THE PANDEMIC AS A NATURAL EXPERIMENT

Commentary by

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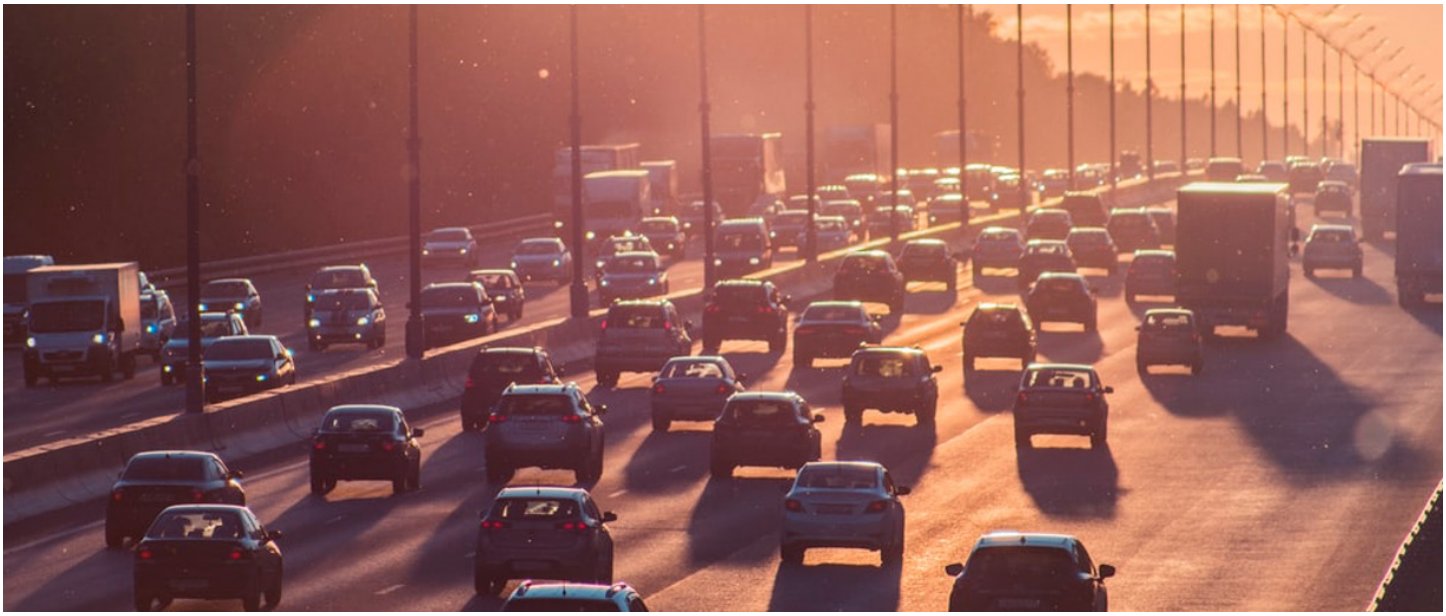
What do a pandemic and a traffic jam have in common? Other than causing pain, almost nothing. However, the Covid-19 outbreak has created conditions that economists can exploit to better understand the behavior of traffic on our highways and improve it.

In most urban places during peak travel times not only are speeds lower than the design speed of roads but the flow of traffic (in vehicles per hour) is also lower than the design capacity of those roads. This chronic ailment of urban places is called hyper-congestion by transportation economists and will return when the economy gets back on its feet. The performance of the highway system will once again be a daily complaint for many Americans.

