005b, fig. 63, p. 93).
59. TfL, 2005b, fig. 64, p. 93).
60. (TfL, 2005b, fig. 68, p. 97).

Table 6. Percentage of Businesses That Consider LCC to Be Responsible for the Outcome in Question

Outcome	*Percent*
Made it easier to get to business meetings	31
Improved journey reliability	28
Made central London a more pleasant place to be	41
Increased the costs of running a business in central London	56

Source: TfL (2005b, section 6).

other words, businesses surveyed thought that traffic congestion had decreased but that at the same time, the means to achieve that end, namely LCC, may have had some negative impact on their performance. Given that speeds in 2006 were almost at precharging levels, it would be interesting to conduct another survey to get an update on businesses' perceptions.

Winners and Losers

Road pricing is an economic instrument that increases efficiency, as the deadweight loss of zero pricing of scarce road resources disappears. However, it is the government that ends up better off; drivers end up worse off. The Kaldor-Hicks compensation criteria work in theory, but they are almost never implemented in practice, and LCC is no exception. In other words, LCC does leave motorists as a group worse off. The key point here is that, as stated above, before LCC only 10 percent of people entering central London in the morning peak did so by car. In other words, in the very worst of scenarios, 10 percent of morning car commuters would have suffered negative impacts from LCC.

However, the percentage negatively affected is less than 10 percent, for three reasons. First, some of those drivers are disabled and therefore entitled to a 100 percent discount. Second, 40 percent of all car trips inside the CZ during charging times are business trips, which certainly gain from the charge due to the high value of time attached to them.[61] Drivers on business trips may commute into the CZ by car at no extra cost because they would pay the charge to be able to circulate later on in the day anyway.[62] Third, some commuters have a very high value of time, even during commuting, nonworking trips.

Santos and Bhakar (2006) estimates that the minimum income required for a car commuter to benefit from a £5 charge is £1,400 per week, a figure based on the assumption that the value of time is lower in uncongested than in congested conditions.[63] A weekly salary of £1,400 is roughly equivalent to an annual

61. Evans (2007, table 7, p.11)
62. Some these business trips may originate and terminate inside the CZ.
63. Santos and Bhakar (2006, p. 29). MVA, ITS, and TSU (1987, p. 176) estimates that the

salary of just under £75,000. Given that, on average, the richest 10 percent of full-time workers in London earn more than £65,835 a year,[64] it is not unreasonable to think that quite a number of car commuters would have benefited from the £5 congestion charge.

If, using the same methodology reported in Santos and Bhakar (2006), one assumes an £8 charge instead of a £5 charge, the minimum weekly salary for a car commuter to benefit from LCC increases to £2,348, roughly equivalent to an annual salary of £122,000. Since the smallest quantiles reported by the Office for National Statistics are deciles, it is impossible to pinpoint the exact percentage of Londoners with an annual salary higher than £122,000, let alone the share of car commuters benefiting from the £8 charge.[65] However, there are some.

The 90 percent of commuters who used transit or a nonchargeable mode of transport before LCC was implemented are winners. They benefit from lower travel times and a better travel environment, without paying the congestion charge and without changing their mode of transportation, schedule, or destination.

The problem of commercial vehicles is quite different. Data on annual changes in traffic show that the number of vans and trucks entering the CZ during charging hours in 2003 was only 11 percent less than in 2002.[66] Their demand is inelastic due to the constraints that they face with respect to delivery times.[67]

Santos (2007) shows that between 2002 and 2003 the generalized cost of travel for vans and trucks increased by almost 18 pence per kilometer (at 2003 values and prices), even when travel time savings and an increase in reliability were taken into account.[68] In 2006, with a charge of £8 (or £7 for those participating in the fleet scheme) and a much smaller increase in speed relative to speeds in 2002, the increase in generalized costs was 32 pence per kilometer. No doubt, commercial vehicles have suffered net negative impacts

value of time in congested conditions can be up to 40 percent higher, and Wardman (2001, p. 125) concludes that it can be 50 percent higher. TfL (2005a, point 7.5.4, p. 99), however, assumes a uniform value of time, regardless of the prevailing traffic conditions.

64. Office for National Statistics (2004, table 7.7a).

65. Office for National Statistics (2004, table 7.7a).

66. TfL (2007b, table 2.1, p. 21). There was a further decrease in the number of commercial vehicles entering the CZ following the charge increase in July 2005, although the decrease in vehicles was followed by a small increase in 2006.

67. The generalized cost elasticity of demand for trips with data for 2002 (the base year) and 2003 (the year of the change) is -0.53 for vans (Santos and Fraser 2006, p. 275) and -0.56 for trucks (Santos 2007, p. 16).

68. Santos (2007, p. 16).

from the charge, and the impacts have gotten worse. The Freight Transport Association (2007) notes that the association has always opposed the application of the congestion charge to commercial operators on the grounds that "they are essential vehicles required by their customers to make deliveries and that there are no other alternatives available to them but to deliver goods by road" and that "most vehicle operators will not be able to pass these charges on to customers."

LCC as an Instrument for Reducing Congestion

The primary aim of LCC was to reduce traffic congestion in and around the CZ—a clear, straightforward objective. Although nothing was said about the "congestion externality" or the "internalization of externalities," it was felt, both by the London government and by Londoners themselves, that traffic congestion had reached unacceptable levels. In practice, it did not matter if they understood that the incorrect pricing of scarce road resources was causing excess demand for travel on the London road network. The basic goal was to reduce traffic—or, to an economist, to reduce the deadweight loss of inefficient traffic levels. In that sense, LCC achieved its goal: the number of vehicles going into the CZ every day was reduced substantially and has stayed at a reduced level ever since. Average speeds in the CZ, on the other hand, increased by 21 percent in the first two years; however, they later dropped, and during 2006 they were just 8 percent higher than precharging speeds.[69] That disappointing result was not due to traffic levels creeping back to precharging levels but to road work and also to the reallocation of road space to other users, such as buses, pedestrians, and cyclists.

An interesting question from a theoretical point of view is how LCC compares with the theoretical model of road pricing. The most basic theoretical construct assumes that the efficient equilibrium is determined by the intersection of the marginal social cost of trips, which includes the marginal congestion cost (MCC), and tripmakers' marginal willingness to pay. However, the unregulated market yields an inefficient equilibrium, where road users pay only their marginal private cost. The Pigouvian solution to internalize the congestion externality is to introduce a corrective charge, equal to the difference between marginal private and marginal social cost at the efficient level of traffic. That all works very well in a first-best world. The underlying assumption that there are no externalities or distortions in other related sectors in the economy is

69. TfL (2007b, p. 47).

almost never verified. For example, commuters pay income tax, and that is a clear distortion in the labor market. Also, Verhoef, Nijkamp, and Rietveld (1995, 1996) shows that first-best pricing is not optimal when there are restrictions, and since there are always restrictions, equating the charge to the MCC may never yield a Pareto efficient solution.

LCC is far from the first-best model. Leaving aside the problem of imperfections in related markets, the MCC for each motorist on each link would need to be estimated in real time. Thus, different vehicle types would pay different charges on different links at different times of the day. In contrast, different vehicle types inside the CZ pay the same charge at all charging times of the day, regardless of where they are or for how long they drive. The London charge is not equal to MCC because its design was based on the recommendations contained in ROCOL (2000), which were not in favor of a sophisticated, fine-tuned system.

In London, a flat charge is not unreasonable. First-best pricing is very difficult to implement in practice. In today's technologically advanced world, the calculation of MCC in real time is not impossible; its cost effectiveness, however, would be a matter for consideration. There are a number of barriers to MCC on roads—technical and practical barriers, legal and institutional barriers, and barriers related to acceptability—moreover, differentiated pricing in time and space could be confusing to users.[70] Lindsey (2006) reviews virtually all the road pricing economics literature and argues that many economists have advised against varying tolls.

