Using Technology to Eliminate Traffic Congestion

Being stuck in traffic is frustrating. Congestion not only wastes our time, it contributes to increased fuel consumption, pollution, and health problems. The economic damage is estimated to globally exceed $1 trillion each year. In 2016, the average U.S. driver spent 42 hours in congestion during peak hours; in Los Angeles that average was 104 hours[1]. Today, the average traffic speed in central Manhattan is that of a brisk walk, 7.6 km/h, down from 10.5 km/h five years ago[2]. Walking often seems the only reliable way to arrive on time. Cities around the world are experiencing comparable congestion levels, and congestion's social costs are growing rapidly almost everywhere due to growing populations and ongoing urbanization. Under existing policies, traffic will inevitably end in crisis.

The habitual response is to call for more roads. However, numerous studies show that an increase in road capacity has limited long-term benefits. "The Fundamental Law of Road Congestion" states that, if new unpriced capacity is added, traffic congestion will become as severe as before the capacity addition[3]. Free roads attract more residents, more transport-intensive commercial and private activity, and other adjustments until congestion is like before. The simple truth is: When roads are unpriced, there is more demand than road capacity. Billions spent on new roads in cities like Los Angeles and Houston did little to reduce commuting times.

Another hope is that artificial-intelligent systems, enabling ride-hailing services and autonomous cars, will solve the looming gridlock. Yet Uber and Lyft appear to increase traffic, which is probably why both services support the introduction of new pricing mechanisms. Self-driving cars will reduce the number of accidents and use the scarce road capacity more efficiently. This, however, will attract additional rides and vehicles. The decrease in costs and increase in the desire for mobility may well swamp any efficiency gains that come with intelligent driving technologies[4].

Solving the gridlock

Congestion is a pervasive phenomenon because motorists do not have an incentive to take the cost they impose on others into account by adding to the congestion. Yes, we consider the congestion we expect to experience. For instance, we drive to work early, to avoid the worst traffic jam. But we do not consider the cost our driving decision imposes on others. As roads become crowded, the distance between vehicles diminish, and thus the speed required to drive safely must also diminish. This way, each motorist who joins a traffic stream slows others down. Because we have no incentive to care about such social costs, we do much less to avoid congestion than that which is best for society as a whole. This bias toward creating congestion holds irrespective of how much road capacity is supplied, and irrespective of whether transport decisions are made by humans or AI systems—as long as the price for using roads does not reflect social costs.

Yet technology remains the solution to gridlock. Through advances in communications, a vehicle's location can be identified and communicated to within a cubic meter, allowing precise measurement of road use. This makes efficient congestion pricing viable for the first time in the history of roads. By internalizing a driver's social costs at each time and location, congestion pricing surgically reduces demand to eliminate congestion. For similar reasons, dynamic congestion pricing is used with airfares, electricity prices, hotel rates, and train fares. Paradoxically, for road use, demand management not only balances supply and demand, but expands supply and thus maximizes the number of vehicles that can use the road. A free-flowing roadway has up to twice the capacity of a congested roadway at peak times[5].

Road-use prices that eliminate congestion are feasible. The reason is that, although some motorists are unable or unwilling to change behavior in response to a price, many consumers can flexibly respond to price changes. Responses include curtailing road demand, shifting times of travel, and changing travel routes or modes. Moreover, only a small fraction of drivers need shift during peak times to significantly improve throughput. This is because of the highly nonlinear relationship between travel time and traffic. More vehicles do not affect other motorists' travel times when traffic is below a road's physical limit. But when the road gets close to its physical limit, a small increase in the number of vehicles leads to a decline in throughput of as much as 50%. Put differently, if dynamic pricing can reduce demand by as little as 5%, congestion can often be eliminated.

But what about equity and fairness?

Congestion pricing often raises equity and fairness concerns. However, motorists pay a 'price' even without congestion pricing, but this 'price' is paid in delay cost and travel time uncertainty. Pricing with delay is wasteful and set incorrectly—the delay cost does not reflect the negative externality one user imposes on others. Efficient congestion pricing, on the other hand, eliminates the wasteful cost to drivers—the revenue from congestion pricing is not lost but can be given back to motorists and society—and dramatically improves the use of road capacity in peak times.