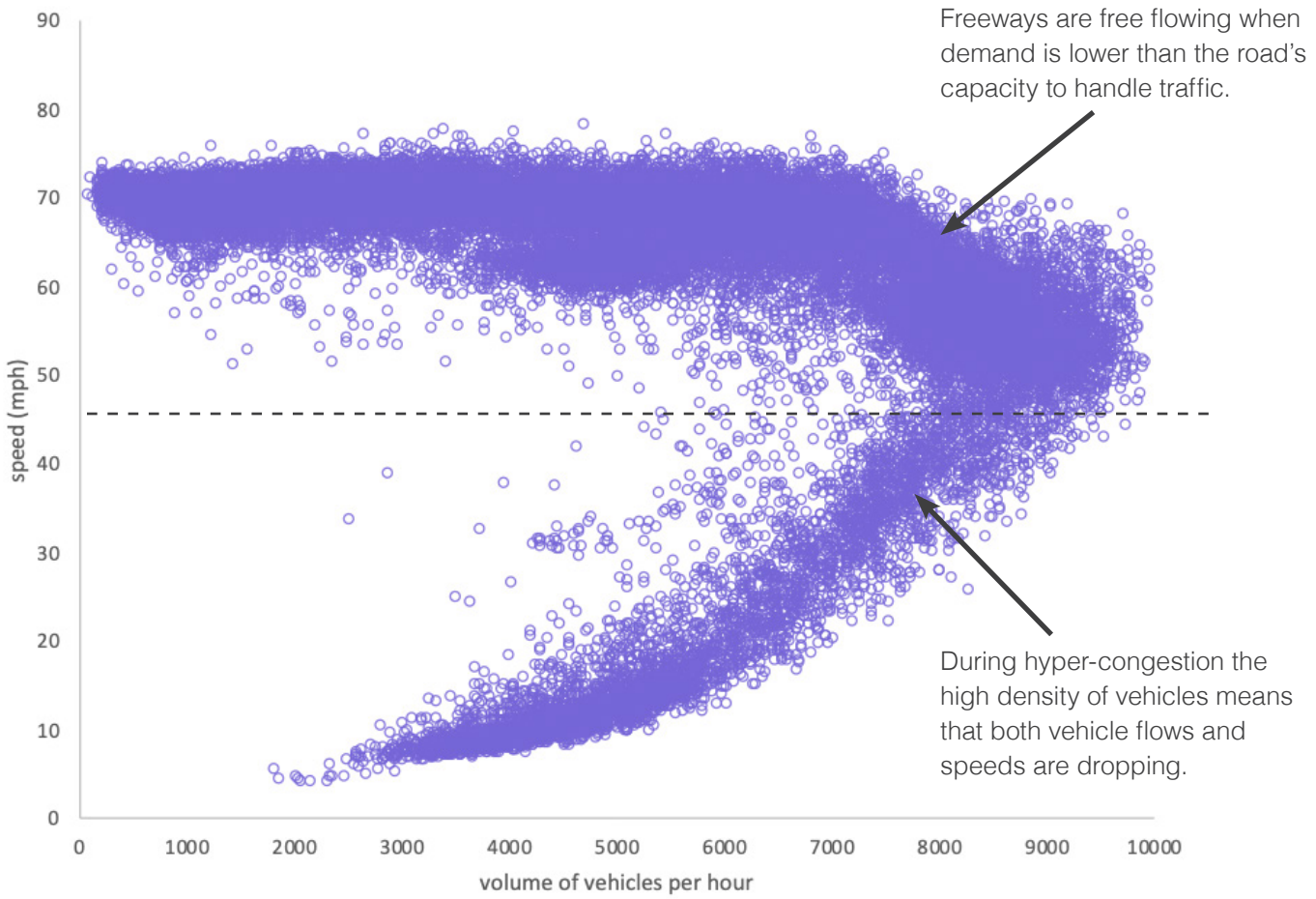
But for now, some of our most notoriously troublesome traffic corridors are operating well below their design capacity to carry vehicles. Data from sensors in our highways confirm this fact. In Los Angeles, on the I-405, in the southbound PM peak direction average daily volumes of vehicles after Governor Newsom's March 19th stay-at-home order are roughly two-thirds of their previous levels. And a similar story can be told across most U.S. cities.

Shifts in demand happen when there are changes in income, preferences of consumers, and technological advances – things we cannot set experimentally. The pandemic provided a shift in demand and an opportunity to control for its influence on road use.

The "shrinking" of the economy in the face of the virus has been massive in scale, and the economic pain that has followed is evident everywhere. In technical terms, the pandemic achieved this free-flowing traffic by reducing the demand for highway travel through the pandemic's effect on incomes[1]. A pandemic is a terribly costly path to free-flowing traffic. However, economists have long recognized that applying calibrated prices (tolls) to roads can fine tune traffic to result in superior travel conditions (both higher speeds and vehicle flows). However, the setting of those prices must be done with care to avoid harming the economy.



[1] A change in income causes a shift in demand, in addition to the actual income and job losses a stay-at-home order itself is analogous to this kind of demand shift.



In contrast to the pandemic, tolls do not act to reduce the income of road users, and thus alter the demand for travel. Rather, by affecting the price of travel, tolls moderate the quantity of travel actually consumed. Nonetheless, the pandemic and its action on demand offer an opportunity to try to measure how sensitive demand for road use is to changes in pricing (tolling) policy. This is because, under normal conditions, we are not easily able to separate out two distinct, but often intertwined, forces: the scale of demand and the level of prices. Changes in prices can be easily observed, or experiments can be designed under various price levels. But shifts in demand happen when there are changes in income, preferences of consumers, and technological advances – things we cannot set experimentally. The pandemic provided a shift in demand and an opportunity to control for its influence on road use.