The problem with trying to compare the London charge with the MCC in the CZ is that the MCC constantly varies and there are no data on this varying MCC. A very rough estimate of the daily average MCC can be obtained by using average speeds before and after charging, traffic volumes, and a value of time. Santos and Shaffer (2004) and Santos and Fraser (2006) attempt to compare the London charge with the average MCC in the CZ during charging hours. Santos (2007) revises and updates those figures, concluding that better targeted charges would be around £3 a day for cars, £6 for vans, and £9 for trucks. With the £5 charge, cars were overcharged while vans and trucks were undercharged. With an £8 charge, cars are even more overcharged but vans and trucks are paying a charge closer to their MCC. Under the fleet scheme, where goods vehicles are entitled to a £1 discount, the £7 paid by vans is not too different from the MCC that they impose. Trucks, on the other hand, are still undercharged. These conclusions are very sensitive to the value

70. De Palma, Lindsey, and Proost (2006); Nash and Sansom (2001); Bonsall and others (2007).

of time used. If the assumed value of time were higher, the London charge could be found not to cover the MCC.[71]

Even with the simple ANPR enforcement system, it would not be expensive to administer different congestion charges (for example, three different levels) for different vehicle types. That has not happened mainly because of lobbying by the freight industry, which is opposed to a congestion charge altogether and especially to a higher charge for goods vehicles.

LCC and the Environment

LCC had no environmental objectives: its only aim was to reduce traffic and congestion. However, the reduction in the number of vehicles and the increase in speed (with less stop-and-go driving) is now estimated to have reduced emissions of nitrogen oxide by 8 percent, emissions of particulate matter by 7 percent, and emissions of carbon dioxide by 16 percent.[72] Those reductions, on the other hand, have not been important enough to have any effect on air quality.

The two main road transport environmental externalities are global warming and pollution, both of which are closely related to fuel emissions, which in turn are closely linked to fuel consumption (and, in the case of pollution, to vehicle type). The easiest and most practical way to internalize them is to impose a fuel tax. In the United Kingdom, fuel taxes are complemented with differentiated vehicle excise duties to reflect the different emissions per unit of fuel consumed by different vehicle types; thus, diesel vehicles pay a higher vehicle excise duty than petrol vehicles because they are more polluting. Newbery (1998) examines the environmental costs of road transport in the United Kingdom and compares them with transport taxes. The author concludes that transport taxes "appear to more than cover the full social and environmental costs of transport, as well as the cost of providing infrastructure"; in the case of carbon dioxide, he finds that even the highest estimates of the social cost of emissions represent a small fraction of existing road fuel duties in 2000.[73]

Petrol historically has been heavily taxed in the United Kingdom. The rising share of taxation in the retail price of road fuel between 1993 and 1999 was due to automatic increases in the fuel duty through a mechanism known as the

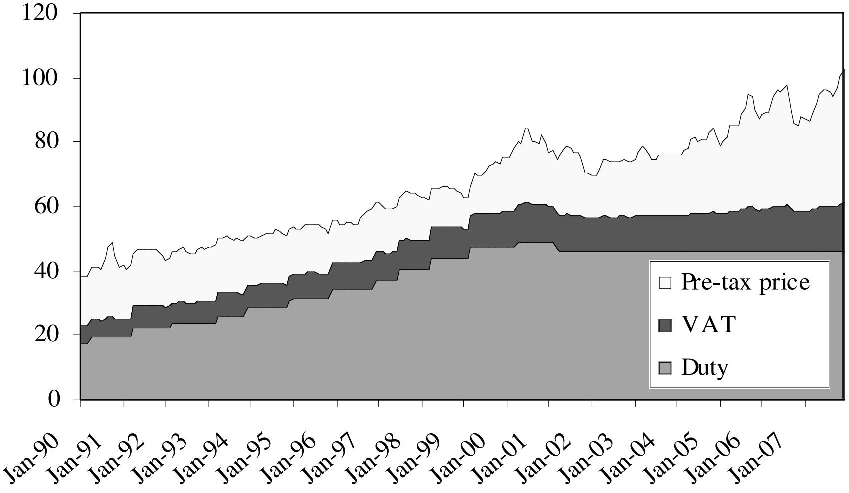
71. Winston and Langer (2006) argues that the cost of delays for freight vehicles includes not just the value of time but also the value of their freight, which may depreciate—for example, because of spoilage of perishables like fruit and vegetables.

72. TfL (2007b, p. 56).

73. Newbery (1998, p. 23); Newbery (2005).

Figure 4. Price Components of the Retail Price of Unleaded Petrol in the United Kingdom

Pence per litre



Source: Based on data from the Department for Business, Enterprise, and Regulatory Reform (2008).

escalator, introduced by the Conservatives and continued by the Labour government, which added a fixed percentage above the rate of inflation to the duty. Although the actual reason for the fuel escalator was the need for revenues, the government claimed that the idea was to reduce traffic growth and emissions. In the March 1993 budget, the escalator was set at 3 percent; it was increased to 5 percent the following November and to 6 percent in March 1997. In November 1999, it was abolished, and any future use of an escalator is to be decided on a budget-by-budget basis.

Figure 4 shows the different components of the retail price of petrol in the United Kingdom between January 1990 and December 2007. In March 1999, the tax component of the retail price of petrol reached almost 86 percent. In January 2008, it was just under 60 percent, a rate that the government is cautious about increasing, mainly because of the increase in the world price of oil. In the summer and autumn of 2000, there was an increase in the world price of crude oil, which, combined with high fuel taxes, caused a significant increase in the final price of fuel. The final increase resulted in a fuel tax protest that triggered shortages, panic buying, and traffic chaos across the United Kingdom.

If fuel duties are the cheapest and most effective way of charging for emissions and if fuel duties in the United Kngdom already more than cover all the environmental costs of road transport, there is no need to impose any additional environmental tax or charge on motorists. Nonetheless—and even though LCC had no environmental objectives when it was conceived—there are now proposals to link the congestion charge to emissions, which can be seen as a case of double-charging.

The emissions-related charging (ERC) project is aimed at vehicles that emit high levels of carbon dioxide. Vehicles that emit the highest levels (more than 225 grams per kilometer) will pay £25 to drive inside the CZ, while vehicles that meet Euro IV standards and emit the lowest levels (up to 120 grams per kilometer) will qualify for a 100 percent discount. Other vehicles (typically emitting 121 to 224 grams per kilometer) will continue to pay £8. ERC would replace the existing alternative fuel discount.

Residents driving vehicles emitting more than 225 grams of carbon dioxide per kilometer will no longer qualify for the 90 percent resident discount, and they will be liable for the £25 charge. Residents driving vehicles emitting up to 120 grams per kilometer will be entitled to a 100 percent discount, while residents driving vehicles emitting between 121 and 224 grams per kilometer will continue to pay the discounted rate of 90 percent.

Just as LCC makes sense, ERC does not. In the United Kingdom, a ton of carbon dioxide is valued at roughly £20.45 (at 2005 prices and values).[74] That means that a vehicle emitting 225 grams per kilometer imposes an externality of 0.46 pence (not pounds!) per kilometer. Such a vehicle would be required to pay £25 per day for the privilege of using the CZ, although even if it drove 1,000 kilometers, it would impose costs of under £5.

Regardless of the economic efficiency or inefficiency of ERC, environmental awareness has risen in the United Kingdom and in other parts of the world to the point that it has become politically acceptable (and even preferable) to undertake measures that reduce carbon dioxide emissions. Green groups will undoubtedly lend their support to such measures, and implementing ERC will probably be the easiest change the mayor will ever make to the congestion charging order because it is unlikely to face as much public opposition as the increase in the charge or the extension of the CZ.

74. Evans (2007, p. 17). This figure in turn comes from Clarkson and Deyes (2002), who reviewed virtually all the published studies (at the time) attempting to place a value on the social cost of carbon emissions. They concluded that the most sophisticated of the published studies that they reviewed produces a marginal damage estimate of approximately £70/tC (tonne of carbon) (2000 prices) for carbon emissions in 2000. This increases by approximately £1/tC per year in real terms for each subsequent year to account for increasing damage costs over time. This figure was taken up by the U.K. government, and it was still used as of January 2008.