Congestion prices are fair. Today, those who drive at peak times, and thus contribute most to congestion and pollution, pay the same price as those who do not impose such costs on others. Indeed, rejecting congestion pricing for fairness reasons is equivalent to demanding subsidies for those who impose the highest cost on others. This is hardly fair. Moreover, most studies show that the rich pay more congestion charges than the poor because they use roads more heavily at the most popular times[6]. If, moreover, revenues created by congestion pricing are used to enhance affordability and to improve public transport, the poor can substantially benefit from congestion pricing, and more so than the rich.

The electricity market provides a useful analogy. What would happen if, say, for fairness reasons a new policy requires that the electricity price is zero at all times? Obviously, those who previously consumed the most and those who previously faced the highest prices would most welcome zero prices. The largest consumers are the richest consumers, and the high-price consumers are those who impose the highest social cost by contributing most to scarcity, congestion and pollution. But even those consumers would suffer from drastically increased total electricity demand leading to clogged networks and blackouts. Of course, abolishing congestion pricing also raises the question of how the infrastructure is financed. For all these reasons, a zero price for electricity is unlikely to find many advocates. So why is a zero price for road use, which has similar implications, still the norm?

One reason is that the effectiveness and benefits of congestion pricing are often underappreciated, and the problems are often overstated. For instance, because of the nonlinear impact of traffic on congestion, one only needs relatively few drivers, and only those who most easily can curb or shift demand, to eliminate congestion. Yet, after people gain experience, support for congestion pricing can be strong. In Stockholm, for instance, before a major road-use pricing trial started, two-thirds were against the charges. After the trial, more than two-thirds were in favor of the charges. In Milan, after gaining experience, eighty percent voted for extending the system to cover more roads and more vehicle types[7].

The challenges to change can be overcome

Traffic congestion is one of modern societies' major social challenges. Yet, the challenge can be overcome by setting a price that reflects the social cost of road use. The non-pricing of roads stems from the fact that roads were originally uncongested, and that pricing, collecting, and enforcing payments was too costly. This is all history.

Today, cities and governments around the world are looking for new pricing approaches. Experiments in the United States, Singapore, and Stockholm, among others, suggest that, if designed properly, pricing mechanisms to address traffic congestion can be effective. But it is important to understand that those applications are most often limited to a cordon around the city, or to a small set of roads within, and prices typically are not responsive to real-time changes in demand. Thus, the two most salient benefits from efficient congestion pricing—maximal throughput and absence of congestion—have not yet materialized.

Now is the time for governments to make the next step toward a comprehensive system of direct, variable road-use charges, allowing a leap forward to the most efficient end-state for road pricing. In fact, in some cases, doing the next step is a logical and incremental path toward eliminating congestion. For instance, Singapore will soon install devices in every vehicle that can measure each vehicle's use of the road network. However, the current pricing of road use is coarse (only at gantries) and unresponsive (updated quarterly). We propose to make prices more granular and gradually move them closer to expected social costs. System performance can be constantly and consistently measured, at each step, so that policy risks are minimized, and the public can see the benefits of the system and its incremental refinement. Moving gradually also allows providers of transport apps, such as Google and Apple, to integrate price information and other innovations into their apps, which help users make better and easier transport decisions.

Then, in the final step, prices are no longer fixed at a given location and time, but adjust in real time as congestion emerges. Thus, prices respond to lane closures or other shocks to supply and demand. This does not involve a significant change for those providing transport apps. The providers simply read the real-time prices periodically, such as every ten minutes. Aside from this dynamic updating, and potentially the provision of smart tools to predict and present future prices, the apps are the same. Also, ride-hailing services and autonomous cars are expected to get compensated for each single ride, which allows seamless integration of dynamic pricing of road use. All this makes the transition to real-time pricing straightforward for consumers, who use the same apps or services as before, but now the prices change in response to events. Consumer risk can be mitigated using forward markets, as we see in modern electricity markets, which must also deal with risks due to stochastic demand and supply shocks in real-time.

