EXPLAINER ESSAY #2

How and Why Would Congestion Pricing Work?

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Abstract

Transportation scholars regularly argue that congestion pricing is the only reliable way to reduce road traffic congestion. The public often resists this advice, often out of confusion about how pricing would work, concern about whether it would be fair, and a belief that some other, less politically-explosive approach might work just as well. This explanatory essay addresses some of those common concerns.

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Introduction

Years ago, for a research project, a colleague of mine and I talked to dozens of elected officials in Southern California about traffic congestion. Everyone we spoke to was worried about congestion, and called it a problem important to their constituents. Most also seemed to think that little could be done about it. Some wanted to build more roads, and many wanted to build more rail, but no one thought either of these was possible on a large scale anytime soon. Many seemed unsure, furthermore, that either of these things would help even if they were possible. Traffic seemed both inevitable and insoluble. One Los Angeles City councilmember really drove the point home, by confiding that he tried to avoid service on the council's Transportation Committee. Being on the committee had no upside, he said; it created an expectation that you would do something about congestion, when in fact there was nothing to be done.

At a certain point in each conversation — after the elected officials had shared their general outlook on the traffic problem — my colleague and I would bring up congestion pricing. What if, we asked, there were tolls on the freeway to manage the demand, and keep traffic under control? The tolls would be higher at busier times, and lower at less busy times, and designed to keep the road flowing smoothly.

Perhaps unsurprisingly, no one was terribly enthusiastic about this idea. Many were skeptical. A few saw their careers flash before their eyes. ("We would all be recalled," one said). One conversation in particular struck me as emblematic. When we asked this elected official about pricing the freeways to control traffic, he thought about it and said:

> If there is going to be congestion I'd rather have it on the freeway, because frankly, it's not a city issue then, from a public official point of view. And if you cause a problem that causes [congestion] now to get on the street and then you hand me a check, I'm not really sure what to do with that money because we don't have any more streets to build.[1]

I like this answer, because it nicely captures a series of common misconceptions about congestion pricing. The first misconception is that pricing doesn't reduce congestion, and instead just moves it around (in this case from freeways to surface streets). The second is that pricing's only real benefit (since it doesn't reduce congestion) is raising money, which implies the third misconception — that money is a useful antidote to congestion. This official, after all, was clearly thinking money could be helpful. Cities could use it to build streets or trains. But as he also noted, spending money to fight congestion was hard in practice. Places with lots of congestion tend to be dense, which means that there is rarely an obvious place to put new roads or trains. New transportation infrastructure might require controversial acts of eminent domain, hugely expensive tunneling, ugly overpasses, or all of these. And fourth, if the end goal is just to raise money to build trains or roads, why should we do that with tolls? There are lots of ways to raise money, after all. We could tax the rich, or tax sales, or tax corporations. Slapping a price on an essential activity like driving just seems like punching down. Drivers already endure terrible traffic, so why compound the indignity by picking their pockets?

All these misconceptions are understandable. But they *are* misconceptions. Congestion tolls aren't designed to raise money. Even if they were, money can't reduce congestion, because you can't build your way out of traffic. Congestion tolls, in contrast, *can* reduce congestion. They don't just move congestion around. A city can't spend its way out of congestion, but it can *charge* its way out of congestion, because charging changes the nature of the road itself, from what economists call a "commons" to that they call a "private good."

1. The study was later published as Michael Manville and David King, 2013. Credible Commitment and Congestion Pricing. *Transportation*. 40:229-249.

A commons is defined as a good that is both "rival" (meaning that if one person is using it another cannot) and "non-excludable" (meaning people can use it even if they do not pay). The road is rival: if a car is occupying a chunk of road space another car cannot. Most roads are also non-excludable: so long as you have a car, you can get on the road without paying a fee to do so.

The signature weakness of a commons is a tendency toward depletion: we often run out of common goods. This problem is sometimes called the "Tragedy of the Commons." Importantly, private goods do *not* suffer from this problem. Most things we buy in stores are private goods, and we encounter far fewer shortages of those things than we do of road space. A private good, like a commons, is rival, but unlike a commons it is excludable — you can't use it without paying. The difference between a commons and a private good, in other words, is a price. And the price makes a huge difference.

Charging for a road, then, is less about raising revenue and more about changing the kind of good a road is. That can be a tricky concept to grasp, and if it isn't grasped then pricing can seem like a perverse idea: if the road is terrible when it's free, why would anyone want to pay for it? This misunderstanding also fuels the perception that pricing is anti-car. Not only does the government give drivers terrible roads, now it wants to charge for them as well. All that reasoning is upended, however, once you realize that the road is so bad *because* it's free, and that charging for it doesn't mean the same bad service at a higher price, but better service, because it will prevent shortages. Pricing will probably reduce the amount of driving people do, but it will also greatly *improve* the driving they do. American driving has too long prioritized quantity over quality. Pricing changes that. A policy that improves driving quality is a pro-driving policy.

This reasoning is, for many people, new. In the remainder of this essay I'll walk through some of the biggest issues and questions that come up about pricing. First I'll reiterate the important distinction between charging a price and collecting revenue, and then I'll explain why revenue doesn't do much good in the fight against congestion. From there I'll explain why tolls don't have to be inordinately high to reduce congestion. After that I'll address the question of alternatives: can a city really price its roads if it doesn't have comprehensive mass transit? Lastly, I'll sketch out a way that almost any city could introduce pricing, fairly and efficiently.

Revenue Targets vs. Performance Targets: The Logic of Congestion Pricing

The U.S. doesn't have a lot of toll roads. Anyone who has driven some of the bigger ones, however, like the New York Throughway or the Garden State Parkway, could be forgiven for thinking they aren't a promising remedy for congestion. America's priced roads often have horrible gridlock. I grew up outside Boston, and throughout my childhood my family regularly drove from Massachusetts to New Jersey to see my grandparents. That trip involved travel on three toll highways — the Massachusetts Turnpike, the New Jersey Turnpike, and the Garden State Parkway — and I still have vivid memories of how terrible their traffic was. Of course other roads had congestion too, but the toll roads stood out for *charging* you to be in traffic. And charging for the road clearly made the traffic worse. Lines would form at the toll booths, as everyone waited for the driver in front to pay and get change, or to find the right combination of coins to toss into a bin. Paying slowed everything down. This was especially the case when we got into New Jersey. The family car would crawl through traffic, stop to wait in a toll line, and then bump along again until the next tollbooth appeared. The tedium was only interrupted if someone spotted a woodchuck on the side of the road. That would get everyone excited for a minute or so, until the woodchuck inevitably scuttled off. I liked going to see my grandparents, and to this day I'm fond of woodchucks, but those roads weren't much fun.

Given this experience, why would I say we need more toll roads? Part of the answer is that tolling technology has dramatically improved. Electronic payment systems like E-Z Pass let vehicles pay tolls without stopping, which all but eliminate long queues at toll booths. The real answer, however, is that I am recommending a very different kind of toll. Most toll roads in the U.S. today, including the three I just mentioned, weren't designed to manage traffic. They were designed to raise money — usually, to pay down the debt incurred from building the road in the first place. These tolls, in short, are levied to *provide* road space. The tolling is valuable because it raises the money necessary to bring the road into existence, and to keep it in good condition once it's there.

When tolls are designed to pay for the road itself, what matters is how much revenue the tolls generate. Highway planners thus think about the tolls in terms of "revenue targets". They look at their budgets, determine how much money they need to maintain the road and pay that year's debt on it, and then set toll rates that they hope, based on projections of how many vehicles will use the road, will reach that target.

Practically speaking, there's nothing wrong with using tolls in this manner. It does, however, present two related political problems. First, in a world where most roads *aren't* tolled, using tolls to finance *some* roads can seem arbitrary and unfair. Second, what happens when the road's debt is paid off? In principle, the tolls should be removed, or at least reduced. In practice, government agencies grow accustomed to revenue streams, and don't like to relinquish them. So the tolls often outlive their original justification. That causes resentment.

The Massachusetts Turnpike, or "Mass Pike" as locals know it, offers a case in point. The Pike was not originally envisioned as a toll road. When the interstate highway program began in the 1950s, transportation officials in Massachusetts wanted to build four highways in and around Greater Boston: Route 93, which would plunge through the heart of the city; Route 95, a "belt" road that would run through the city's inner suburbs; Route 495, a secondary belt road running through the outer suburbs, and Route 90, which would connect Boston to the western part of the state. All these roads would be funded like most U.S. highways: through bonds that would be paid off via revenue from state and (mostly) federal gas taxes. The state used this financing mechanism to get Routes 93, 95 and 495 going, and then it basically ran out of money. But it still needed a western extension, so it formed a turnpike authority and built Interstate 90, paying for it with bonds backed by toll payments instead of gas taxes.