Conclusions

Clearly, imposing a flat congestion charge, equal for all vehicle types and times of the day, is an inefficient policy. However, in the case of London it has paid off. While economists spent their time developing models of various charges and cordon locations and politicians spent their time explaining to economists why the public would never accept the charges, a very determined mayor decided to take the risk and implement a feasible, practical, unsophisticated policy, which has proven to be very effective. He did so despite significant opposition. None of the public consultations showed widespread support for a charge in London, or for an increase in the charge, or for the extension of the charging zone. Yet Mayor Livingstone went ahead with the original project and its alterations.

Although speeds are almost back to precharging levels, the reason for their deterioration is not that traffic has increased but that part of the road space has been reallocated to other users. During 2006 there also were a number of road work projects in London, which contributed to slowing traffic down. The number of vehicles with four or more wheels (cars, vans, trucks, buses, and taxis) entering the CZ decreased by 18 percent in the first year and has remained at that level. The number of cars decreased by 33 percent, suggesting that the car trips being made now probably are worth making.

The ratio of annual operating costs to annual revenues has always been around 50 percent, and the benefit-cost ratio is around 2. By law, net revenues have to be spent on transport in London. Net revenues have been used mainly to improve bus service. The ring-fencing of revenues to transport in London has helped to increase the political acceptability of road pricing.

The United Kingdom's fairly stringent and bureaucratic planning system may have prevented any change in land use as a result of the London charge. The two basic and fairly incomplete studies of commercial and residential property prices commissioned by TfL show no evidence that the London charge has had any effect on them. Future research should look at this problem, using a hedonic pricing model.

The reasons for the success of the London charge can be found in both the political determination of the mayor and the special conditions that prevailed in London before the charge was introduced: unusually low average speeds and high transit use. Ninety percent of people commuting into the CZ used a non-chargeable mode of transport, and those commuters have experienced only positive impacts from the charge.

Making the best of current environmental awareness, Mayor Livingstone is now planning to link the charge to emissions. Vehicles with high carbon dioxide emissions will have to pay £25 a day, although the high fuel duties in the United Kingdom more than cover the related environmental damage. An emissions-related congestion charge does not make sense and violates any principle of efficiency.

Although Singapore has had road pricing since 1975, it is London that has made the world aware of the potential benefits of such a policy. Stockholm adopted road pricing in 2007. San Francisco is assessing the idea. Maybe the time has come when road pricing will be seen as a real-world policy, not just a theoretical solution to a market failure of interest only to economics students.

Comment

Kenneth Button: Georgina Santos offers a very clear and thorough account of the events in London regarding the road charging regime now in operation there. There really is very little of substance that I can add to the factual account of events. What I would like to do is to expand a little on three slightly overlapping issues of importance that arise from the London case. The first is how the policy came to fruition; the second is why the demonstration effects seem to have been so muted elsewhere; and the third is whether the London regime has been captured by those with nontransport efficiency objectives.

The Political Economy of Congestion Charging in London

The idea of charging for congestion in London was clearly not new in 2003, and indeed a number of earlier studies had been commissioned to explore the idea. So why were charges introduced when they were? As the story goes, Ken Livingstone, the subsequent mayor of London (strictly speaking, of the Greater London Authority), came across an obscure paper by Milton Friedman on road finance that set in train the events that led to congestion charging in England's capital.[1] Obviously, that did have some impact. But in itself, the rather bizarre juxtaposition of a dusty manuscript authored by a free market economist and the perhaps fortuitous election of a left-wing mayor of London cannot in itself account for the policies pursued.[2]

What is certainly true—and is in many ways a serious indictment of much of modern economics—is that the veritable industry of academic scribbling on road pricing that has emerged in recent years had relatively little impact on getting the policy in place or on the form that it has taken.[3] While the work of a

1. Friedman and Boorstin (1951[1966]).

2. The major right-wing contender, a former deputy chairman of the Conservative Party and a best-selling author, ended up in jail for perjury and, potentially more damning, being suspended from the Marylebone Cricket Club because of lies he told in a libel trial.

3. Lindsey and Verhoef (2001) offers a literature review.

generation of abstract theoreticians has no doubt stimulated production of significant quantities of mental adrenalin as they merrily dance their intellectual jigs, their work has followed its own abstract course, some distance from the practice of public policy. The scheme in London, with a neat initial fee of £5 a day and discounts and exemptions for many groups, would, as Santos indicates, hardly meet any ideal positive criteria relating to efficiency. The charging regime has never, in fact, borne any real resemblance to marginal cost pricing as understood by Oscar Lange and other socialist planners.

In London in the latter years of the twentieth century, traffic congestion continued to be a problem despite various efforts expended on civil engineering projects, traffic and parking control, and public transport improvements over the years. While many of those efforts had added to the capacity of the system, they had had minimal impact on demand growth or on equating demand with costs. While congestion was thus a problem, it was a long-standing one that had gradually gotten worse. What was fresh in London was the introduction of a new, area-wide transport authority with the power to coordinate policies across the city. The Thatcher government of the 1980s and 1990s had disbanded the Greater London Council, and most responsibility for transportation had reverted to the individual London boroughs. The beggar-thy-neighbor attitude that often characterized that structure made area-wide initiatives, such as a congestion charge, unlikely to materialize.

Implicitly linked to that, as brought out in Santos's paper, is the wide range of exemptions and allowances that accompany the London charges in order to make them more palatable for those living and working in the areas most affected. The politics of London are inevitably complex; it is a large, multicultural city.[4] The package of charges, exemptions, and cross-subsidies that formed the initial charging scheme allowed coalitions of interests to form that, at the least, would not oppose it. While the cult of personality can be exaggerated, the mayor, besides being an experienced politician, had the advantage of serving for many years and in various capacities on different London-based administrations, including being leader of the Greater London Council in the 1980s and a member of Parliament. In other words, the congestion charging scheme had an able advocate who had an extensive record of public service in London and who also had been involved in other attempts to reduce congestion, the introduction of which had been thwarted by national legislation.[5]

4. General discussions of the political challenges confronting those advocating congestion charging are numerous; Lave (1994) and Giuliano (1992) cover many points germane to the U.S. situation.

5. In particular, the "Fares Fair" initiative in 1981 that sought to booster public transport use.

But there also was wider, nationwide legislation that helped with introducing congestion charges. In the past, the uses made of the very significant revenues that can accompany congestion charges had posed problems for advocates.[6] In recent years, lack of confidence that elected officials can be trusted to act in the public interest has often been the main obstacle to deploying rational pricing for public infrastructure. While there had been considerable academic thought put into the issue—whether revenues should go to reduce other road charges, to subsidize other forms of transportation, or to contribute to nontransportation expenditures has attracted particular attention[7]—the political economy of formulating local transportation policy makes the creation of a viable, dominant coalition of interests difficult. In the London case, national laws stipulated that net revenues for the initial ten years after introducing any congestion charges must be spent on local transportation. That condition effectively removed one tier of difficulties from the debate about the exact nature of charging in London, although, of course, the question of exactly what forms of transportation would benefit remained open.

The Suppressed Ripple Effect

Many advocates of road pricing initially saw the success of the London congestion charging regime as providing the positive demonstration effect that earlier road pricing experiments, most notably that of Singapore, had not. After all, London was the capital of a large Western democracy. Those people have largely been disappointed. There have been subsequent initiatives, but they often have involved systems that were being considered in advance of the events in London; in any case, they hardly constitute a flood of actions.

An important thing to remember is that the city of London is somewhat exceptional, in the strict sense of the term. Its transportation environment is, for example, substantially different from that of most North American metropolitan areas. While London's center is severely congested, the automobile share of commuter traffic was only about 12 percent before the introduction of charges; parking charges already were extremely high (about £4.00 an hour); and an array of frequent and efficient subway, rail, bus, and taxi services are available to and within the city center.[8] The central area where the charges ini-

6. Button (2006).
7. Small (1992).
8. Transport for London (2003b).

tially applied also is compact, and walking is widely enjoyed, at least when the weather is reasonable.

