

COMMENT

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Late-night gridlock on Beijing's roads.

Set road charges in real time to ease traffic

Track vehicles to link tolls with demand and cut congestion, urge **Peter Cramton, R. Richard Geddes and Axel Ockenfels**.

Traffic jams cost us time, money and health. In 2016, the average US driver spent 42 hours in congestion during peak hours, and those in Los Angeles, California, spent 104 hours¹. New Yorkers can walk almost as fast as vehicles crawl along streets in central Manhattan². Being stuck is frustrating and stressful. Jammed cars can burn up to 80% more fuel than those in free traffic³⁻⁵. This leads to more air pollution and greater carbon dioxide emissions, increases the incidence of heart attacks, strokes and asthma and contributes to poor infant

health^{6,7}, especially among city dwellers.

The economic damage of congestion last year in the United States, Germany and Britain totalled US\$461 billion⁸. Such costs are rising as the world's population grows and urbanizes. The six most congested countries in 2017 were Thailand, Indonesia, Colombia and Venezuela, with Russia and the United States tied in fifth place.

The usual response is to call for more roads. But they don't diminish traffic⁹. Quite the opposite: more drivers move in. Nor will artificial-intelligence systems, ride-hailing

services and autonomous cars ease the gridlock. Navigation systems draw more drivers to certain routes and can spread congestion to formerly quiet streets. The ride-hailing apps Uber and Lyft, for instance, have increased traffic because people make more car journeys. Without ride-hailing, according to one US survey, around half of such trips between 2014 and 2016 would have either not been made, or would have been done on foot, bicycle or public transport¹⁰. Similarly, self-driving cars use roads and fuel efficiently (and reduce accidents), but those gains might be ▶



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Singapore has experimented with electronic pricing on roads in its inner zones.

► swamped by an increased desire for cheap and easy transport¹¹.

The answer lies in dynamic road pricing. The location of individual cars can now be tracked to within a few centimetres. This makes it feasible to measure and price road use in real time according to demand. If the price were set at the right level, enough car drivers would choose to drive at a different time or take a different route or mode of transport to cut congestion. Limited road space would be managed in a similar way to airfares, electricity, hotel rooms and train journeys. Uber already balances demand and supply of its cars through surge pricing.

Overall, dynamic pricing does not drive motorists away. It can double the capacity of a congested route in peak times by preventing traffic jams¹² — just as managing fisheries can ease overfishing. Pollution and stress would decrease. The funds raised could be used to improve roads and public transport, and to reduce fuel and other taxes.

Fixed pricing schemes have been tried. Since 2015, 5,000 volunteers in Oregon have been trialling a tax on miles travelled by car. Around a dozen countries, including Germany, Austria and Switzerland, follow a similar approach for lorries. In recent decades, some cities in the United States and elsewhere, including Singapore and Stockholm, have experimented with electronic charging for roads in their inner zones.

But such schemes do little for congestion,

because prices often do not change meaningfully with supply and demand¹³. A low price does little to mitigate jams at peak times. A price that is fixed high to eliminate peak congestion would be as inefficient and unacceptable as having Thanksgiving airfares all year.

Instead, policymakers and city managers need to track cars' positions and adjust charges continuously, depending on how busy the roads are.

What has stopped them? There are three research gaps: technology needs refining to measure road use by cars accurately and at low cost; an equity and privacy framework needs hammering out; and the implementation of network-wide, real-time road pricing needs better economic and computational modelling.

FREE RIDE

Congestion is pervasive because motorists take no account of the cost that they impose on others. Prices should instead reflect motorists' impact on each other. The system would operate in a similar way to an electricity market, making road space a commodity that can be bought and sold. An independent operator for the system would determine prices on each road segment to balance supply and demand, and thereby maximize the network's value to users while keeping traffic flowing¹⁴.

Prices would be levied on all roads in a region. Charges could vary with time and place every ten minutes, say, according to

traffic conditions. Prices would thus respond to lane closures, weather and sporting events, as well as to peak commuting times.

Research is needed to estimate the best levels for market prices. Most of the time, they would be near zero. On popular routes in Europe or the United States, an urban commute might cost as much as \$20 — but the trip would take 30 minutes rather than, say, 45–90 minutes. The actual price would depend on how easily drivers can shift away to other times or modes of transport.

Fees would be tailored to vehicle types. Lorries would pay more. An autonomous vehicle, driven using algorithms to promote free flow and possibly coupled with other cars to decrease spacing, uses less road capacity than a standard car and would pay less.

An advantage of dynamic pricing is that it includes the means with which to charge the full social cost of a vehicle's use — both congestion and pollution. Prices could be varied to keep air-quality measures, such as particulate matter, within limits. Although this would not affect the number of cars at peak times, it would increase the road price for dirty vehicles and make room for clean ones. Electric cars, for instance, would pay less. This would be a cheaper and less-intrusive way of fighting pollution than banning diesel cars from city centres, as is being discussed and implemented in Germany.