As a result, the Boston area now has four highways, three of them free and one tolled. That arrangement has never sat well with people who regularly travel the Pike. They pay every time they get on the highway, while drivers on the state's other highways don't. This inequity seems particularly galling because the Pike's original bonds matured in 1983. The road was paid off, but the tolls didn't end. The continued tolling feeds a narrative, especially in the western part of the state, of transportation officials in Boston finding ways to tax people in the hinterlands.[2]

These feelings of political alienation arise, in part, because Pike drivers believe they are getting nothing for something. The Mass Pike costs more than other highways, but doesn't *deliver* more. In many places it's every bit as congested as Routes 93 or 95. This occurs because the tolls don't vary with demand. Driving ten miles on the Pike costs the same at 8 AM as it does at midnight, which means that a trush hour it's more expensive than I-95, but still too low to noticeably reduce congestion. The price to drive is high enough to annoy motorists, but not high enough to make driving better. At midnight, meanwhile, drivers pay a price and drive on open roads, but the roads would be open anyway — the free roads are also uncongested at midnight.

It doesn't have to be that way. A very different sort of toll road charges *performance prices*. Performance-priced roads are successful if, as their name implies, the road performs well — if it lets a lot of vehicles move with minimal congestion. Rather than start with a revenue target, the regulators start with a performance target — for instance, a constant average speed of 45 to 55 mph

2. For example, see: Editorial Board, 2014. "Our Opinion: Mass Pike Tolls Go On Forever." *Metrowest Daily*. April 1,. https://www.metrowestdailynews.com/article/20140330/OPINION/140339877

— and then let the price float to achieve it. The optimal price is not the price that raises the most revenue, but the lowest price that maintains the performance. Such roads are rare, but they do exist. The I-15 Express Lanes in San Diego, for example, have tolls that range from 50 cents to $8, depending on how far drivers travel and how many other demand want the road at that time. Similar toll lanes exist in Orange County, CA, outside San Jose, and in a handful of other metropolitan areas. When few people want to travel, the price is low. At rush hour, the price is high.

The goal, for these roads, is not revenue. The goal is something that has been, for over a century, far more elusive: a quality public service for drivers, and a road system that actually works. Performance is the goal. The price is a means to that end, and the revenue is a mere byproduct of that means. Of course revenue can be useful, but critics of tolling are right when they say governments have many ways to raise revenue. Most of our roads, after all, *are* funded by gas taxes. So pricing is not important because it can raise money. Pricing is important because it is the *only* way to make the road work.

This point, about the importance of tolls and the relative unimportance of revenue, illustrates one of the most deceptively difficult concepts in economics: the social benefits of pricing come from a price being charged, not from the spending the price enables. This idea can be confusing because most people think of prices in terms of their *private*, not social, costs and benefits. When people sell goods and services, either to customers or employers, the price they charge matters primarily because of the revenue it delivers — that price determines their income. For a shoe salesman, the private benefit of shoe prices is the revenue that lets him house and feed his family. Selling rather than randomly distributing shoes, is privately valuable to shoe sellers because if shoes were just given away shoe sellers would have no money.

But selling rather than randomly distributing shoes is valuable to *society* because it prevents shortages, and ensures that people who want shoes can find them. Handing out shoes for free is a recipe for running out of shoes. For most people, however, these social gains of pricing are not very salient. Most people participate in markets through individual transactions that they evaluate based on their private benefits and costs ("are these shoes worth more or less to me than their price?"), so they don't pause to consider that their atomized exchanges, when aggregated with those of many others, might serve a collective purpose. But the fact that the benefit is less visible doesn't make it less real. The sum of all those private judgments — those moments when you pause to consider the price — is a system that ensures, for the most part, that when you walk into a shoe store on a whim there are shoes on the shelves.

The same is true for roads. Imagine you get on a congestion-charged road, at a time when the toll to drive 10 miles is $2. Assuming no one has coerced you onto this road, in your judgment being on the road is worth at least $2 to you, and your private benefit is the difference how much you value the road and the $2 you paid. But — and this is the key — the fact that you gave $2 to the government doesn't, by itself, represent any increase in *social* value. To see why, imagine that you hadn't gotten in your car that morning, and had instead just mailed a check for $2 to the toll authority. Would this create any value? Certainly you wouldn't expect the road to flow any better. One could argue that the government will spend the money in some way you couldn't, and create some value that way. But that's an argument that requires an additional assumption (about what the government does once it has the money), and that assumption won't always be a valid one. Governments do a lot of good, but they are no strangers to wasting money or doing harm. In point of fact, all you have done is move $2 from one place to another. In economics we call this a transfer. No value has been created or destroyed.

So what makes the toll different? It isn't the amount of money involved, or where the money goes. You're still giving $2 to the tolling agency, just as if you'd put a check in the mail. The difference is that by charging for the road, the tolling agency has not just taken $2 from you. It has also convinced some people *not* to drive on that road at that time. And convincing some people not to drive fundamentally improves the road for the people who do drive: it reduces the congestion. Reducing congestion, and by extension the problems that accompany it, like pollution and crashes, has enormous value. But the value arises from the driving prevented, not the money collected. Indeed, it is the revenue *not* collected — the deterrent effect of the price — that creates the

valuable good we call a free-flowing road. When everyone writes a check to a transportation agency, the transportation agency gets money. But no one has a reason to change their travel behavior, because the decision to send money isn't tied to any decisions about travel. If the agency charges a varying price for its roads, however, then it says you will either pay the $2 *or* not use the road, and it sends a clear signal that ties the same personal cost ($2) to a particular personal decision (whether you get on the road). The price thus influences behavior in a way that mailing a check to the road agency, or the road agency subsequently spending the money, cannot.

The lesson here isn't that the revenue is pointless. Revenue is money, and money is useful. If the government takes the revenue and does what we hope governments will do, which is create goods or services of legitimate value that people could not have created on their own or through private markets, then so much the better. And if the government doesn't do that, and instead squanders the revenue or does something harmful with it, of course we should be upset. The beauty of pricing, though, is that even if the government wastes all the revenue — indeed, even if it sets the revenue on fire, or sinks it in a harbor — the program still has some benefits. Because it is the charging, not the spending, that leads to the congestion being reduced.

You Can't Build Your Way Out

A government that needs revenue has many options, while a government that wants to reduce congestion has only one: pricing. That straightforward idea is rarely translated into actual transportation policy. For decades, governments have resisted pricing, and tried to fight congestion by raising money and then spending it to build more roads, to expand the roads they have, to build more transit, or some combination of all of the above. The track record isn't good. The costs have been large and the benefits less so. Consider the newspaper headline below, from the Los Angeles Times:

TRAFFIC PROBLEM TO BE SOLVED SOON

Street Railways Tackle Congestion Puzzle With $7,000,000 Improvement Program, and That Vast Outlay is Only a Starter for Great Expansion

BY FRED C. SPAYDE

In response to an overwhelming popular demand and under the leadership of Mayor Cryer, the City Council and the Board of Public Utilities, a real start has been made toward relieving the deplorable transportation conditions existing in Los Angeles. So far the utilities board has granted authority to the

The article that follows describes a massive public-private effort to build street and transit capacity, which the paper calls "a real start ... toward relieving the deplorable transportation conditions existing in Los Angeles." It sounds promising, but the headline is from 1923. Whatever they did, didn't work.

L.A.'s sorry state of affairs is not for lack of trying. Congestion has vexed Los Angeles for over a century, and billions have been spent in various efforts to fight it.[3] In the 1920s the city began widening its streets, and basically never stopped.[4] Many of its arterials are now 80 or 100 feet wide, and streets throughout the city get wider every year.[5] Freeway construction began in the 1940s, really gained steam in the 1950s and 1960s, and didn't end until the 1990s, when the Century Freeway (Interstate 105) was completed. It was also in the 1990s that the region began resurrecting its rail service. Since 1991, the region has opened over 500 miles of commuter rail, and over 120 miles of light rail and subway. Much of this construction, of road and rail alike, was done to fight congestion.[6]

None of it worked. Consider the 405 Freeway. The 405 was congested soon after it opened, remained congested as the state opened more freeways around it (some of them connected to it), and stayed congested even as it was expanded in places where bottlenecks were common.