Attitudes toward policing and enforcement in London also differ from those often found in the United States. The system itself, as Santos highlights, involves relatively simple technology, but also important is that it has many features already familiar to U.K. drivers. Essentially, it is derived from the system used for enforcing speed limits and deciding traffic flow priorities—which flows get more green lights than others. Other countries, again notably the United States, have less of a tradition of electronic surveillance and law enforcement, and the policing authorities are perhaps seen in a different light. The U.K. context is in part a legacy of the response to the Irish Republican Army (IRA) terrorism attacks that began in the 1960s, but it may also reflect a different social attitude toward crime in general.[9] Whatever the underlying cause, there seems to be greater acceptance of electronic monitoring than is the norm in many democracies.

The charging regime in the United Kingdom also followed other relatively successful quasi-market developments that demonstrated that economic concepts can be useful. In particular, the London Regional Transport Act of 1984, although it was not operational until 1993, had introduced tendering for subsidized bus networks in London premised on Harold Demsetz's idea of "competition for the market," and that had proved very successful in reducing costs.[10] Such more market-oriented approaches to transportation, although not uncommon in interurban transportation, cannot be found in most cities, potentially leading to fear on the part of residents of regime change in any part of their local transportation system.

There may be another important distinction between the London situation and that found in the United States in particular. In some ways the U.S. attitude toward publicly supplied infrastructure is more socialist. There is less interest in its optimal use than in finance and cost recovery. Hence, while the "value pricing" schemes in California and elsewhere can be sold on the notion that new infrastructure offers better service than existing facilities, it is difficult to sell the idea that existing facilities would be better used if pricing was more rational.[11] The argument is that roads have already been paid for through fuel taxes and thus should now be "free" to users.

9. After all, the United States came into existence only after colonists refused to pay a quite legitimate tax on tea.

10. Kennedy (1995).

11. To many that appears to be a rather odd view of the world. If the charges for using new roads are meant to reflect the value derived from using them, then that would logically suggest that existing roads that are free at the point of consumption are valueless because there is no charge.

The obvious economic response to that argument has been echoed since Jules Dupuit and other researchers first published their work on efficient resource utilization in the 1840s. Moreover, the argument runs counter to what is the norm for the private sector. For example, there seems to be no public opposition in the United States to the fact that Wal-Mart prices are the same in old stores whose capital costs have been paid off many times over and in new stores that still have outstanding debt. That may be a cultural problem that extends beyond the narrow confines of pricing road use and perhaps reflects the greater impact of socialist thinking in the United States.

Finally, there is the matter of whether the traditional idea of road pricing à la Pigou is that relevant today. The experiences of California in value pricing, with road user charges rising so as to limit traffic on designated routes to a target speed, suggests that pricing may be able to play a more efficient role. The Pigouvian approach basically involves setting a target traffic flow rate or density (partly determined by safe speeds) and then setting the price that produces that flow.[12] That approach is in some ways akin to the now discredited forms of economic regulation applied to transportation, public utilities, and other sectors in the United States until the 1980s. In effect, it involves calculating both quantity and price outside of the market, essentially trying to meet an externally determined target for congestion by using an externally estimated price. Given the complexity of urban road networks, the interaction between road and pedestrian flows, the impact of traffic incidents, and so forth, estimating the ideal road price requires an impossible amount of real-time information.

The alternative is to set a physical traffic target (flow, speed, or density) and then let the price fluctuate to attain the target. In other words, it calls for wider use of the type of pricing applied to the Orange County, California, 91 Express Lane and to Interstate 15 around San Diego. That moves away from the Langian notion of administrative social cost price setting and instead uses flexible pricing to allocate the predetermined capacity level. Putting this approach into operation may take a little longer, but it may be seen as more efficient overall than the Pigouvian approach that underlies Ken Livingstone's scheme in London.

12. Strictly Pigouvian pricing involves adding the congestion costs of road use to the private costs; the optimal flow then is determined exogenously. In practice, however, estimation of the congestion charge requires knowledge of the engineering speed-flow relationship that is itself normally calculated by including an implicit measure of road capacity.

Capture of the London Scheme

Perhaps the most interesting part of Santos's paper, given the large literature that already exists on the initial impact of the London charging case, concerns what has been happening recently. The levels of road congestion in London are returning to those that existed before charging took effect. Although, as Santos indicates, part of that can be explained by the transitory disruptions caused by road work financed by the charges, a large part is due to road capacity being transferred to public transportation, notably buses. While in normal market conditions a case may be made for that if buses at least cover their costs; if not, there is the danger that some of the revenues from a congestion charging regime will become captured.

First, purely from a traffic perspective, the public transportation lobby has captured congestion pricing revenues to further subsidize public transportation. That has two potential sources of inefficiency. On the consumer surplus side, the transfer of monies from car users who are willing to pay for their consumption of road space to public transportation users who have to be bribed to use buses is a straightforward dead-weight loss of the kind associated with any cross-subsidy. But in addition, there is the X-inefficiency that goes with the supply of public transportation. While tendering systems for bus service provision may well have reduced the loss to a minimum on the operation side, there remains the potential for X-inefficiency in the way that bus-ways (bus-only lanes) and other public transportation infrastructure are supplied and increased. Decisions on these outlays are clearly not based on any commercial criteria, and there is an opportunity for decisionmakers to capture the rather basic cost-benefit techniques that are applied.

The second concern is the confusion that Santos implicitly highlights concerning the environmental costs of transportation. While one can hardly argue with the need to internalize environmental effects, subsidizing public transportation with the money collected from congestion charges is unlikely to produce anything like an efficient solution. While traffic congestion and traffic-induced environmental damage may be correlated, they are different and causality over the long term is complex. Simply put, if all the cars in London were solar powered, that would eliminate their associated greenhouse gas emissions (excepting the carbon dioxide associated with the manufacture of the hardware) but not have a jot of impact on traffic congestion. As the first Nobel Prize winner in economics, Jan Tinbergen, so famously pointed out in the context of macroeconomic policy formulation, you need at least as many policy instruments as policy objectives to achieve your desired aims. Seeking to tie the London congestion charges to environmental policy, as environmentalist groups have done, is, therefore, unlikely to optimize congestion or environmental damage. The more recent efforts to introduce explicit environmental charges, while logical, are, as Santos indicates, seriously flawed in execution.

Final Thoughts

The situation in London and other major cities over time testifies to the over dramatization of the notion that somehow generic "gridlock" will arise if nothing is done to combat congestion. The fact is that London and other metropolitan areas have tended to use their road infrastructure inefficiently because of the universality of "Gresham's Law"—in this case the bad currency, "allocation by time," is driving out the good currency, "allocation with money"—but, while that is economically wasteful, it does not stop the system from functioning entirely. London as well as a few other locations has provided a practical example of how even a very crude monetary pricing regime is more efficient at allocating resources than the use of queues. The London regime is not without flaws, as Santos shows. What I have tried to do here is to examine London's experience in a slightly different way by highlighting in particular the peculiarities of this case and the general lessons that may be learned from it.

Roger G. Noll: One of the most important insights in economics, which originated with A. C. Pigou a century ago, is that a cleverly designed system of taxes and subsidies can solve problems arising from externalities (that is, costs or benefits arising from activities that are experienced by people who do not directly participate in the activity).[1] Canonical examples are the pollution and congestion that are caused by vehicle traffic. Notwithstanding the genius of this insight and a few highly publicized examples of its implementation, governments have not widely adopted corrective taxes to combat pollution and congestion. Thus, the decisions to implement congestion charges in a few cities—London, Milan, Singapore, and Stockholm—and the reductions in congestion that followed have been met with considerable enthusiasm by many economists.