Prices would be tracked using navigation apps such as Google Maps and Waze. Such tools would present both real-time

information and forecasts of future prices, much as they do today for trip duration. Prices would be integrated into fares for taxis and ride-hailing services.

As in other markets, changes in pricing should be smooth to avoid price shocks. And consumers need time to react. Advance purchases, such as the ability to buy a pass for the daily commute, would let consumers plan and avoid the risk of expensive real-time prices. The operator for such purchases could offer packages as part of a road-use plan.

Not everyone will need to respond to prices. Dynamic pricing would still reduce congestion even if most drivers do not react. Yet more motorists would adapt as they became familiar with the system. Some would commute earlier or later; others would cycle or take the train or bus. In the long run, other adjustments, such as moving house, more work flexibility, investments in public transport and smarter mobility technologies, are possible. People already make similar trade-offs — the price of current road use is the length of delay.

There is much to learn about how best to manage a road network and how to target investments. Aggregate data about pricing and transport choices will need to be made publicly available. This would allow researchers and innovators to glean insights about the effectiveness of different measures and to develop apps that help motorists.

CONCERNS

Equity. Road-pricing schemes are often criticized as perpetuating inequality. People with lower incomes might be less able to afford to drive at popular times of day than those in wealthier groups. More research on such consequences is needed. But the problem could be smaller than feared. Pricing can make everybody better off — even before the revenue from congestion pricing is redistributed. For instance, suppose the left lanes of a busy multi-lane highway are priced at peak times. Because this increases throughput on the left lanes, there are fewer motorists on the right lanes, so everyone wins.

Even a worker with less money, who absolutely must be at work at 8 a.m. and who has no access to public transport or other travel options, can be better off — even if all lanes on all roads are priced. For example, suppose the free-flow travel time is 30 minutes, the expectation is 60 minutes and the maximum is 90 minutes. Today, without road pricing, the worker must depart at 6:30 a.m. to get there on time. With efficient pricing, if the worker cannot afford the price to depart at 7:30 a.m., she or he can continue to depart at 6:30 a.m. at zero cost, say, but his or her travel time will be halved and so fuel costs and pollution will be reduced. Moreover, the revenue from congestion pricing could be given back to motorists, for example, through a lower

road tax and less fuel duty. It could also be invested to improve public transport.

The current situation, by contrast, is unfair. The free use of roads is equivalent to governments subsidizing people who impose the biggest congestion and pollution costs on society. Roads are an essential service. The norm for other essential services such as electricity, gas, water and communications is for consumers to pay for what they use. The fact that road use has not been priced is a fluke of history — until recently, technology did not allow for the measurement and communication of pricing.

Scepticism. Voters and politicians underestimate the benefits of pricing. Public support builds once people experience such schemes. For instance, before Stockholm introduced a €2 (US\$2.3) charge during peak hours for vehicles entering the inner

“The fact that road use has not been priced is a fluke of history.”

city, two-thirds of residents were against the plan. About 2 years later, when the policy had reduced traffic by 20%, two-thirds of people were in favour of it¹⁵. After a similar scheme was trialled in Milan, Italy, 80% of people voted to extend charges to more roads and vehicle types. More research is needed on how to communicate the impact of road pricing.

Privacy. Road pricing raises concerns about personal data. Monitoring and enforcement require that the system operator know the location of each vehicle. Technically, this is easy and cheap: each vehicle would have a Global Positioning System (GPS) device. Strict privacy rules governing the operator imposing the charges would ensure that no individual data would be shared with others, as is standard in telecommunications and related industries. Modern cryptography makes it possible for the operator to run the market without any human having access to the data, yet prove that the rules are followed faithfully. Research is needed on whether such advanced systems give motorists comfort, although their embrace of apps for navigation and ride-hailing suggests that users are happy to accept some loss of privacy for improved services.

MAKE IT HAPPEN

The first step is to get devices in vehicles to measure road use. Singapore plans to install tracking and payment technology in all cars from 2020. Oregon's volunteers have GPS equipment on board so the state can levy a fee per mile. These are excellent starting points.

Governments and city authorities should establish independent operators to introduce and adjust prices for times and locations.

Researchers should study the impacts on motorists' behaviour, traffic conditions and

pollution, the distribution of benefits and costs and public responses. This will involve studies by behavioural scientists of individual perceptions and changes in driving behaviour; by transport engineers, economists and computer scientists of aggregate traffic flows through the network; and by market designers, to evaluate the effectiveness of the underlying incentive mechanisms.

Service providers, such as Google, Apple, Uber and Lyft, are likely to seize the opportunity to develop innovative tools that enable consumers to make informed decisions. These tools would integrate past driving behaviour and relevant price information.

Let's get a move on. Dynamic pricing is the only way forward for roads. ■

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