Between 2011 and 2012, state and local officials widened it once more, to add a 10-mile carpool lane in both directions in a section called the Sepulveda Pass, which runs through the Santa Monica Mountains. The expansion was expensive and complicated. Six houses had to be taken by eminent domain and demolished. On-ramps had to be altered and realigned. Most daunting, logistically, was that a bridge over the freeway needed to be taken down and rebuilt. There was no way to do that while still letting cars underneath. As a result, for one weekend in July 2011 and another in 2012, one of the busiest freeways on earth had to close. The mere prospect of this event prompted fears of epic traffic delays, and the local media quickly nicknamed the coming closure "Carmageddon." Months ahead of time, local officials were issuing pleas to stay off the roads during the closure, and making dire warnings of what would happen if those pleas weren't heeded.[7] Public-minded celebrities joined the campaign. Kim Kardashian, Ashton Kutchner, and Conan O'Brien, among others, urged their Twitter followers to stay home.[8]

Perhaps amazingly, people listened. Angelenos did in fact stay home, and what was prophesied as a traffic doomsday instead came and went without incident. Congestion that weekend was almost nonexistent. Aerial photos showed a few lonely cars driving unimpeded on the freeway's open portion. With so many cars off the road, pollution monitors recorded a giant improvement in air quality.[9] The construction crews got their work done. The bridge came down, the lane was added. Soon the project was complete. And within a few years, the verdict was in: Rush hour traffic was, if anything, moving more slowly.[10]

The Trouble with Building New Roads to Fight Congestion

The 405 is now, in some places, 14 lanes wide — a monument to hope's triumph over experience, and a testament to the idea that some lessons might simply be unlearnable. The main unlearnable lesson is that adding road space doesn't reduce congestion. The reason is straightforward: congestion, right now, is the largest cost of driving on a busy road at rush hour. That means congestion deters some people from driving. Which means that removing congestion will reduce the deterrent, and *encourage* some people to drive. Driving, of course, is what causes congestion. And therein lies the rub. A plan to fight congestion that encourages the behavior that causes congestion is not a plan that is going to work.

3. Martin Wachs, Peter Sebastian Chesney, and Yu Hong Huang. 2020. *A Century of Fighting Traffic Congestion in Los Angeles*. UCLA Luskin Center for History and Policy. Also Elkind, Ethan. 2014. *Railtown*. Berkeley: UC Press.
4. Michael Manville. 2018. Automatic Street Widening. *Journal of Transport and Land Use*. 10(3):1-18.
5. Michael Manville. 2018. Automatic Street Widening. *Journal of Transport and Land Use*. 10(3):1-18.
6. Elkind, Ethan. 2014. *Railtown*. Berkeley: UC Press.
7. Martin Wachs and Brian Taylor. 2014. Carmaggedon: The Sizzle and the Fizzle. *Access*. 44(Spring): 10-16.
8. Shelby Grad. 2011. Carmaggedon: LAPD Thanks Celebrities for Twitter Help. *Los Angeles Times*. July 15.
9. Arthur Winer, Yifang Zhu and Suzanne Paulson. 2014. Carmaggedon or Carmaheaven? *Access*. 44(Spring):17-21.
10. Megan McCarty Carino. 2015. Stuck in Gridlock: Why 405 Expansion Didn't Improve Rush Hour Delay. *KPCC*. June 4.

At the heart of this reasoning lies an important idea: not having a *price* is not the same as not having a *cost*. A price is simply one particularly efficient way to make a cost manifest. Prices convey information — they are "a signal wrapped in an incentive", as two prominent economists like to describe them.[11] If more people want to use a road then there is road space available, the rising price alerts people to that problem, and deters some of them from using the road.

If we don't use a price, we don't change the underlying problem — there are still more people who want to use the road than there is road space available — we just change the way we deal with it. Instead of charging drivers money to get on the 405 at 8 a.m., we end up, by default, charging them in time and stress. Time and stress, in a sense, become the "price" of driving at a busy time. This isn't a monetary price; no money is collected. But the fact that no one is collecting doesn't mean no one is paying.

Now suppose, in these circumstances, we add some lanes to the 405. Suddenly the road has more room, so vehicles start moving more quickly, even on a weekday at 8 a.m.. The average speed rises, and the time and stress of a typical trip falls. Since time and stress are the trip's largest costs, when they fall the price of driving on the 405 at rush hour falls as well. Now the Law of Demand, from Economics 101, kicks in: when prices fall the quantity demanded rises. As goods get cheaper, people consume more of them. With rush hour driving, the Law of Demand manifests in the form of "triple convergence": travelers converge onto the 405 at 8 a.m. from other routes, other times, and other modes.[12] Here's how this works specifically:

> *Other routes:* people who once traveled at 8 a.m. but didn't use the 405 because it was so slow now decide to use the freeway, because the freeway is moving faster.
>
> *Other times:* people who drove on the 405 but woke up early (or left late) to beat the traffic now drive on it at 8 a.m., because it's moving faster.
>
> *Other modes:* people who biked or used transit to avoid congestion now switch to driving on the freeway at 8 a.m., because the freeway is moving faster.[13]

The problem, of course, is that the freeway is moving faster because the widening gave each vehicle more space. That new space, however, also *attracts more vehicles*. The faster speed, as a result, becomes self-undermining and short-lived. The new cars devour the new space, and the road returns to its previous speed, albeit with more cars.

Triple convergence gives the lie to a conceit that is often unmentioned but nevertheless omnipresent in much transportation planning. The conceit is as follows: any given area will have some fixed and finite amount of driving that people want to do, meaning that a reasonable goal for transportation policy is to just build "enough" road space to hold that driving. But that's not the way driving, or humans, work. People are adaptive animals. If some of them ride the train right now because the road is congested, they may not stay on the train when the road get faster, even if we need them to stay on the train for our plan to work.

The upshot is that adding road space won't reduce congestion, if by "reduce congestion" we mean "allow drivers on that road at busy times to move faster than they otherwise would." Adding capacity, instead, lets more people sit in a given bout of congestion.

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11. Tyler Cowen and Alex Tabarrok. 2019. *Modern Principles: Microeconomics.* McMillan.
12. Anthony Downs. 2004. *Still Stuck in Traffic*. Washington DC: Brookings.
13. Some additional details: Convergence can also involve a combination of these three reactions. For example, I sometimes take the bus to UCLA. When I do, I usually wait until 9:30 AM to leave my apartment, so that traffic will have died down. Doing so lets me avoid the headache of driving in congestion but also gives me a faster bus trip. If congestion in LA disappeared, I might not just drive but drive at 8 AM, meaning I would switch both time and mode. Note too that I've left out a fourth possible way that new road capacity could attract more vehicles: people who wouldn't have made a trip at all — who were just sitting at home watching TV or making pancakes — might decide to take a trip, and do so by car, because capacity expansion has made the road move faster. I leave this reaction out not because I think it unlikely, but because it is harder to measure, and because it requires a slightly stronger assumption, which is that congestion doesn't just deter some vehicle trips from occurring at particular times, but that it reduces the *absolute* amount of travel in the region. It may well do so, but the elegance of triple convergence, in part, lies in its ability to illustrate the futility of road expansion even if demand is only redistributed, rather than induced.

That's not useless — arguably it makes congestion more efficient, since more vehicles get moved per minute of delay — but it's far from a huge benefit, and it's very different from making the road flow freely. (When elected officials widen a road with a promise of "improved congestion" the message they are *not* sending to voters is "your commute won't be faster, but you will have more company in traffic jams.") Whatever gains come from road expansion, moreover, are probably more than outweighed by the costs, which include not just the monetary costs but also the costs to people who lose their homes and the added pollution that comes from more vehicles idling in traffic.[14]

Nothing I'm saying here is new. People who study congestion have known for a long time that adding road capacity won't solve it. The phrase "triple convergence" was coined in 1962 by economist Anthony Downs, and the general principle was understood long before that. Miller McClintock, the first person to receive a Ph.D. in transportation, who wrote the first textbook on congestion (1925's *Street Traffic Control*), wrote in that book that "any reasonable increase in street capacity, either through a more rapid movement of traffic, or through the widening of a thoroughfare, will not reduce the density of traffic, for the land made available will be taken by those drivers said to be on the margin of convenience."[15] In 1928, similarly, a Los Angeles transportation official described the problem of induced demand in more succinct albeit more florid language: "A newly-opened or widened street immediately become[s] glutted by the access of cars that hitherto have reposed more in their garages than they utilized the streets."[16]

These sentiments mostly reflected people's observations and considered opinions, rather than any careful measurements. But starting in the 1980s, improvements in statistics, along with better data collection, allowed researchers to test triple convergence quantitatively. The empirical evidence reaffirms both the theoretical work and the commonsense observations.[17] New capacity doesn't help.[18]

Nevertheless, building roads to battle traffic has a seemingly inescapable allure. Road widening is an example of a "Zombie idea": a nonsensical concept that, no matter how many times you kill it, just won't die.[19] When it comes to traffic, the undead are all around us. In 2018, LA Metro floated a $6 billion plan to widen the 710 Freeway, and in 2020 it floated the idea of widening multiple freeways in the eastern portion of L.A. County. Across the country, state departments of transportation continue to push widening as a way