The success of these programs in reducing congestion has helped to generate enthusiasm for proposals to create similar programs elsewhere. For example, in 2007, the U.S. Department of Transportation awarded $1.1 billion in grants to Miami, Minneapolis, New York, San Francisco, and Seattle for congestion

1. Pigou (1912).

reduction, and plans in all five cities included a program to impose congestion charges.[2] A U. S. national commission on transportation endorsed congestion pricing in metropolitan areas having a population of more than 1 million.[3] Finally, someone seems to be listening. As David A. Hensher and Sean M. Puckett put it, a "stream of pricing consciousness . . . is surfacing around the world."[4]

The paper by Georgina Santos provides details about the London program, describes several design flaws that detract from its overall efficiency, and summarizes the effects of the program on vehicular traffic inside central London. Citing the results of a benefit-cost analysis by Transport for London, the agency responsible for the program, she concludes that despite design flaws the program has increased economic welfare, primarily by reducing travel times.[5] Although she does not specifically recommend the adoption of London's congestion charge system elsewhere, she nevertheless argues that London's system is a "not unreasonable" and suggests that congestion pricing may no longer be "just a theoretical solution to a market failure of interest only to economics students," but a "real-world policy."

Santos provides convincing support for her most important conclusion, that the London program is a success if judged according to its political goals, which were to reduce congestion and to raise revenues for public transportation. Vehicle presence and travel times in central London have fallen, and more than L100 million annually has been raised for public transportation. She also provides convincing arguments and evidence to support three other conclusions: one, that using congestion charges to reduce emissions from large passenger vehicles is not an efficient means of attacking pollution and detracts from the efficiency of the congestion charge system; two, that a congestion charge program need not be optimally designed to improve the welfare of society in general and local travelers in particular; and three, that the extension of the congestion charge zone (the Western addition) in 2007 most likely imposed more costs than benefits and detracted from the overall positive impact of the program.

Regardless of the plausibility of these conclusions, Santos and others who have reached similar conclusions do not offer convincing evidence that the London program provides an attractive model for implementing congestion charges elsewhere or that it was even a good choice for London. Indeed, other work by Santos casts doubt on the London system.

2. U. S. Department of Transportation (2007).
3. National Surface Transportation Policy and Revenue Study Commission (2007, pp. 21–22).
4. Hensher and Puckett (2007, p. 615)
5. Transport for London (2007).

The key issue in designing a practically feasible congestion charge system is to adopt simplifications from the theoretically optimal system that entail as small a sacrifice of net social benefits as possible. Santos correctly observes that the optimal program is not feasible, but her examination of the compromises that were made in implementing the London system is incomplete. In particular, she does not analyze in any detail the net costs to society of two important sources of inefficiency in the London system: one, the extensive exemptions and discounts available, and two, the uniform charges for all vehicles, which are based on daily presence rather than on the effect of each type of vehicle on congestion, the time that a vehicle is in the charging zone, and the allocation of time between driving and parking.

Roughly 40 percent of the vehicles entering the congestion zone are exempt from charges, and residents of central London pay a deeply discounted charge. The scope of exemptions and discounts goes far beyond the recommendations of the mayor's expert advisers, which were presented in a study of road charging options called the ROCOL report.[6] Because so many vehicles are exempt or receive deep discounts, the charge on those who pay full price must be far higher than either the optimal charge or the charge that would achieve current levels of congestion if all or nearly all vehicles were subject to the fee. As a result, the allocation of the burden of congestion reduction is too great for nonexempt vehicles (notably passenger cars), nonexistent for vehicles with exemptions (notably taxis), and far too small for those trucks and vehicles that are eligible for deep discounts.

For those who pay, the charge is based on the daily presence of a vehicle on the streets at some time during the business day rather than the congestion that the vehicle causes by being driven or parked. According to the ROCOL report, the decision not to vary charges by route, time of day, and length of travel made the program more attractive politically because it allowed the mayor to implement a program before he stood for reelection in 2004, after he had made transportation a major issue of his election campaign in 2000. This political requirement is unlikely to apply to other cities, and it probably should not apply to London in the future as the city government amends the program. Hence, to assess whether the London program serves as a valid model for any locality, including London in the future, one needs to assess the costs to society of the inefficiencies of the London scheme.

6. Independent Working Group (2000).

Optimal Vehicle Use Charges

Although the textbook "first-best" tax on vehicle use is impossible to implement, outlining its key features is useful because doing so highlights the potential pitfalls of an imperfect system and the issues that must be addressed in order to implement a system that delivers maximum practically attainable social benefits. Travel costs can be decomposed into four components: the direct cost of using a vehicle for travel, consisting of fuel consumption and wear on the vehicle; the effect of vehicular traffic on the long-run costs of building and maintaining roads; the implicit cost of travel time for passengers; and the societal costs arising from vehicle emissions. Congestion increases costs because it increases the implicit time cost of travel, the operating cost of the vehicle due to reduced fuel economy, and the pollution created during a trip of a given distance.

In the absence of charges for travel, vehicle users pay only the direct costs of vehicle operation plus the value of the time spent traveling. The costs that a vehicle imposes on others due to increased travel times and more pollution and the road deterioration caused by driving are not paid directly by the vehicle operator unless special taxes are imposed either directly or indirectly (through fuel taxes) on driving. An optimal system of charges includes a congestion charge, a road use charge, and an emissions charge, each separately calculated to equal the incremental effect of a vehicle on those costs.[7] A system of optimal charges on vehicle use causes vehicle travelers to face the full social cost of their decision to travel, which causes travelers to curtail driving to the extent that the value of travel by vehicle is less than its social cost.

The remainder of this comment focuses exclusively on congestion charges and ignores road consumption and emissions. A comprehensive evaluation of a toll system that seeks to improve the efficiency of transportation must take these into account; however, the main focus of this comment is on how the London congestion charge is seriously flawed strictly as a means of reducing vehicle congestion.

The basic features of the optimal system of congestion charges has been well known for a long time. A half-century after Pigou set forth the core idea in 1912, William S. Vickrey and A. A. Walters roughly simultaneously proposed detailed congestion pricing systems for Washington, D. C., and London, respectively.[8] The key theoretical insight about congestion is that the cost of road travel for a particular vehicle rises with the number of other vehicles on

7. Newbery (1990).

8. Pigou (1912); Vickrey (1959, 1963); Walters (1961).

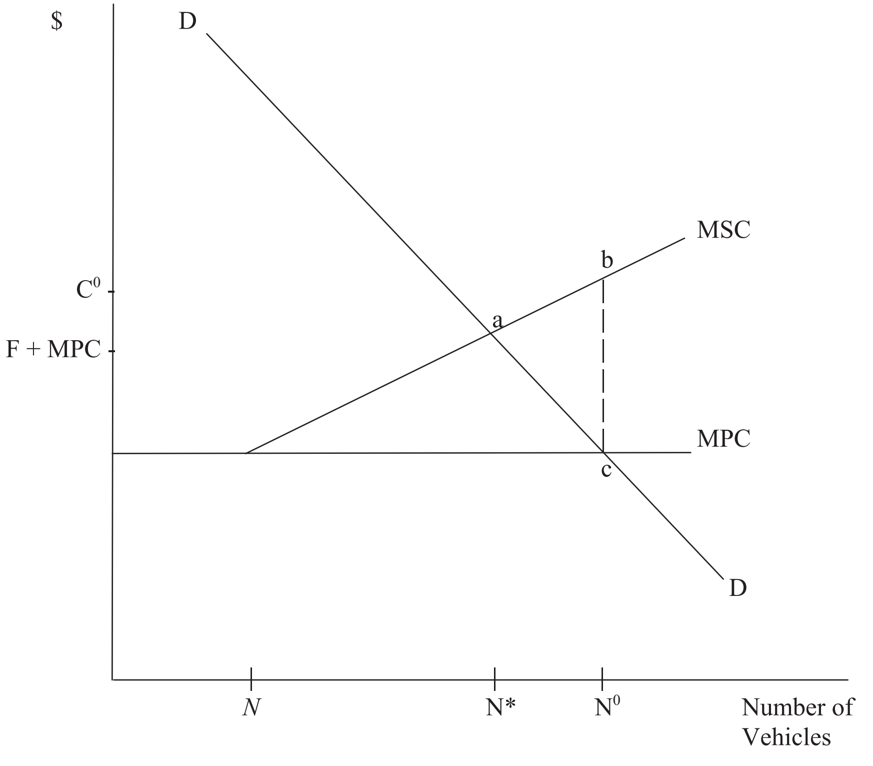
the road or parked in a congested area. The optimal congestion charge system consists of fees *per time period for driving on a congested road* and separate fees *per time period for parking in a congested area*. The fees for each time period are set to equal the cost of the slower travel that the presence of a vehicle imposes on all other vehicles that are traveling at the same time. Vickrey and Walters proposed time-sensitive charges, based on the demand for traffic at different times of the day. Vickrey's 1959 proposal envisioned electronic monitoring of vehicles, while Walters proposed a "mile-ometer," or a device something like that used by taxis. Both concluded that effective time-varying congestion charges were feasible and offered net social benefits forty years before the London system was designed.