WHY ROADS CONGEST

ECONorthwest has a well-established practice in the analysis of traffic congestion, traffic and revenue studies for toll roads, and optimal transportation pricing. So examining the data on road use and performance during the Covid-19 events was an instinctual response. First, we drew from our models and theories that describe how roads congest.

Much like water in a pipe or a press of school children rushing to get out of class, when too many vehicles wish (demand) to join a highway facility at the same time the vehicle flows become unstable and often "collapse" into stop-and-go traffic. When roads become congested the high density of vehicles can lead to some bizarre queuing conditions. When this happens, vehicles jostle with each other—getting into each other's way, forming queues, slowing down – and the flow of vehicles leaving the queue drops.

This hyper-congestion is a wasteful, low-flow, low-speed, high-density condition, that is all too common on many urban travel corridors. However,

a small reduction in demand can free up the flow of vehicles substantially, thus reducing the burden of congestion and also reducing vehicle emissions.

But demand for travel is complicated and is associated with many other human activities. So understanding how that demand responds over time, how sensitive demand is to the costs of travel, and how that demand might best be shifted in a manner that reduces traffic congestion is a seemingly never ending area of research.

Using data gathered during the pandemic we have built a mathematical model whose equations incorporate information on how real-world roads behave (as determined by the engineering characteristics of the roadway – lane width, curvature, quality of the surface, etc.) and relationships between travel speeds and utilization (traffic flow and density).

We assembled the data required to accurately render the real-world performance of the roadway over a time period that included pre-pandemic and post stay-at-home order levels of activity. The data includes speed, flow and density information obtained in five-minute intervals from the California Department of Transportation's PeMS traffic counting system. We focused on corridors in Southern California due to the hyper-congested state of much of its road network.

LEARNING FROM THE PANDEMIC

What we learned, or rather confirmed, is that demand is relatively inelastic with respect to changes in price (toll levels). This means, for example, that if the costs of travel (including the toll) were to increase by 10% then the quantity of travel demanded (in this case traffic density) will decrease by something less than 10%. In the case of I-405 in Los Angeles we estimate that a 10% increase in cost might result in between a 2% and 5% decrease in travel demand depending on which specific hour of the day is being examined.

No one wants to solve traffic congestion by partly shutting down the economy. But during the transition into our current economic pause an interesting pattern emerged, if only briefly. Again, looking at the I-405 in Los Angeles we see that as the density of traffic declined the speeds and vehicle flows increased during the busiest hours of the day. That's right, the density of traffic declined but flows increased, and reasonable freeway speeds were restored. This happens when the density of vehicles is below about

20 percent and corresponds to freeway speeds in the 45-50 mph range.