14. For evidence about the pollution impacts of congested roads, see Janet Currie and Reed Walker. 2009. Traffic Congestion and Infant Health: Evidence from E-Z Pass. *American Economic Journal: Applied Economics*.3(1):65-90.
15. Shortly thereafter McClintock assumed the directorship of a research institute funded by the automobile manufacturer Studebaker, which had a vested interest in seeing congestion defined as a problem of too few streets rather than too many cars. Probably not coincidentally, he changed his mind about widening roads. See Brian Ladd. 2012. You Can't Build Your Way out of Congestion – Or Can You? *The Planning Review.* 48(3):16-23. Peter Norton. 2008. *Fighting Traffic*. Cambridge: MIT Press. Michael Manville, 2018. Automatic Street Widenings, *Journal of Transport and Land Use*.
16. Ladd, 2012.
17. Anthony Downs. 2004. *Still Stuck in Traffic*. Washington, DC: Brookings. Gilles Duranton and Mathew Turner. 2011. The Fundamental Law of Highway Congestion. *American Economic Review.* Bento, Antonio, Daniel Kaffine, Kevin Roth, and Matthew Zaragoza-Watkins. 2014. "The Effects of Regulation in the Presence of Multiple Unpriced Externalities: Evidence from the Transportation Sector." *American Economic Journal: Economic Policy,* 6 (3): 1-29. Clifford Winston and Ashley Langer. 2006. The Effect of Government Highway Spending on road users' congestion costs. *Journal of Urban Economics*. 60(3):463-483. Eberts, Randall W. 2009, "Understanding the Contribution of Highway Investment to National Economic Growth: Comments on Mamuneas's Study." Prepared for the Federal Highway Administration, Department of Transportation.
18. In the book *Rethinking America's Highways,* Robert Poole offers a contrary opinion. Drawing on data from the Texas Transportation Institute (TTI's) 2012 *Urban Mobility Report*, he suggests that in the 17 metropolitan areas where road supply rose faster than roadway demand from 2000-2010, congestion delay grew more slowly than it did in other areas. He concludes from this evidence that building roads can reduce congestion delay. I think this analysis is mistaken. The big issue is as follows: road capacity can grow faster than driving because a region is adding lots of roads, because driving is growing slowly, or both. Driving might grow slowly, in turn, because the economy is small or declining — a place with fewer people and opportunities will see less driving than a booming place. As it happens, the 17 areas Poole highlights are either small or struggling. The largest of them are Pittsburgh, Wichita, and St. Louis, all of which had been contending with falling population and employment. At best, this evidence suggests that new road space in declining regions can help mitigate congestion. But building new infrastructure in declining regions is rarely considered wise.
19. See John Quiggin, 2012. *Zombie Economics*, Princeton University press, and Paul Krugman, 2020. *Arguing with Zombies*. New York: Norton.

to reduce congestion. And in a 2020 "expert consensus" report, the Transportation Research Board of the National Academy of Sciences called for spending $22 billion a year to add new highway capacity over the next 20 years.[20]

But it was in 2016, four years after the 405 was widened, that the road-capacity zombie lurched most dramatically back onto the L.A. scene, in the form of tech billionaire Elon Musk. One day Musk announced, (via Tweet, of course), that he was going to solve L.A.'s congestion problem by building an elaborate network of tunnels, some of them hundreds of feet underground. Musk never fully fleshed out this idea, but he did almost immediately start a tunnel-boring company and begin digging on his own property. Essentially, however, cars would drive onto large elevator platforms located on or near city streets. The platforms would lower the cars down into tunnels, and then the platform — car and all — would turn into a skate and be fired through the tunnels at over 125 mph. When the car got close to its final destination, the platform would convert back into an elevator, and rise back up to the street. The driver could then wheel back onto a conventional road and go about her business, while another driver would pull on the platform, be lowered into a tunnel, and shot across town.[21] Musk stated confidently that he would complete a 17-mile tunnel from LAX to the San Fernando Valley by the end of 2018.[22]

The media ate this up, probably because people like to read things about eccentric billionaires. But the plan never made a lot of sense. Some of the issues were logistical. For one, there were the safety implications of having many large, hundreds-of-feet-deep elevator shafts on city streets. That's a problem that could keep a city's attorneys awake for days. For another, there was the question of whether long lines would form at the platforms themselves. If a platform could shoot you across L.A. in four minutes, but only after you waited 25 minutes in line to get on it (during which time you snarled up traffic around you) the platform might not actually offer an improvement, or at least not enough improvement to justify the massive expense of tunneling.[23]

The bigger issue, though, was that elevators and electric skates aside, the plan just wasn't new. Musk was essentially proposing a form of freeway expansion. The tunnels would provide new road capacity. The new capacity would be underground, but there's nothing special about underground roads, and nothing that remotely suggests they are immune to congestion.[24] Manhattan commuters get stuck in the Holland Tunnel every day. Perhaps the best evidence about tunnels and their limits comes from Boston. Transportation officials there spent over a decade on a massive project called the "Big Dig," which involved taking down a double-decked freeway (the aforementioned Route 93) and burying it under downtown Boston, and adding an additional tunnel under Boston Harbor. The cost was immense: over a billion dollars a mile, and the project involved, in addition to the tunneling, relocating 30 miles of utility lines, 5,000 miles of fiber optic cable, and 200,000 miles of telephone cable. Its goals were to remove an eyesore that had cut through urban neighborhoods, free up valuable urban land for other uses, and ease Boston's notorious congestion.

As the saying goes, two out of three aint bad. The double-decker freeway is gone, the land it once cast in shadow is now a lovely greenway, and by most estimates driving in Boston is just as miserable as it was before — some of the delay has been pushed further up the freeway, and a lot of is now underground, but it remains.[25]

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20. Laura Nelson. Metro Staff Support a $6 Billion Widening of the 710 Freeway. *Los Angeles Times*. February 13. National Academies of Sciences, Engineering, and Medicine 2019. *Renewing the National Commitment to the Interstate Highway System: A Foundation for the Future*. Washington, DC: The National Academies Press.
21. The plan underwent some different iterations, but one early description of the proposal is here: https://www.cnbc.com/video/2017/05/12/elon-musks-new-underground-tunnel-project-will-transport-cars-at-125-mph.html
22. Matt Tinoco. 2017. Why Experts are so Skeptical of Elon Musk's Tunnels. *Curbed LA*. December 18.
23. In Musk's defense, there is some logic to the idea of slowing people down when they would be going slowly anyway, if it lets them move *really* fast when they would be going faster. That basic tradeoff is the logic behind freeway ramp metering. For the system to work, though, the trips have to be long and the waiting times relatively short. See David Levinson and Lei Zhang (2006) Ramp Meters on Trial: Evidence from the Twin Cities Metering Holiday. *Transportation Research part A* 40(10) 810-828.
24. Musk's original idea, he later explained, was to double-deck the 405. He later realized, though, that to solve traffic "you have to go 3D", which is a phrase he ended up using numerous times in explaining his tunnels. To Musk, presumably, the "three dimensions" in 3D are above ground, on the ground, and below ground. See Jenna Chandler and Alissa Walker. 2018. Elon Musk First Envisioned Double-Decker 405 Before Tunnel Idea. *Curbed LA*. November 9.
25. Alan Altshuler and David Luberoff. 2003. *Mega-Projects*. Washington, DC: Brookings. Also see Sean Murphy. 2008. Big Dig Pushes Bottlenecks Outward. *Boston Globe*. November 16. Also Anthony Flint. 2015. Ten Years Later, Did the Big Dig Deliver? *Boston Globe*. December 29. (Note that the Big Dig could still be worthwhile even without reducing traffic, simply because land in Boston is so valuable and the elevated freeway had consumed so much of it.)

It's too soon to know if Musk's plan will share the same fate, or if it will even come to fruition. But early signs aren't promising. At the end of 2018 Musk staged a press event on his property. He didn't unveil the promised tunnel from LAX to the Valley, but he did pull back the curtain on a prototype, which he called "profound", and had high hopes for. "We're not saying there shouldn't be other attempts at solving traffic and movement," he said. "We're not saying stop all other solutions, but we think this is the only solution that will actually work, and we're not confident that other solutions will work."[26] With that, the audience was treated to a 12-foot-wide, just-over-1-mile-long tube that could carry a single electric car on a track, as long as that car was driven by a professional driver and didn't exceed 50 mph. Also, the ride was bumpy. ("We had some trouble with the paving machine," Musk said).

Reactions ranged from underwhelmed to stunned. Musk had promised the future, then delivered the world's lamest highway.[27] In his defense, Musk said his crew had just run out of time, and that the tunnel was only a prototype. Future iterations would carry many more people, perhaps with vehicles that would have higher capacity. That's not a bad idea. Certainly if you're going to fire a vehicle across town in a tunnel, it's more efficient to have that vehicle carry more people. But it's also not a new idea. A high-capacity vehicle going through a tunnel is called a subway. We've had subways for 120 years. And subways, like roads, don't reduce congestion.