Time enters into the calculation of optimal congestion charges in two ways. First, the value of vehicle travel to passengers varies by time of day. Because of employment schedules, demand for local travel typically is greater during peak hours (roughly 7:30 to 9:30 a.m. and 4:30 to 6:30 p.m. on weekdays) than at other times. Consequently, optimal congestion charges are higher in those periods. Second, the congestion that a vehicle creates depends on the time that it is in a congested area. While the vehicle is traveling, it directly adds to road congestion. While the vehicle is parked, it indirectly adds to road congestion by increasing the difficulty that others face in finding a place to park and hence the time that they spend on the roads looking for parking. The congestion effect of driving is not likely to equal the congestion effect of parking, so optimal charges are likely to differ for the two activities.[9] This difference was recognized in the ROCOL report, which recommended separate charges for driving and parking.[10] The plan as implemented did not include parking fees.

Figure 1 illustrates the optimal congestion charge for driving a vehicle at a particular time at a particular location. To simplify the analysis, the discussion focuses only on driving, not parking, although the analysis of parking is qualitatively similar. In figure 1, MPC is the marginal private cost of driving in the absence of congestion in a given time period. MSC is the marginal social cost, which is the sum of the marginal private cost and the costs arising from the increase in congestion that a vehicle creates, given that there are *N* vehicles on the road. *N* corresponds to the maximum number of vehicles that can be on the road without creating congestion. The demand for being on the road in this time period is the line DD. Each point on DD represents the willingness of a vehicle operator to pay to enter the road, with all vehicles arrayed in descending order of their value of traveling at that time. F is then the optimal fee at

9. Arnott and Rowse (1999).
10. Independent Working Group (2000, p. iii).

Figure 1. Optimal Congestion Charge per Time Period



which each vehicle on the road pays the marginal social cost of the congestion that it creates. When this fee is charged, the number of vehicles on the road in this time period is reduced from N^0 to N*, and the cost of congestion for each vehicle on the road is reduced from (C^0 – MPC) to (F – MPC). The net benefit to society from the reduction in travel is given by the reduction in congestion cost among N* vehicles, which is N*(C^0 – F), plus the excess of social costs over driving benefits for the (N^0 – N*) vehicles that are taken off the road by the congestion charge, which is the area of the triangle abc.

In the absence of the costs and complexities of implementation, the optimal congestion charge system sets a separate fee, F_t, for each moment of time at each location. The total charge is then the sum of the congestion fees for all of the time that the vehicle operates on congested roads. This system of charges generates distinct net benefits at each moment of time, with the magnitude of each benefit depending on the position of the demand curve at each time and place.

Of course, a continuous charge per unit time is too costly to implement because it would require continuous monitoring of every vehicle. A more practical approach is to divide a city into areas and the congested hours of the day into discrete periods and then to set separate fees for each period in each area. In areas where and at times when congestion is less—demand for travel is nearer the origin—the optimal fee is lower than for more congested periods and places. For areas and periods for which the demand for travel is sufficiently low, the number of vehicles on the road if no charge is imposed will be at or below *N*, in which case the optimal congestion charge is zero.

In some localities, a "peak charge" is set for travel during the morning and evening rush hour periods, a "shoulder charge" for an hour or so before and after each rush hour period, and a "standard charge" for the period between the late morning and early afternoon shoulder periods. Rather than base charges on distance or time on the road, the system can be simplified by creating "cordons"—geographic boundaries that separate areas with different traffic patterns and degrees of congestion—and charging vehicles for crossing a cordon boundary. Cordon fees are easier and less costly to implement because distance and route need not be monitored.[11] If the area enclosed by a cordon is sufficiently small, average travel distances among vehicles that enter an area will not vary greatly, so the cordon fee can reasonably approximate the optimal distance-based toll. Thus, the policy design problem is to identify the best simplification from the theoretical optimum: how many areas should be defined, and how finely should the periods of the day be divided?

Departures from Efficiency in the London Congestion Charge

Santos briefly describes some of the differences between the London congestion charge and both the optimal system and a plausible best simplification. Two such differences that impose especially high costs are that in London, fees vary in ways that are not related to actual congestion costs from different vehicles and charges do not vary over the business day. A third potentially important difference is that London contains only one charging zone, which originally was the central city but was expanded to include additional western districts in 2007.

Although several vehicle types are exempt from charges, the most important on both a total vehicle and fee-per-passenger basis are taxis, which account for 20 percent of all traffic in central London.[12] In addition, vehicles registered

11. Santos, Newbery, and Rojey (2001).
12. Transport for London (2007, p. 26)

to residents of central London pay only 10 percent of the congestion fee when they pay for an entire week at one time. The effect of exemptions and deep discounts is apparent from further analysis of figure 1. Suppose that half of the original N^0 vehicles are exempt or receive deep discounts. In order to reduce total traffic to the optimal level N*, the remaining $1/2N^0$ vehicles must bear the full brunt of the reduction in traffic, which implies a fee for them far above F, the optimal universal fee. After congestion charges are adopted, exempt and discounted vehicles continue to drive as before and so continue to impose congestion costs on others that exceed the value of travel for such vehicles. Meanwhile, some remaining drivers curtail travel at the higher fee who would have continued to travel if the fee were F. The congestion cost that the remaining drivers would impose if they traveled the optimal amount is less than their value of travel, so that excessive curtailment of their driving creates a net cost to society.

Judging from London travel patterns, this inefficiency is important. Vehicle kilometer-miles (vkm) for chargeable vehicles fell 28 percent between 2002 and 2006, but vehicle kilometers traveled by nonchargeable vehicles rose 16 percent.[13] For taxis, vkm rose 12 percent. Buses, too, are exempt, but their exemption is less distorting because buses carry so many more passengers that on a per-passenger basis, the optimal congestion charge would be very small. Consequently, the exemption for both taxis and buses causes too many people to ride by taxi instead of mass transit. Moreover, to the extent that congestion charges induce travelers to substitute taxis for passenger cars, the increase in taxi travel probably imposes more costs than benefits. For a fixed number of passengers, taxis are likely to cause more congestion because taxis but not passenger cars spend time traveling to look for passengers or to return from destinations where taxi demand is low.[14]

Likewise, as Santos states, charging the same fee for all vehicles that do not qualify for discounts causes additional inefficiency. According to Santos, actual fees are near the optimal daily charge for vans, are too low for trucks (lorries), and are too high for passenger vehicles. Passenger cars account for about 60 percent of all travel by chargeable vehicles, while large trucks account for about 5 percent.[15] When the system undercharges for trucks and overcharges for passenger cars, curtailment of driving by the latter is greater than the optimal amount (N* for cars) but less than optimal for the former (N* for trucks). In fact, vkm for passenger cars in the congestion zone fell by 37 percent between 2002 and

13. Transport for London (2007, p. 26)
14. Yang and others (2005).
15. Transport for London (2007, p. 26).

2006, while vkm for trucks fell by 7 percent.[16] In 2002, chargeable passenger cars accounted for more than twice as many vkm as vans and trucks, but by 2006 car vkm were about 1.5 times vkm for trucks. Thus, too little of the burden of congestion reduction falls on the vehicles that contribute the most to it.

