Policy brief
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Benefits and costs of road traffic congestion pricing

Evidence from Bangalore

In brief

- Chronic road traffic congestion is ubiquitous in developing countries. Congestion pricing is a theoretically appealing and technologically feasible policy, yet to date has not implemented in developing countries.
- This brief examines an experiment with congestion pricing pilot policies to learn how commuter change their driving behaviour due to charges, focusing on when trips take place (during or off peak-hours).
- Commuters value the time they spend driving highly, that is, traffic congestion is costly. In relative terms, commuters are moderately flexible to change their schedules.
- However, travel times during peak-hours are not very responsive to the volume of traffic. This result is in stark contrast to findings for highways in developed countries.
- The social gains of re-allocating vehicle trips away from the peak-hour period using congestion pricing are small. Intuitively, the social value of travel time saved by inducing commuters to avoid peak-hours is not much larger than the costs to those commuters of traveling at different, more inconvenient times.

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Policy motivation

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Traffic congestion is a chronic problem in large cities across the world. Millions of urban commuters experience slow traffic, noise, and pollution fumes on a daily basis. For example, commuters in Bangalore in this study spend on average 1.5 hours driving per day, with an average trip speed of 14 kilometres per hour. Morning and evening peak-hours are up to twice as slow as uncongested times.

Economists have long recommended charging road users fees that scale with the amount of congestion. Pricing policies are backed by common sense, as well as by economic theory. The idea is that drivers impose an externality, namely a cost on society, by slowing down traffic, generating pollution, etc. Typically, drivers do not take this into account, which leads to excessive congestion. Well-chosen pricing can in principle remedy this situation.

Technologically, pricing can be implemented using car GPS devices, as well as license plate reading cameras. These technologies also allow fine pricing, differentiated by time of day and routes. Some cities, such as Jakarta, are in the process of implementing such policies.

However, driving pricing policies need a careful assessment of costs. Traveling at one's desired time is inherently valuable, so if charges are too high, the costs to commuters induced to change when they travel may be larger than the travel time improvements. An ideal policy will only eliminate *excessive* congestion, but finding this policy requires a quantitative understanding of how commuters value alternatives, and how road speeds depend on traffic volumes.

Project summary

This study measured how commuters in Bangalore respond to congestion pricing pilot policies. It focuses on *peak-hour congestion*, and how drivers can adjust the times when they travel. In general, congestion pricing may also have other impacts, affecting pollution, whether drivers switch to public transport, and where people live and work. For tractability, these margins are assumed to stay constant.

The first step was to collect detailed data on how commuters travel from a sample of car and motorcycle drivers recruited in randomly chosen gas stations in Bangalore. Precise GPS location data was collected using a smartphone app installed on study participants' phones. Participants are younger than all general commuters, but otherwise similar in terms of vehicle price.

Secondly, two broadly realistic congestion charge policies were designed and implemented. Under the "departure time" policy, trips are charged according to departure time, with higher rates for peak-hour departures. Under the

"area" policy, commuters face a flat fee for driving through a small area along their usual route, chosen such that there exists a longer, untolled alternate route. Charges were calculated automatically and subtracted from a prepaid virtual account. The account balance was transferred to the participants' bank account at the end of each week in the study. Overall, almost 500 commuters took part in this experiment. The charge policies were embedded in a randomised field experiment. This made it possible to measure how commuters change their behaviour with charges, relative to commuters who do not face charges.

The third part of the study was to measure the road technology component of the externality. This relationship describes the improvement in travel times from removing a certain volume of vehicles from the peak-hour period. The GPS trip data was used to quantify average traffic volume, and Google Maps travel time data was used to measure typical travel times Bangalore.

The final part uses a simulation model to understand the impact of city-wide peak-hour congestion pricing. The model focuses on (travel time) benefits and (schedule) costs, holding fixed other margins such as carpooling, public transport, and pollution.

Project findings

The experimental results show that commuters place a high value on time spent driving, and they are moderately flexible to change their schedules. Surprisingly, the marginal effect of adding a vehicle on the road on average travel time is similar during peak hours and at times with lower congestion. Taken together, there are only small gains from optimal congestion pricing in terms of re-allocating peak-hour commuter trips to different times of the day.

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With departure time charges, commuters left earlier in the morning, but not later, to avoid charges, and vice-versa in the evening. These results are consistent with work hours being an important constraint on schedules. In response to area charges, some commuters took longer detours around the congestion area to avoid paying the fee.

It is useful to interpret these results in terms of how commuter value two aspects of their commute. Focusing on the morning commute, commuters value the *time spent driving* highly, at around Rs. 1,100 per hour, approximately four times higher than the self-reported hourly wage. Hence, the benefits of reducing congestion are high. Commuters appear moderately schedule flexible to leave earlier (in the morning), with the *schedule cost of arriving early* at around Rs. 320 per hour.

Schedule flexibility alone suggests that commuters have a viable alternative to traveling during (congested) peak-hours, yet the overall gains from congestion pricing depend on the magnitude of the social benefits achieved by inducing

commuters to avoid the peak-hours. On this dimension, times of the day with higher traffic volume have higher travel times, yet this effect is linear. Quantitatively, a half-hour trip during the peak-hour increases the aggregate driving time of everyone else by around 17 minutes, a moderate or even large social cost. Akbar and Duranton (2017) describe a similar relationship in Bogotá, Colombia. However, previous research on highway segments in rich countries typically finds that adding a vehicle when the highway is already congested has a larger effect than adding it with less congestion. More research is necessary to identify why Bangalore and Bogotá roads are different.

Simulations reveal small gains from city-wide congestion pricing leading commuters to re-allocate when they travel. First, the optimal policy only improves congestion by a small amount: travel times are 1 minute faster from a base of 37 minutes in the unpriced case. Moreover, the schedule costs experienced by those induced to travel at inconvenient times are of similar magnitude overall, so that on net the average gain is extremely small, around Rs. 5 (or $0.07) per commuter per day. Additional simulations show that this result is driven by the shape of the externality. In other urban contexts where peak-hour congestion is more responsive to the volume of traffic, congestion pricing may yield higher net gains.

Policy implications and future research

- For traffic policies that affect how commuters behave, the increase in traffic speeds is not an appropriate metric for evaluation. The cost to commuters induced to switch to alternative options must also be taken into account. In some cases – such as peak-hour pricing in Bangalore – these costs can be similar to the benefits.
- Severe traffic congestion does not automatically imply that congestion pricing can significantly improve the situation.
- Policies such as congestion pricing or restrictions are most likely to be beneficial in urban areas where peak-hour congestion is highly responsive to the volume of traffic. This is unlikely to be the case in cities such as Bangalore, at least at the scale of the entire city.
- It may be important to explore other inefficiencies in road use, such as compliance with traffic rules, separation between pedestrians, parking and traffic, etc. Improvements along these dimensions may raise road speeds, and these improvements may also make congestion pricing *more* attractive.
- Future research should quantify pollution effects of traffic congestion across two different margins: pollution *generation*, understanding how vehicles of different types and at different speeds emit pollutants, and pollution *exposure*, namely how congestion affects the amount of exposure for participants in traffic. The social costs of traffic congestion may be significantly higher due to these pollution mechanisms.