Similarly, California and Oregon are experimenting with modern technologies to measure road use. Policymakers are considering the use of a road charge as a potential replacement for the gas tax. Yet, oddly, dynamic pricing has not yet been considered. But measuring road use without dynamic pricing means incurring almost 100% of the cost of a perfectly efficient pricing infrastructure, but then reaping only 10% of the system's benefits. Here, too, policymakers should consider the next, logical step toward congestion pricing to eliminate congestion.

A fully efficient congestion pricing system may seem like a radical idea. However, it has been successfully applied in electricity markets for over a decade. Indeed, the market design for road use can build on the extensive experience from the electricity sector, where today effective and robust mechanisms dynamically price network capacity[8]. Doing so eliminates the inefficiency, frustration and unfairness of current road use. It is the inevitable future of roads.

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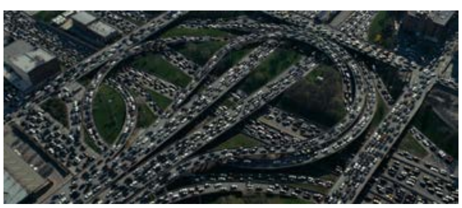
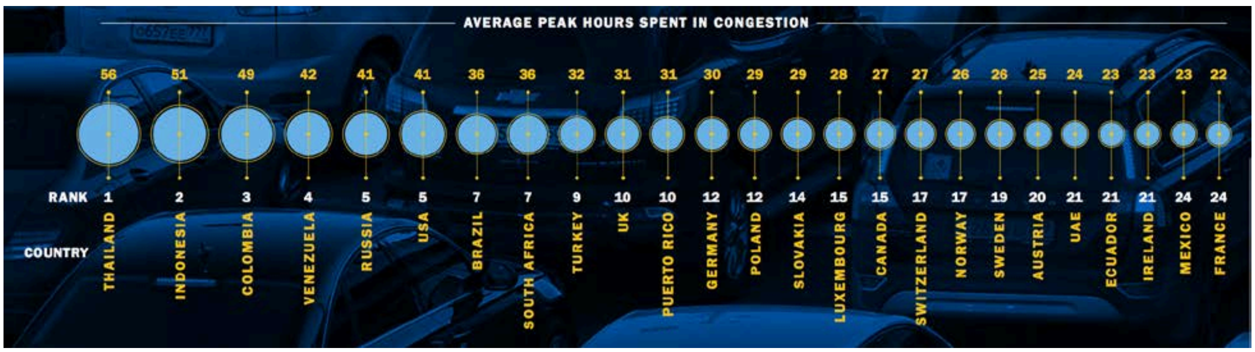
Art work

We do not have figures for this comment, but our corresponding PowerPoint presentation has a couple of photos (which we do not own) that might be useful suggestions for your art department (see below).



Our text and endnotes cite statistics and quantitative studies of congestion levels that could be used to illustrate the problem. For instance. here are very recent statistics by INRIX about the average peak hours spent in congestion around the world (taken from http://inrix.com/resources/inrix-2017-global-traffic-scorecard/; a corresponding ranking of cities can be found here: http://inrix.com/scorecard/):



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[1] Pishue, Bob (2017) *US Traffic Hotspots*, INRIX Research.

[2] Wall Street Journal (2018) "Push for New York Congestion Charge Picks Up Steam," 1 January.

[3] Duranton, Gilles and Matthew A. Turner (2011) "The Fundamental Law of Road Congestion: Evidence from US Cities," *American Economic Review*, 101:6, 2616-2652.

[4] Fulton, Lewis, Jacob Mason, and Dominique Meroux (2017) "Three Revolutions in Urban Transportation," Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-17-03.

[5] Federal Highway Administration (2008) Congestion Pricing – A Primer: Overview, US Department of Transportation, April.

[6] Eliasson, J. (2016) Is congestion pricing fair? Consumer and citizen perspectives on equity effects, Transport Policy 52, 1-15.

[7] Eliasson, J. (2017) Congestion pricing, in Ison, S. (ed.): Handbook of Transport Economics, forthcoming, Routledge.

[8] Cramton, Peter, R. Richard Geddes and Axel Ockenfels (2018) Market Design for Road Use, Working Paper, University of Cologne, January 2018.