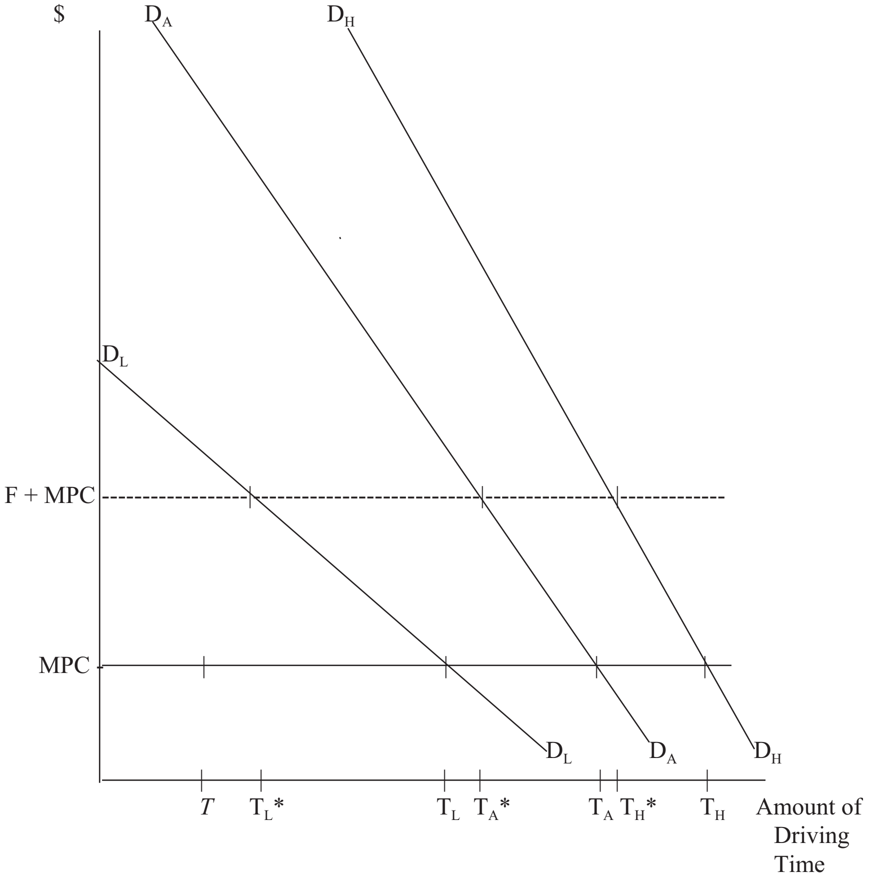
Another inefficiency arises because the congestion charge is a fixed daily fee. The justifications for a daily fee in the ROCOL Report were that congestion does not differ much during the day, although it is much less before 7:00 a.m. and after 6:00 p.m. than between those hours, and that a more complicated charging system might be confusing and less acceptable politically. Santos supports the latter justification but does not discuss the former. If true, these rationales amount to stating that the optimal values of F_t do not differ enough during the day to make a variable fee schedule worth implementing, but they do not justify charging a fixed daily fee rather than a fee that depends on the time of day that the cordon is crossed. If demand were the same in all periods, the optimal charge for each vehicle would roughly equal FT, where T is the number of time periods that the vehicle is on the road, rather than a fixed fee that is independent of the amount of time spent traveling.

The data do not support the claim that travel demand is roughly the same across all periods of the business day. Before the congestion charge plan was adopted, congestion was only slightly higher between 8:00 a.m. and 10:00 a.m. than at other times,[17] but since congestion charges were imposed the differences between peak hours and the rest of the day have increased dramatically. In 2006 mid-day traffic was about two-thirds as high as during the morning rush hour.[18] Moreover, the original charging period ended at 6:30 p.m., which caused a new peak congestion period around 7:00 p.m., when traffic exceeded mid-day traffic by about 30 percent. Most likely, 2007 data will show a shift in the new peak to 6:30 p.m. following the change in the end of the charging period to 6:00 p.m. In short, the facts do not indicate the desirability of either the choice of endpoints for the period in which charges are imposed or the imposition of equal charges in all periods between the endpoints; they do support implementing separate peak and shoulder prices. This finding is hardly news, as Newbery (1990) estimated that the optimal peak charge was about 20 percent higher than the optimal mid-day charge more than a decade before the London plan was adopted.

By having one large charging area, the London system cannot even loosely base charges on distance traveled, which could be accomplished crudely by

16. Transport for London (2007, p. 26).
17. Leape (2006, p. 161).
18. Transport for London (2007, p. 22, 28).

Figure 2. Effects of Optimal Congestion Charge with Heterogeneous Drivers and Equal Congestion in All Periods



dividing the central city into two or three zones and charging separately for crossing each cordon. The inefficiency introduced by not charging on the basis of distance traveled during congested periods is illustrated in figure 2.

For simplicity of exposition, assume that demand is the same in all periods and areas, so that the optimal fee per unit of driving is the same at all times and places. In figure 2, MPC is the marginal private cost of vehicle travel, and F is the optimal fee per unit of time on the roads, as derived from figure 1. Lines D_LD_L, D_AD_A, and D_HD_H, represent the demand for travel for travelers with low demand (L), average demand (A), and high demand (H), respectively. If a fee F is imposed for each period, each traveler will curtail driving. Specifically, the high demand traveler H will cut the time spent driving from T_H to T_H*, while

A and L will cut back from T_A and T_L to T_A* and T_L*, respectively. Total congestion charge revenues will be $F(T_L^* + T_A^* + T_H^*)$, with H both driving and paying the most, and L driving and paying the least.

The London congestion charge is a fixed daily fee for driving in the entire central zone, and it does not depend on driving time or distance. Suppose that the fixed daily fee is equal to the optimal fee multiplied by the optimal period spent driving by the average driver, T_A*. That is, the daily charge for all vehicles in the congested zone is FT_A*. Each consumer then has the choice of paying FT_A* and having unlimited access to congested roads or staying out of the zone entirely.

The first source of inefficiency arising from a daily fee is that a consumer who has paid the daily fee FT_A* has no incentive to curtail driving once he or she has entered the zone. That is, if consumers L, A, and H pay the fee, each will continue to spend driving times T_L, T_A, and T_H on the roads rather than curtail driving to their individual optimal amounts. If all consumers have the same demand for driving—that is, each has an individual demand for driving represented by D_AD_A—then a daily fee based on the optimal charge per time period (F) and the optimal average amount of driving (T_A*) would have no effect on driving time or congestion. All vehicles would be charged and continue to be driven the original amount. The only effect of the fee would be to generate revenue for the government.

A daily fee works as a policy to reduce congestion only because vehicle operators differ in their demand for travel, which causes some to stop driving rather than pay while causing others to pay but not change their driving intensity. The optimal charge system would cause all drivers to curtail driving that was of low value to them but not to reduce driving to zero.

