Evidence Review

Congestion charging

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Brief evidence review

This brief review summarises the available empirical evidence on the impact of congestion charging policies on outcomes of relevance to city decision makers, such as traffic conditions, air pollution and property prices.[1]

We focus on econometric analysis and impact evaluations that try to identify the causal effect of the introduction of congestion charging policies. We consider any study, published in English, that provided before-and-after comparisons or cross-sectional studies that control for differences between areas with and without congestion charges, most often during peak traffic periods.

We found a total of 12 studies that met our inclusion criteria: one study of Electronic Road Pricing (ERP) in Singapore, five looking at impacts of the London Congestion Charge (LCC), three about the road pricing scheme in Milan, and three covering a number of different schemes together. Our findings can be summarised as follows:

- **Congestion charging can lead to significant improvements in traffic conditions.** Studies find that the LCC improved traffic conditions, and reduced the number and rate of accidents in the charge zone as well as in adjacent areas. Milan also saw significant reductions in congestion.
- **Congestion charging can also have positive effects on air pollution**. The LCC reduced the concentration of some pollutants in the charged area (although there is some evidence of displacement to the uncharged surrounding areas). There was also an increase in the use of public transit in London. Again, studies in Milan also showed a reduction in air pollution as a result of the charge.
- **Congestion charging may decrease retail property values and increase housing values**. The LCC was associated with an increase in housing values (of around 5%). Singapore experienced a drop in retail real estate prices in the ERP zone relative to non-ERP zones. However, the policy had no effects on private offices and residential real estate within the ERP zones. It is possible that the 90% resident exemption from the LCC means that house price rises that were observed inside the London zone may not occur in zones where residents do not receive exemptions.

1 Congestion charging is a form of road pricing designed to discourage driving and may also aim to achieve secondary objectives (e.g. reduce the use of particular kinds of vehicles).

Things to consider:

- Congestion charging in highly-congested areas is likely to improve traffic conditions and reduce air pollution, which may justify the tax. However, it is still unclear how these policies affect overall welfare, labour market outcomes, retail sales and other firm outcomes. More evaluation considering longer time scales is needed to understand some of these factors.
- Improved public transport is an important policy complement to congestion charging.[2] Congestion charging can provide a reliable source of revenue to fund these improvements.
- In places where there is no reliable alternative to travel by car the impacts of congestion charging are likely to be less. Policy makers should consider how they can ensure that public transport improvements can be 'front funded', or alternatively expect that there may be a lag between charge implementation and mode shift whilst public transport improvements (funded by a charge) are implemented.
- The successful implementation of congestion charging depends on a large number of variables, many of which are place-specific. Only so much can be learned from existing schemes so it is crucial that local areas introducing schemes put in place effective plans to monitor and evaluate impacts of the scheme.
- The impact of design elements should be considered carefully. For example, the effect of exemptions could matter for the impact on traffic as well as broader outcomes. One study of Milan finds a major increase in the use of motorbikes, which were exempt from the charge – this may be creating a new problem in terms of noise and safety. The resident exemption for the LCC may explain the positive effect on house prices.

Things to consider when developing monitoring and evaluation plans:

- Keep information on how the policy is targeted (e.g. analysing the effect of a congestion charge zone (CCZ) requires information on the boundaries of the CCZ).
- Develop a theory of change and identify and acquire data on potential outcomes, for example:
  - Detailed firm-level employment data from the ONS Business Structure Database.
  - Housing transactions from the Land Registry database (these can be linked to Energy Performance Certificate data to allow a price per square metre to be derived, as Land Registry data only gives total price).
  - Average annual daily traffic flow ideally split by mode (e.g. from Department for Transport or local sources. Depending on the approach taken this may be provided by cameras used to enforce any charge).
  - Data on air quality (e.g. from local models).
- Think about how to construct a comparison group. Much of the literature uses 'difference-in-difference' approaches that compare firms or households inside the charging area to similar firms or households in nearby areas outside the zone.
- Because effects may spill over to immediate neighbours think about using both boundary areas (i.e. areas just outside the zone) and other similar areas slightly further away from the zone boundary.

2 According to TfL reports using survey data (http://content.tfl.gov.uk/impacts-monitoring-report-2.pdf) journeys by bicycle bus and taxi increased, while commutes on rail and underground decreased.