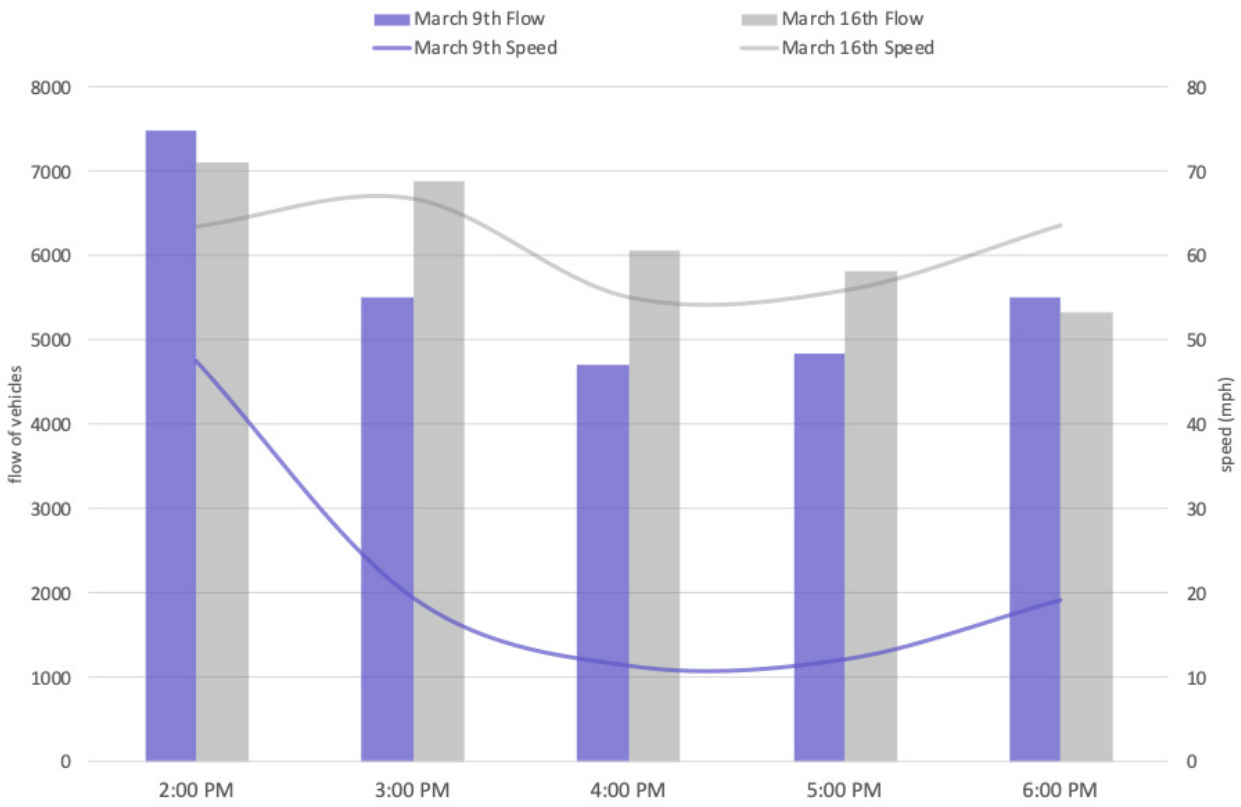
On March 16th, three days before the Governor issued the stay-at-home order people had already started altering their travel in ways that was evident in the traffic data. The figure below compares vehicle flows and speeds on March 16th to the same day of the week, one week earlier. That afternoon peak looked pretty good in terms of speeds, and the traffic flows were 25% higher than on a typical weekday prior to the effects of Covid-19.

Within a few more days demand for travel had dropped even lower, to the point where highways and urban streets were dramatically under used. But unlike a virus, a stay-at-home order, or largescale losses in jobs and income, there are tools, such as variable tolls, that can target for remedy specific troublesome traffic conditions. An example would be to target reoccurring congestion in peak afternoon travel hours southbound on the I-405 in Los Angeles, or dozens of other highly congested corridors in cities across the United States.

In the I-405 case the modestly lower demand for travel observed on March 16th resulted in a 25%

increase in vehicle flow and a 70% reduction in the travel time dedicated to that travel during the 3 busiest hours of the day on a segment of the facility. For this one-mile stretch of freeway the value of those saved time resources could easily have exceeded $6 million on an annualized basis. Over an entire corridor, or larger network, those benefits would be substantial.

With data and analysis from this challenging period in our economy we are now better able to design and evaluate toll policies that are intended to improve roadway performance. The methods that have been developed can be tailored to local conditions, providing insights into managing traffic in a manner that could help many cities to thrive and prosper.



TECHNICAL APPENDIX

In this appendix, we briefly portray the underlying economic theory behind the analysis of the pandemic effects described in this memorandum. The theory is represented by the graphic that follows. The graphic is a demand and supply diagram where the horizontal axis represents the quantity of travel demanded and the vertical axis represents the generalized cost of travel per mile.

There are two demand curves, Q1 and Q2 that represent the demand for travel in the corridor at two different times. In our case, these times are before and after the desired demand has shifted due to the pandemic's effect in a hypothetical highway corridor. The pandemic weakens demand due to closure of workplaces and other places where people come together. The curve F(G) represents the quantity of travel activity associated with each level of generalized cost (price) associated with each level of travel.

There are two equilibrium conditions associated with the two levels of demand, Q1 and Q2. Before the pandemic, demand to use the corridor was strong. Thus, the highway was very congested, hyper-congested, in fact, and the cost of travel is high due to slow speeds. During the pandemic, demand for travel has shifted back dramatically. The road is then in a free flow state.

These conditions offer the opportunity to compare the road performance under high versus low demand and see what level of generalized cost is associated (in equilibrium) with each level of demand. The demand equilibrium in each case equals the effective demand (flow) plus latent demand (occupancy or density). We assume that the demand equilibrium with respect to generalized cost can be represented by constant elasticity demand curves, and that the performance of the roadway is such that the generalized costs of its use rise exponentially with demand.

The goal of this exercise is to learn about the parameters of a mathematical specification of the highway economy represented in the figure at right. Specifically, we are interested in the price elasticity of the demand curve and the shift parameter that links the highway economy to the greater macro economy and the pandemic.