The Trouble with Building Transit to Fight Congestion

Transit advocates don't have much in common with road-widening advocates. When it comes to congestion, however, they often share, unknowingly, a belief in the power of new capacity. The idea that a new train will reduce congestion is based on the same underlying logic as the idea that a new lane will. Both assume that freeing up some capacity will make the road flow more smoothly. One way to free up capacity is to widen a road: keep the number of drivers the same but add some lanes. Another way is to keep the number of lanes the same but remove some drivers — for instance, by building a train to lure those drivers away.

Transit's opponents often object to this reasoning. They note that building a train isn't the same as convincing people to ride it. People like to drive, they argue, so building a train to fight congestion faces a challenge that widening a road doesn't — the challenge of getting people to switch modes once the train is built. Plenty of rail systems get unveiled to much fanfare and then see ridership levels disappoint. The skeptics then point out that even if people switch, having people ride transit isn't the same as having transit reduce congestion. For a train to reduce congestion, it needs to attract people who would have otherwise driven, and in particular people who would have otherwise driven on busy roads and busy times.[28] A train that carries former bus riders, or people who drove at off-peak hours, won't cut it.

There's some validity to these criticisms, but the problem actually runs deeper than that. Suppose we build a rail line in Los Angeles, running right alongside the 405. And suppose it works just as we hope. A bunch of rush hour drivers on the 405 decide they've had enough and switch to the train. The drivers who don't switch, and remain on the 405, now have more room, and can go faster. Congestion falls.

Note what has happened here. It is *as though* the road has been widened. No one built another lane — we built a train instead — but just as spending less can feel like earning more (in both cases you have more money at month's end) removing some vehicles can feel like adding some lanes. What that means, however, is that even in the best case building new rail sets in motion the same process as building new roads. When the vehicles that remain on the 405 at 8 a.m. start moving faster, the price of driving on the

26. Alissa Walker. 2018. Elon Musk Debuts Test Tunnel in Hawthorne. *Curbed LA*. December 18.
27. Alissa Walker. 2018. Elon Musk Debuts Test Tunnel in Hawthorne. *Curbed LA*. December 18.
28. Michael Manville, Brian Taylor and Evelyn Blumenberg, 2017. Falling Transit Ridership. UCLA ITS Report to the Southern California Association of Governments. Also, Genevieve Guiliano, Sandip Chakrarbati, and Mohja Rhoads.2016. Using Regional Archived Multimodal Transportation System Data for Policy Analysis: A Case Study of the LA Metro Expo Line." *Journal of Planning Education and Research*, 36(2): 195-209.

405 at 8 a.m. falls. Now triple convergence rears its head; new vehicles arrive to claim the empty space. We are back in the trap of trying to reduce congestion by making driving less expensive.

So building transit can't reduce traffic congestion. If that sounds hard to believe, make a list of cities with the world's best mass transit systems. Congratulations: you have also just made a list of some of the world's most congested cities. Comprehensive rail systems are rarely far from gridlocked roads.

The point isn't that mass transit *causes* congestion (it doesn't), only that good transit and bad congestion tend to coincide; both are byproducts of density and vitality. For that reason, road congestion probably does more for transit ridership than transit ridership does for road congestion. Transit thrives in places where driving is harder, and — again — congestion makes it harder to drive. A transit system that reduced congestion would make driving easier, and thus not just make driving more attractive but also, potentially, make transit *less* attractive. Transit designed to reduce congestion becomes a mode designed to make another mode more effective, and as such it would, through its success, discourage its own use. Even if this were possible, it would not be a good use of transit resources.

Now for some caveats. None of the above should be taken as an argument against transit. It's only an argument that new transit can't *reduce congestion,* if (again) by "reduce congestion" we mean "allowing drivers on high-demand roads at peak hours to move faster than they otherwise would." Transit can't do that, but that hardly makes transit worthless. Nothing can do everything. The polio vaccine didn't cure cancer, but it's still a signature triumph of public health. Transit is important. Many of the world's most dynamic urban environments — from Manhattan to London to Hong Kong to Paris — couldn't exist without mass transit.[29] Mass transit is also an essential lifeline for people who are financially or physically unable to drive, and when it is well-used it conserves tremendous energy, making it an important part of fighting climate change. It just can't reduce congestion.

Like new road capacity, moreover, mass transit can *improve* congestion, even if it doesn't reduce it. It can do so in two ways. The first, and probably most obvious, way is that transit lets people avoid congestion. New York's subway doesn't make New York's roads less congested, but it does allow many New Yorkers to minimize their exposure to the terrible congestion that exists. New York's subway riders zip along beneath the city's clogged roads. The subway gives people an extra option: they can trade congestion *between* vehicles, which slows them down, for congestion *within* vehicles, which — while it is sometimes uncomfortable — does not. Subways let people exchange personal space for speed. But the speed is only available to people who *don't* use the road. The road itself stays congested.

The second way transit can improve congestion is that it can, like new road capacity, make congestion more efficient. A train that pulls some drivers off a road and lets other drivers replace them allows the transportation system as a whole to move more people per hour or minute of delay, even if the delay experienced by each individual driver doesn't fall. That's not nothing, and it explains why, when transit systems suddenly break down, traffic congestion often gets a lot worse.

A sudden loss of transit capacity can send some former transit riders surging back onto the roads. Since at busy times even a small number of new cars can dramatically increase delay (a point we examine more in the next section), the effects of this shift are substantial. Michael Anderson, an economist at UC Berkeley, studied the effect of a strike that shut down L.A. County's largest transit provider for a month in 2003. Anderson used speed data from L.A. freeways and showed that when the strike began, congestion delay also spiked dramatically (by about 50%) along freeway segments that ran parallel to high-ridership transit routes.[30] Anderson concluded, based on his analysis, that L.A.'s rail system contributes billions of dollars every year in congestion relief.

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29. For example: see Stephen Heblich, Stephen Redding and Daniel Sturm. 2020. The Making of the Modern Metropolis. *Quarterly Journal of Economics*. 135(4):2059-2133. Also David King, 2011. Developing Densely. *Journal of Transport and Land Use*. 4(2):9-32.
30. Michael Anderson. 2014. Subways, Strikes and Slowdowns. *American Economic Review*. 104: 2763-2796. A similar result is found in Shih-Che Lo and Randolph W. Hall, Effects of of the Los Angeles Transit Strike on Highway Congestion. *Transportation Research Part A: Policy and Practice*, 2006, vol. 40, issue 10, 903-917

Should we look at this finding, and others like it, and conclude that adding transit is a good way to fight congestion? No, for two reasons. First, as Anderson is careful to point out, his cost-benefit analysis is predicated on the assumption that the roads aren't priced. Even if transit reduces congestion, it isn't the best way to do so. That's pricing the roads. Building and operating transit costs money. Pricing roads raises money. Pricing is preferable.

Second and more important, Anderson's result shows what happens when all transit capacity is suddenly lost. In situations like that, travelers have little time or ability to adapt. It's a mistake to extrapolate from that situation to one where some transit capacity is gradually added. The fact that congestion gets worse when transit abruptly disappears does not mean that congestion gets better when transit incrementally increases.

Transit advocates may not like that conclusion, and think I'm splitting hairs, but capacity is capacity. Anyone holding fast to the argument that more transit will reduce congestion might find themselves in the position of having to argue that more roads will as well. After all, while it's true that congestion gets worse when transit suddenly goes offline, congestion also gets worse when roads suddenly go offline. Think of the problems caused by road construction, or by street closures for parades and festivals. Or consider a weird and notorious political scandal from 2015. In that scandal, Republican operatives who worked for the governor of New Jersey punished the Democratic mayor of the city of Fort Lee by strategically closing two of three access lanes to the George Washington Bridge (Fort Lee is located right off the bridge). With the lanes closed, traffic backed up, and Fort Lee was flooded with cars.[31] Pandemonium ensued, until the operatives ordered the lanes reopened, at which time traffic abated and returned to its normal (and still miserable) levels. Less capacity: more congestion. More capacity: less congestion.

A bigger albeit older example is the Northridge earthquake, which hit Los Angeles in 1994. The quake caused a 1-mile portion of Interstate 10 to collapse, with the predictable outcome of short-term traffic chaos. The sudden loss of capacity "threatened to strangle the region" in the words of one newspaper, and local authorities asked businesses to stay closed to relieve pressure on the roads.[32] Should we look at these examples and conclude that the I-10 and the George Washington Bridge should be wider? Of course not. Triple convergence. But sauce for the road goose is sauce for the transit gander. Sudden losses aren't the same as gradual gains.