Consider the decision whether to pay the daily fee. The cost to society of adopting the daily fee, rather than time-varying charges, can be derived from figure 2. A consumer will pay the daily fee if, despite the charge, the net benefit to the consumer from entering the congestion zone is positive. The gross benefit of driving is the area under the consumer's demand curve between zero driving and the amount of driving that the consumer would choose after paying the fee. Thus, consumer L will drive T_L (not T_L*) after paying the fee, which will give that consumer a gross benefit from driving equal to the area under D_LD_L between zero and T_L. The cost of being in the congestion zone and driving for T_L periods is the sum of the daily congestion charge, assumed to be FT_A* (the amount the average driver would pay under an optimal tax), and the marginal private cost of driving, $MPC(T_L)$. In figure 2, the benefit triangle for consumer L is less than the sum of the costs (the rectangle under MPC between zero and T_L plus the rectangle defined by F + MPC, MPC, and T_A*), so consumer L would choose not to pay the congestion fee and would reduce driving to zero. Thus, the imposition of a fee equal to FT_A*, if it achieves the optimal average amount of driving T_A*, does so by causing L not to drive at all, while having no effect on A and H. The cost associated with forcing L not to drive at all is the net value to L if the fee F were charged per time period and L responded by driving for T_L* periods. This net value is the triangular area between D_LD_L and F + MPC between zero and T_L*.

In addition, the daily fee creates the social cost of excess driving by type A and H drivers. In figure 1, the social benefit of congestion charges is the triangle abc. Type A and H drivers in figure 2 have similar triangles of social loss, measured by the difference between social costs and demand for all driving between T_A* and T_A and between T_H* and T_H. The sum of these triangles for all A and H drivers is the cost of excess driving that would be avoided by the optimal fees.

The effect of exemptions and discounts is similar to the effect of charging a fixed fee for a vehicle that will continue to be driven after the fee is imposed. Free or deeply discounted daily access rights also have no effect on the amount of driving by vehicle that qualify for them. The only difference between these vehicles and the vehicles owned by A and L in the previous example is that in the former case the government gets either zero or very little revenue. But every exempt or discounted vehicle creates a similar triangle of excess social costs.

Estimating Net Benefits

Several studies contain estimates of the net benefits of the London program. Since 2004, all annual impact studies by Transport for London have contained estimates of the benefits and costs of the program.[19] Independent studies include Santos and Fraser (2006), Santos and Shaffer (2004), Leape (2006), Mackie (2005), Prud'homme and Bocarejo (2005), and Raux (2005). The independent studies provide lower estimates of the net benefits of the program than the estimates of Transport for London that Santos includes in her paper, although all but Prud'homme and Bocajero (2005) conclude that the benefits exceed the costs.

The direct benefits of the program are the sum of estimates of the value of time to travelers multiplied by their time savings, the value of greater predictability of trips, the reduction in fuel costs because driving times are reduced,

19. Transport for London (2004, 2005, 2006, 2007).

the value of reduced vehicle emissions, and savings due to fewer road accidents. By far the most important benefit is reduced travel time. In essence, because type L vehicles no longer drive in the zone, congestion is lower; types A and H therefore spend less time traveling to any given destination. Although travel per vehicle is higher than before the program was implemented and the remaining vehicles still are on the road more than is optimal, their drivers still benefit from the reduction in congestion and the social cost of their excess driving has been reduced.

Estimates of the ratio of benefits to costs vary between 2.3 (Transport for London) and 0.6 (Prud'homme and Bocajero), with the rest concluding that the benefit-cost ratio exceeds one, but by less than the TFL estimate. The major source of differences among the studies is their estimates of the cost of travel time. Santos and Fraser, who provide estimates under varying assumptions about implementation costs and the benefits from reduced emissions and accidents, find benefit-cost ratios of between 1.4 and 1.7.

No study has attempted to estimate the additional net benefits that could have been generated if the charges in London had varied by time of day and the congestion zone had been divided into several areas. However, Santos is the coauthor of two studies—Santos and Newbery (2001) and Santos, Newbery, and Rojey (2001)—that evaluate a system in which tolls for entering and exiting eight smaller cities apply only in peak periods. In most cases, Santos and Newbery find that the benefit-cost ratio is substantially higher than any estimate of the ratio for London.[20] In the case of Cambridge, they further examine the net benefits of three cordon systems: a single cordon far from the central city, single cordon near the central city, and two cordons at the same locations as the previous two. That analysis enables them to identify the best of the three designs (a single outer cordon).

The fact that London cordon charges—with exemptions, discounts, excessive fees for passenger cars, and insufficient fees for trucks—depart substantially from the cordon charges that would maximize net social benefits is a serious concern. Santos, Newbery, and Rojey (2001) examined the net benefits of peak period cordon tolls in eight smaller English cities and performed a sensitivity analysis of the effect on net social benefits of an error in the toll. They found that introducing a toll that was either double or half the optimum toll caused the net benefits to fall by an average of 28 percent, with an extremely wide range of losses varying between 2 percent and 148 percent (in this case, the net benefits became negative).[21] The estimated losses in these cities would have

20. Santos and Newbery (2001, p. 13).
21. Santos, Newbery, and Rojey (2001 pp. 13–14).

been higher if the incorrect fees had been paired with the abandonment of peak load charges. Because these cities are much smaller than London, this study sheds no empirical light on the effects of London's departures from optimal cordon charges, but in qualitative terms, these results should give others pause before recommending implementation of the London system elsewhere.

Technology

The final problem with the London system is that it relies exclusively on purchases of daily passes to drive in the zone and photos of license plates to collect and enforce the charge. As a result, the London system is very costly. The net benefits of the program—as well as the ease of implementing time-of-day cordon charges—would be substantially enhanced if the system made use of electronic road charging. Since Vickrey proposed it in 1959, the least-cost method for implementing cordon tolls has been to employ electronic sensors to detect vehicle presence and to link the electronic sensor system to an automatic billing system.

Cordon pricing can be implemented by placing a radio frequency identification (RFID) chip on a vehicle; the chip allows a sensor to identify the vehicle when it crosses a cordon and automatically debit the registered operator's account. RFID chips cost less than fifty cents, and the cost is falling.[22] At greater expense, distance-based fees can be implemented by connecting smart cards to the odometer. When the vehicle enters the congestion zone, the smart card is enacted. The card measures the distance traveled until the vehicle passes another cordon, at which time the vehicle is billed on the basis of distance traveled. Systems based on both technologies have been used to collect bridge and road tolls, including the cordon charge system in Singapore and the abandoned experimental systems in Cambridge, England, and Hong Kong.[23] Indeed, because electronic road charging is the dominant technology, Santos and Newbery (2001) assumed that it would be the technology of choice in undertaking their benefit-cost analysis of cordon pricing in eight English cities.

22. Loukakos and Benko (2007).
23. Kahn (2001); May (1992); Ison and Rye (2005); Small and Gomez-Ibanez (1997).

Conclusion

The London congestion charge system is important because it proves that congestion charges are effective and can be implemented without generating so much political opposition that the system must be abandoned—although abandoned it has been in Cambridge and Hong Kong. But the London system is poorly designed, and no city should pattern its congestion charging system after London's without undertaking a serious analysis of alternatives that are very likely to deliver more benefits at less cost.

First, cities should at least provide the option of using an electronic charging system. Prepurchased entry permits that are enforced by photographic license identification still can be an option, but the permits should cost more because they are much more expensive to implement. In San Francisco, for example, RFID chips can be purchased for $25 from many retail establishments (including WalMart and Costco) and the entire payment credited to the purchaser's account when the buyer registers the purchase (with a payment option) with the toll authority.[24] Once activated, the chip entitles the vehicle to a $1 discount on all tolls because of the lower cost of the system. This system is likely to form the basis of the San Francisco congestion charge program.

Second, cities should let economic analysis guide the basic design of the charging system: the choice of boundaries of charging zones, the number of such zones, whether to implement entry or distance-related charges, and the degree of variation in fees for different types of vehicles and time of day. Each city is likely to find that in some ways its optimal design is unique due to geographic and demand peculiarities. Judging from the informative work of David Newbery on this topic, frequently conducted in collaboration with Santos, the likelihood is vanishingly small that a large city with a severe congestion problem will find the London system best; for example, see Newbery and Santos (1999) and Santos, Newbery, and Rojoy (2001). Most likely the optimal system will involve peak, shoulder, and regular pricing periods during the day and early evening, and, if a cordon system proves most attractive, that more than one charging zone will be created.

24. Loukakos and Benko (2007).

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