Annex

We assess the quality of the evidence based on the scoring of papers on the Maryland Scientific Methods Scale (SMS), which ranks policy evaluations from 1 (least robust) to 5 (most robust) according to the robustness of the method used and the quality of its implementation. Robustness, as judged by the Maryland SMS, is the extent to which the method deals with the selection biases inherent to policy evaluations. You can read more about this in our scoring guide: https://whatworksgrowth.org/resources/scoring-guide/

Agarwal, Sumit, Koo, Kang Mo, & Sing, Tien Foo. (2015). "Impact of electronic road pricing on real estate prices in Singapore." Journal of Urban Economics, 90, 50–59.

(SMS3) Singapore's ERP system was introduced in 1998 and involves a network of toll gantries to tax vehicles entering designated areas in the city centre during peak hours. This paper uses the congestion rate price increase of 1 November 2010 as an exogenous shock to test the effects of the ERP rate on retail, office and residential real estate prices. The results show that the November 2010 congestion toll rate increase caused a 19% drop in retail real estate prices within the cordon ERP areas, relative to retail real estate prices outside the cordon ERP areas.[3] The results are statistically and economically significant. However, the toll rate hike had no significant impact on private office or residential real estate within cordoned ERP areas.

Keat Tang, C. (2016). "The Cost of Traffic: Evidence from the London Congestion Charge" SERC discussion paper 205

(SMS3) This paper looks at the effect of the LCC. It finds that the LCC is associated with significant improvement in traffic conditions and housing values. Instrumenting local traffic conditions with the enforcement of the LCC, and limiting the analysis to properties proximate to the LCC boundary, the paper finds that the elasticity of housing values with respect to traffic ranges from -0.34 to -0.58. These findings suggest that the consequential improvement in traffic conditions due to the LCC has generated a windfall of £3.11 billion for homeowners in the zone. These effects may be partly or wholly explained by the fact that drivers living inside the LCC boundary receive a 90% discount on the charge.

Green, C., Heywood, J. S., & Navarro, M. (2016). "Traffic accidents and the London Congestion Charge" Journal of Public Economics, 133, 11–22.

(SMS3) This paper considers the impact of the LCC on traffic accidents. It finds that the policy generated a substantial reduction in both the number of accidents and in the accident rate. The paper considers whether the charge caused displacement of traffic and accidents to other areas (or other more dangerous modes) but finds that it did not. In fact, it finds that the charge also reduced accidents and the accident rate in adjacent areas, times and for uncharged vehicles.

Percoco, Marco. 2015. "Environmental Effects of the London Congestion Charge: a Regression Discontinuity Approach." Mimeo

(SMS4) This paper evaluates the causal effect of the LCC on the level of pollution using a unique dataset consisting of daily observations, concentrating on eight pollutants: CO, NO, NO_2, NOx, O_3, PM2.5, PM10, SO_2. The paper uses a regression discontinuity design with thresholds around the dates

3 There are a number of possible explanations of this effect. For example, consumers may find substitutable goods in regional shopping malls located outside the charge zone to avoid paying higher toll charges or there may be a supply response as developers adjust the location of new shopping malls.

of the introduction of the charge and of the beginning and end of Western Expansion. Results suggest a negligible adverse (overall) impact of the charge. A spatially disaggregated model suggests that the road pricing scheme has reduced the concentration of NO, NO_2 and NOx in the charged area and increased it in surrounding areas. A general deterioration of pollution concentration is found in the case of O_3, PM2.5, PM10. These results are consistent with an overall increase in travelled kilometres, due to traffic diversion from the charged to the uncharged area. Furthermore, there is an unclear, possibly adverse, impact of increased speed on pollution.

Beevers, Sean D, & Carslaw, David C. 2005. The impact of congestion charging on vehicle emissions in London. Atmospheric Environment, 39(1), 1–5.

(SMS3) This paper studies the effect of the LCC. It finds that the LCC reduced traffic flows in central London. The air pollution impact of the scheme is difficult to assess using ambient measurements alone as the air pollution concentrations in 2003 were higher than in 2002 because of unusual meteorological conditions. To address this problem the paper models emissions by combining detailed traffic data with the Environmental Research Group's road traffic emissions model. This suggests total (modelled) NOx emissions reduced by −12.0% ±12% in the charged zone and increased on the inner ring road (IRR) by +1.5%. (Modelled) PM10 emissions reduced by −11.9% in the charging zone and by −1.4% on the inner ring road. The paper suggests that increased vehicle speed and reduced vehicle numbers both played a role in reducing emissions. Changes in vehicle km are large (−15% ±4%) particularly in the charging zone itself. A potential increase in emissions from increased bus use was mostly offset by the widespread introduction of particle traps to the new and existing bus fleet as well as the introduction of newer technology bus engines. Finally, there is a reduction in (modelled) emissions of CO_2 (−19.5%).