Triple convergence explains why new capacity won't work. It also explains why pricing *does* work. Like adding capacity, pricing removes the deterrent of time. Unlike adding capacity, pricing replaces the time cost with another deterrent, which is the money cost. That money cost, crucially, is the barrier that prevents the gains in time from being eaten away. Pricing, unlike capacity expansion, does not make peak hour driving cheaper. It just makes it better.

Helping Many by Deterring Few: The Nonlinear World of Traffic Delay

One could accept that prices can work, and new capacity can't, but still worry about how high those prices would need to be. Given how heavily freeways are used, it's easy to think that congestion tolls would have to be extraordinarily high. How else could we get

31. Kate Zernike. 2015. The Bridge Scandal, Explained. *New York Times*. May 1.
32. Andy Furillo, Martin McNeil and Steve Wiegand. 1994. 6.6 — LA Buckles. *Sacramento Bee*. January 18.

all these people off the road? The prospect of a high price, in turn, raises other concerns. Is pricing just some mercenary proposal that rewards selfishness? Where will all the cars that can't or won't pay go? Will they spill onto nearby surface streets, and flood neighborhood roads with pass-through traffic? Or will the price just mean that some people who need to travel won't be able to?

I'll address the last of these concerns (whether pricing would prevent some people from traveling) in the next section. In this section I'll discuss the issue of how high the tolls have to be, and whether they'd push a lot of traffic onto nearby unpriced streets.

One way to address the concern that traffic will spill onto nearby streets is to observe that traffic already spills onto nearby streets. Congestion pricing might cause spillover, but so does congestion. In Los Angeles, for example, vehicles overwhelm Sepulveda Boulevard in part because Sepulveda runs alongside the equally overwhelmed 405. If pricing made the freeway better but Sepulveda worse, that might still be an improvement. You'd have one road that was functioning and one that wasn't. As it is now, neither works.

It's also possible, however, that pricing could make *both* roads better. If prices made the 405 less congested, then yes, it could also push some cars onto Sepulveda Boulevard. But remember that congestion is itself a barrier to using the road, so if prices reduce congestion they could also pull some cars *off* the boulevard and onto the freeway. If that's the case, then the relevant question becomes how many cars a priced road pushes off, versus how many it pulls on.

Answering this question requires an understanding of how congestion works, and in particular an understanding of the fact that it is *nonlinear*: a relatively small share of vehicles account for a large share of total delay. Congestion's nonlinearity is important for two reasons. First, it means that the number of vehicles the price has to deter is relatively small, suggesting that the volume of traffic it might push elsewhere is pretty small. Second, because the price doesn't have to keep everyone, or even most people, off the road, the price does not have to be very high. It has to be just high enough to keep those last few vehicles off, and thus prevent the road from tipping into congestion. And contra concerns about prices being engines of selfishness, pricing works because it forces drivers, in a sense, to take other drivers into consideration. There is a difference between self-interest and selfishness. Congestion charges harness the power of self-interest to make everyone on the road a bit less selfish.

All these points make more sense if you understand how traffic jams actually occur. Picture yourself on a highway at night, well outside any city. It's 4 a.m. and you're in the far-left lane, alone on the road. As you approach the next exit, headlights and a blur of motion appear on the on-ramp running alongside the freeway. Another car is joining you. Because you're in the left lane, you're well clear of this newcomer. You watch as it glides into the right lane, switches to the middle, and then zooms off, all without you needing to react or slow down. The highway added a car, but didn't add any delay. A transportation engineer would say that the highway's volume (or flow) rose, but its speed didn't decline.[33]

Now suppose you keep driving, and as dawn approaches you draw nearer to a city. The world is waking up around you, the sky is turning orange, and more cars are flowing off the on-ramps and onto the freeway. The first wave of these vehicles, like the lone vehicle you saw hours earlier, won't slow you down. The road is wide and you're still in the left lane, so even as cars enter the freeway neither you nor the vehicles around you need to slow down. The relationship between speed and volume still holds: volume rises, speed stays unchanged.

Eventually, however, the road starts to fill up — what we call *traffic density* rises — and as it does the relationship between speed and volume starts to change. Now each new car increases volume but *reduces* speed, because each new car forces the vehicles already on the road to slow down, and to slow each other down. Here's how that happens. At rush hour, a vehicle slides off the on-ramp to join the freeway's flow. Unlike before, there are now drivers in the right lane, and as the new vehicle bears down on

33. Some quick definitions: speed is just what it sounds like—how fast traffic is moving. Volume and flow are traffic engineering concepts that are basically interchangeable. Both describe the number of vehicles that pass a given point in a set amount of time (for instance, 50 vehicles every five minutes).

them, they need to react. They could slow down to let the new car on, speed up to get ahead of it, or switch lanes to get out of its way. Because the road is already crowded, any decision they make forces other drivers into similar decisions. If a driver in the right lane taps her brakes, the driver behind her either must either do the same or switch lanes. If that driver switches lanes, the vehicles behind him, in the lane he switches to, will need to slow down or switch lanes themselves (or see that he is switching lanes and speed up to get ahead of him). And so on. Each decision injects a bit of friction into the otherwise smooth flow of vehicles, and that friction creates delay.

At first, the delay is almost imperceptible. But it is real, and with each additional vehicle it accumulates and starts to compound — because there are more drivers on the road that need to react, because there is less room for them to react without slowing other drivers down, and (not least) because no one knows exactly what any other driver is going to do. If every driver were sure that every other driver would tap their brakes and not switch lanes (and, in a perfect world, knew *how much* every other driver would tap their brakes), then each new vehicle would create slightly less uncertainty, and thus less delay, for everyone else.[34] But in fact none of us know what other drivers will do, other drivers don't know what we will do, and really *we* often don't know what we will do — how we will respond to a new car braking or changing lanes — until we find ourselves doing it. All of us, from the view behind someone else's steering wheel, are ciphers, and we compound the imperfection of our own reactions with our need to account for the unpredictability of everyone else.

So speed falls. The delay, which started a point of friction — like an on-ramp or an interchange — starts to work its way backward. What's happening now is a classic problem of collective action. No one woke up that morning determined to create a traffic jam. Everyone just did what made sense for them. They got on the freeway, because the freeway, congestion and all, was the best way for them to get where they had to be. In making that decision, however, they did not fully consider the fact (why would they?) that by choosing their own fastest route they would also be slowing down everyone else on that route. People think about their private costs of congestion (the costs it imposes on their time and stress) but not the social costs (the costs they impose on others by being a part of the congestion). This yields a situation where everyone slows each other down *because* everyone is in a hurry.

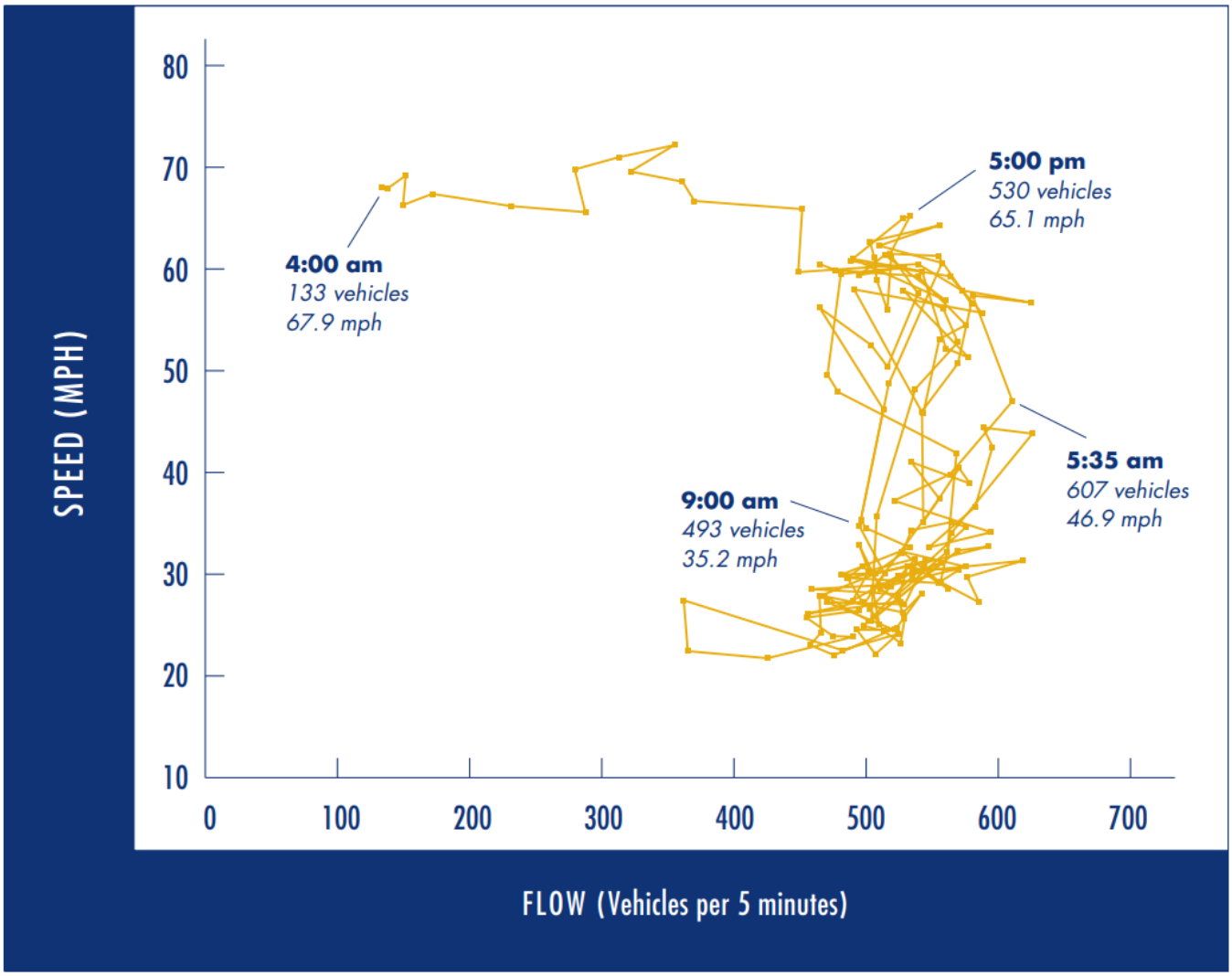
From this perspective, it's easier to understand the point I made above, about how a price can be a mechanism to make drivers think a bit more about everyone else. Economists like to say that a congestion charge "internalizes an externality" or that it forces people to account for the social costs of their action. Put more simply, prices make people a bit more considerate. A high price, after all, is a sign of how important the road is to *other people*. Someone who considers the price before deciding to drive is someone who, if only implicitly, is considering other people's wants before acting on his or her own. If enough people did that, our roads would flow more freely.