Atkinson, Richard W, Barratt, Ben, Armstrong, BHRA, Anderson, H Ross, Beevers, Sean D, Mudway, Ian S, Green, David, Derwent, Richard G, Wilkinson, Paul, Tonne, Cathryn, et al. (2009). "The impact of the congestion charging scheme on ambient air pollution concentrations in London." Atmospheric Environment, 43(34), 5493–5500.

(SMS3) This paper considers the impact of the LCC scheme on pollutant concentrations (NOx, NO and NO_2 PM10, CO O_3) measured at roadside and at background monitoring sites across Greater London. Changes in pollution concentrations within the congestion charging zone were compared to changes, over the same time period, at monitors unlikely to be affected by the charge, and in the boundary zone between the two. Similar analyses were done for LCC hours during weekends (when the charge was not operating). The paper suggests the introduction of LCC was associated with a decrease in NO and increases in NO_2 and O_3 relative to the control zone. There was little change in background concentrations of NOx. There was also evidence of relative reductions in PM10 and CO. Similar changes were observed during the same hours in weekends when the scheme was not operating. The paper urges some caution in the causal attribution of these changes as the scheme was introduced concurrently with other traffic and emissions interventions.

Gibson, M., and Carnovale, M. (2015). "The effects of road pricing on driver behaviour and air pollution" Journal of Urban Economics, 89, pp. 62-73.

(SMS 3) This paper examines the effects of road pricing on driver behaviour and air pollution in the city of Milan. To identify the causal effect of road pricing, the study makes use of an unanticipated suspension of Milan´s road pricing policy for around eight weeks. Using a difference-in-difference strategy, the study finds that road pricing decreases vehicle entries into the targeted area by 14.5%, and also reduces air pollution by 6-17%.

Percoco, M. (2014). "The effect of road pricing on traffic composition: Evidence from a natural experiment in Milan, Italy" Transport Policy, 31, pp. 55-60.

(SMS 4) This paper analyses the impact of road pricing on the composition of traffic in Milan. Similar to STUDY 8, it uses the unexpected and temporary suspension of a road pricing policy in the central area of Milan. The charge rate was a flat rate €5 to most cars, but the most polluting older cars (Petrol Euro Class 0 and Diesel Euro Class 1 to 3) were banned; whilst hybrid and electric cars were exempt. Using a regression discontinuity design around the date of suspension, the study finds that the policy shifted users from highly-polluting to less-polluting vehicles. These effects are offset to an extent by an important increase in the use of motorbikes which were exempted from paying the charge.

Percoco, M. (2014). "The impact of road pricing on housing prices: Preliminary evidence from Milan" Transportation Research Part A Policy and Practice, 67, pp. 188-194.

(SMS 3) This paper analyses the effect of a road pricing policy on house prices in the city of Milan. Using a difference-in-difference, the study finds a decrease in house prices in the targeted area. These adverse effects are likely to be explained by the design of the policy which did not charge motorbikes, and as result ended up substantially increasing the number of motorbikes in the targeted area.

Anas, A, & Lindsey, R. (2011). "Reducing urban road transportation externalities: Road pricing in theory and in practice." Review of Environmental Economics and Policy, 66–88.

(review) Based on a review of theory as well as empirical evidence from existing schemes, this article draws four conclusions about urban road pricing: (1) the benefits of road pricing exceed the costs; (2) the benefits of congestion relief are larger than the benefits of improvements in environmental quality; (3) success depends in part, but only to a limited extent, on the presence of public transit and on how services are adjusted; and (4) the distributional effects and public acceptance of road pricing pose important challenges for policy design.

Diana Vonk Noordegraaf, Jan Anne Annema, Bert van Wee, (2014). "Policy implementation lessons from six road pricing cases." Transportation Research Part A: Policy and Practice, 59, pp. 172-191

(review) This paper presents a content analysis of 106 scientific papers relating to six road pricing schemes. Four of them were implemented (Singapore, London, Stockholm and the Norwegian cities) and two were proposed but ultimately not implemented (Hong Kong and Edinburgh). Based on all the papers, the analysis identified a number of contextual factors and scheme characteristics relating the six schemes, with the aim of identifying common success factors that might help cities considering road pricing schemes. The authors were able to identify six factors that the implemented schemes had in common (general political support; general public support; information campaign; various actor perceptions; characteristics of the transport system; and marketing of the scheme) that seemed to make a positive contribution to successful scheme delivery. However, there were many other contextual factors and characteristics that varied widely between schemes. This may suggest that many of the 'success' factors that resulted in each city's successful implementation were place-specific.

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