Most roads, however, don't have prices, so most people, when they make travel decisions, think primarily of themselves. Hence, in our example above, the delay starts, and then rolls backward, and pretty soon, for reasons they often don't completely understand, drivers well away from any bottleneck start seeing red tail lights in front of them, and drive into a wave of stop-and-go traffic. Voila. Congestion.[35]

And it doesn't end there, or at least it doesn't always. What I've described above is a garden-variety traffic jam: as volume rises speed falls. Sometimes things progress further, into full-on gridlock. When that happens, speed *and* volume fall. In classrooms, we illustrate this with a graph like Figure 1, which I've borrowed from an article by UC Berkeley professor Pravin Varaiya.[36] The figure shows, using speed and flow data from the I-10 in Los Angeles, a phenomenon that transportation scholars call congestion's

34. Arguments that autonomous vehicles (AVs) will reduce congestion are premised largely on the assumption that most or all of the AV fleet will either be programmed to react in the same way to uncertainty, and/or that different vehicles will be able to communicate with each other and transmit their intentions. In both cases, a new car creates less uncertainty and thus less friction and delay.
35. For a more detailed and entertaining discussion of this process, see Tom Vanderbilt, 2009 *Traffic*. New York: Vintage.
36. Varaiya, Pravin. 2005. What We've Learned About Highway Capacity. *Access*. Fall: 2-7. https://people.eecs.berkeley.edu/~varaiya/papers_ps.dir/accessF05v2.pdf

"backward-bending curve."[37] The backward bend is the point at which flow starts to fall alongside speed, and where travel on the road truly breaks down. In this figure it happens between 5:00 a.m. and 6:00 a.m. Flow, which started at 133 vehicles traveling at 68 mph at 4 a.m, has steadily risen, and as it increased speed has started to decline. At 5:35 a.m. flow exceeds over 600 vehicles, and speed falls to 47 mph. Then the curve bends. By 9 a.m. speed is down further, to only 35 mph, but so is volume, to under 500 vehicles. The traffic has reached a point where a new car doesn't just slow all the other cars down, but also reduces the total number of cars that can use the road.[38]



This situation, sometimes called "hypercongestion", is counterintuitive. How can *adding* a car *reduce* the number of cars on the road? The key here is that we measure volume and flow dynamically: we ask how many vehicles pass a given point in a given amount of time (in the figure, for example, flow is measured as vehicles per five minutes). We do this because roads are conduits:

37. Varaiya, Pravin. 2005. What We've Learned About Highway Capacity. *Access.* Fall: 2-7. https://people.eecs.berkeley.edu/~varaiya/papers_ps.dir/accessF05v2.pdf
38. The road has returned to a more "normal" flow at 5 PM. That's also rush hour, but rush hour going in the other direction.

they are designed to move vehicles, not hold them in place. So if we want to measure a road's productivity, we measure the number of vehicles rolling over it, not the number it holds at any given time.

That point helps explain why a full road can add more cars but carry fewer. Basically, the road fills up to a point where no one can move. There was a recurring joke, in the old comedy show "The Three Stooges," called the Doorway Gag. In the gag the Stooges — Larry, Moe and Curly — would get excited and all try to run through a door at the same time, at which point they would all get stuck. The Doorway Gag offers a window into hypercongestion. If you were to take a snapshot of the door right after the Stooges converged on it, speed would be low (they are stuck) and volume high (three people in the door, all at once!). But volume, again, shouldn't be measured as a snapshot. If you measured the doorway's speed and volume in three-minute intervals, speed would still be low (they're still stuck) but so would volume, because the *same three people* are in the door. Precisely because the Stooges are jammed in the doorway, no one else can use it. Adding Larry to Moe and Curly caused the doorway's productivity to plummet. Had each Stooge waited and walked through one at a time, or if just one had waited while two went through, fewer people would have been in the frame at any given moment, but many more people would have passed through it: speed and flow would have been higher.[39]

What's true for the Stooges is true, albeit with less entertainment value, for highway commuters.[40] A common euphemism for gridlock is that it "turns the road into a parking lot." The phrase resonates because in a parking lot little moves. That means a parking lot's volume will be relatively low. Look at a parking lot, turn away, and then look again five minutes later. Probably the same cars are there. That's fine for a parking lot, but less than ideal for a road.

What all this suggests, however, is that a policy instrument that regulates entry onto the road can, paradoxically, let *more* vehicles use it, by preventing a jam. That's what a congestion charge does. Nor, as the Doorway Gag also shows, does the charge need to deter a large proportion of would-be travelers. Just as the doorway problems could have been avoided through the restraint of a single Stooge, a charge that discourages a small share of drivers can dramatically increase speeds, since the few vehicles entering the road account for a disproportionate share of the delay.

If charging lets more people use the road, it may well alleviate, not exacerbate, traffic on nearby streets. It's true that some drivers deterred by a toll might choose to drive on a nearby arterial instead, and help clog it up. But not all deterred drivers would do that — some might take transit or travel at a different time — and in any event, as was mentioned above, congestion also pushes people off freeways and onto nearby surface streets. What the backward-bending curve tells us, moreover, is that pricing could pull some drivers *onto* the freeway. The uncongested freeway, after all, is moving more people, and they have to come from somewhere. When the Stooges are jammed in the doorway, anyone who wants to get into the room on the other side of the door has to go find another route — maybe walk through a bunch of other rooms that get them there indirectly. Getting the Stooges out of the doorway pulls people out of those other rooms. The same holds true for roads.

39. Appropriately, the Doorway Gag usually ended with Moe, the head Stooge, telling the others to "spread out".
40. A caveat: My description of hypercongestion aligns with the general consensus of people who study traffic. In 2020, however, Michael Anderson and Lucas Davis released a carefully-done paper arguing that hypercongestion doesn't actually exist—that even as speeds fall dramatically, the number of cars using the road does not decline. This paper has yet to be peer-reviewed, so the jury remains out. See Michael Anderson and Lucas Davis. 2020. "An Empirical Test of Hypercongestion at Highway Bottlenecks".

But Don't We Need Alternatives?

A priced road network can let more people use roads when they need them most. This improvement, however, will only occur because the price will deter at least some people, some of the time, from choosing to travel on the priced road. That fact raises the question of what those deterred people will do, and whether tolling would be fair to them. Roads don't have many substitutes. There's only one 405 Freeway running through Los Angeles, and only one Interstate 95 running through New York. Transit can sometimes be a substitute for roads, but transit service in most of the U.S. is badly inadequate. This reasoning can easily lead to the conclusion that roads, because they are essential goods and have few alternatives, shouldn't be priced. Particularly in places without good mass transit, congestion pricing might only work if prices are high. Since many of our most congested urban areas are also characterized by extreme inequality, high prices could in turn push average people off the roads, while the rich, who can and will pay almost anything, just keep driving.

This concern is understandable, but right out of the gate the reasoning behind it is flawed. If roads are essential because driving is essential, then presumably cars are essential as well. Using a freeway is hard without a car, and vice versa. Thus an argument that roads should be free because driving is essential strongly implies that cars should be free as well. Yet no one, to my knowledge, says all cars should be free.

One could try to wriggle out of that conundrum by arguing that cars, unlike roads, aren't monopoly goods: many companies make cars, but the roads are controlled by a single owner, which is the government. Competition will eventually drive the price of cars down, but the road monopoly is insulated from competitive pressure. I'm not sure I find that completely persuasive, but for the sake of argument let's accept it, and assume that priced cars are okay but priced roads might be a problem. The problem, specifically, would be that a regime of priced roads would lead to the rich driving as much as they please and the poor being pushed off the roads. For this dystopian outcome to occur, two criteria need to be satisfied. First, it must be the case that higher-income people won't reduce their consumption in the face of modest price increases, and will instead spend freely and run up the price. Second, the high price would in turn deprive everyone else of the ability to travel, because driving at peak times has so few substitutes.

Neither of these conditions is likely to hold. Let's look first at the idea that affluent people will be largely immune to congestion charges. Without question, compared to poor people, rich people will drive more on priced roads. But that fact alone doesn't tell us much. Rich people also drive more on *free* roads.[41] Cars and gas and insurance and maintenance all cost money, which means that driving, priced roads or no, costs money. Since the rich, by definition, have more money, it is easier for them to drive.

The question at hand, though, is not whether the rich will use priced roads more than others. It is whether the rich will drive *less than they otherwise would*. Will they respond to the price? Here the answer is almost certainly yes. Even rich people consume less when prices rise. We can see this fact pretty clearly when we examine how the super-rich consume land. In rural areas where land values are lower, wealthy people purchase giant estates, often with multiple buildings arrayed across sprawling properties. In dense urban centers where land values are high, in contrast, equally wealthy consume much less land. The billionaire Michael Bloomberg, for example, summers at a Hamptons property that has 22,000 square feet of living space on 35 acres of land. The Hamptons aren't cheap — land prices in 2019 were about $800,000 per acre. But Bloomberg's primary residence is in Manhattan, where land prices

41. Michael Manville and Emily Goldman. 2018. Would Congestion Pricing Harm the Poor? Do Free Roads Help the Poor? *Journal of Planning Education and Research*. 38(3):329-344.

are over $6 *million* per acre. Bloomberg's Manhattan residence, as a consequence, is "only" 12,500 square feet.[42] Obviously no one needs to feel sorry for Michael Bloomberg. Even his smaller home is many times the size of the typical American's, and orders of magnitude larger than the studio apartments occupied by many of his fellow Manhattanites. The point is only that even the megarich, when confronted with higher prices, consume fewer resources.

That example is about the superrich, of whom there are admittedly only so many, and — as F. Scott Fitzgerald noted — they are different from you and me. The example is also about residential land, rather than land used for transportation. But Manhattan also offers a lesson in how more ordinarily affluent people react when the price of transportation-based land rises. Manhattan has high average incomes and low average car ownership. In most of America it is almost unheard of for a middle- or upper-class household to not own a car. In Manhattan, however, it isn't uncommon at all. Across the U.S., only 2% of households with incomes between $100,000 and $200,000 don't have a car. Almost 90% have two cars or more.[43] In contrast, almost 70% of Manhattan households with incomes between $100,00 and $200,000 have no car at all, and fewer than 5% have two cars or more. The median income of a carless household in Manhattan is over $60,000. To give a sense of how high that number is, across the bridge on Staten Island, the median income of a household without a car is $19,000. In Los Angeles, it's $15,000.[44]

Affluent Manhattanites don't eschew cars because *cars* are expensive in Manhattan. Cars are, obviously, very portable, and it's hard to make a portable good more expensive in one place than another. Manhattan has few car dealerships, but anyone living in Manhattan who wants to buy a car can ride a train off the island, buy a car for roughly the same price being offered elsewhere in the country, and then drive it back. It's only *then* that you'd run into the problem, because what's expensive in Manhattan is not buying a car but *storing* a car once you buy it. Relative to its population, Manhattan has notoriously little parking. Its streets are narrow, many of its buildings lack off-street parking, either because they are old enough to predate widespread automobility or because of Manhattan's zoning, which actually restricts parking.[45] As a result, Manhattan car owners must either jockey for street space or buy an off-street spot, which will likely cost $150,000 to $300,000, and that might top $1 million.[46] Faced with such costs, in time or money, many Manhattanites choose not to own cars, even though their incomes would, anywhere else, almost guarantee ownership of multiple vehicles. Prices matter.

But what about pricing the roads, specifically? The world only has a few congestion pricing programs, but the evidence we have from those programs suggests the same basic lesson: even rich people drive less when roads get tolled. Since 2003, London has had a congestion charge covering what is basically its financial district — a few square miles that are the U.K.'s equivalent of Wall Street. The area is dense with historic buildings, and parking is scarce and expensive, which explains why, even before congestion charging, almost 80% of people commuting into the area didn't drive. Expensive parking meant that vehicles entering the area were often taxi cabs (which don't have to park) or cars owned by well-paid financial industry workers, who could afford the area's high parking prices (or whose deep-pocketed employers paid for parking for them). Yet when congestion charging began, traffic levels and congestion delay plunged, by almost a third in the first year.[47] And no, this wasn't because the charge displaced all the taxis. Taxis were exempt. Driving fell because even well-off people, people who could in all likelihood "afford it", still responded to prices.

Singapore provides an even better example. Singapore began congestion charging in 1976, and since 1998 it has had electronic road pricing on all the highways running through its center. Singapore is a rich country. Its per capita income, in U.S. dollars, is $95,000

42. Allie Jones. "Michael Bloomberg's Many Mansions." *Vanity Fair* February 24, 2020. Land prices come from American Enterprise Institute's Land Price and Land Share Indicators database, https://www.aei.org/housing/land-price-indicators/
43. Calculated with IPUMS from the US Census 2018 American Community Survey.
44. David King, Michael Smart and Michael Manville. 2019. The Poverty of the Carless. *Journal of Planning Education and Research*.
45. Michael Manville, Alex Beata, and Donald Shoup. 2014. Turning Housing into Driving. *Housing Policy Debate*. 23:2, 350-375.
46. Dennis Green, 2015. New Yorkers Will Pay $1 million for something most Americans Get for Free. *Business Insiders*. August 21. Also Lauren Price. 2014. There's more than One $1M Parking Space in Manhattan. 6sqft.com. September 13.
47. Santos, Georgina. 2008. London Congestion Charging. *Brookings-Wharton Papers on Urban Affairs*. 177-234. Also Jonathan Leape, 2006. The London Congestion Charge. *Journal of Economic Perspectives*. 20(4): 157-176.

(U.S. per capita income, by way of comparison, is about $64,000). Driving in Singapore, however, is extremely expensive, largely because the government goes to great lengths to restrict it. Singapore levies a high tax on vehicle purchases, and strictly controls the number of vehicles that are operating. Anyone who wants to drive a car, in fact, must bid for the right to do so in a government-run auction.[48] When those bids, along with other taxes and fees, are accounted for, it isn't unusual for a midsize sedan to cost up to U.S. $150,000.[49] One result of this system is that vehicle ownership in Singapore is reserved largely for the rich. Yet Singapore is able to manage its congestion with relatively *low* tolls,[50] suggesting that affluent people will change their behavior if nudged by even modest prices.

Now here's a problem with the argument I've been making: Singapore, London and Manhattan are also places that offer many alternatives to driving. Dense development, narrow streets and scarce parking don't just make driving difficult; they also make transit use and walking easier. So while these places might demonstrate that affluent people respond to prices, they may not offer much reassurance about what will happen to less affluent people. People priced away from cars in Manhattan or London or Singapore know that a subway stop is never far away. Walking in these places, moreover, is pleasant. The narrow streets mean you aren't walking near many lanes of fast-moving traffic, the many intersections common to dense street grids slow cars down and provide many places to safely cross, and the absence of off-street parking prevents the experience of walking next to unsightly surface parking, and removes the worry that cars will slide out of driveways and run you over. None of this describes Los Angeles, Houston or Atlanta. It's hard, in short, to extrapolate from places where driving is difficult to the typical American metropolis. Hence the concern that in most places pricing would need to wait for dramatic improvements in public transportation.

I don't agree. It is probably true that *politically*, congestion pricing will be easier to implement if it comes with more and better transit service. It's also true that many places, pricing aside, should have better transit. Transit service is so bad in so many parts of the country that it isn't hard to come up with good reasons to improve it. But conceding those points doesn't mean better transit is necessary to introduce pricing. London and Stockholm (which also has a congestion charge) both had excellent transit service before they began pricing, and many observers will tell you that the high-quality transit made pricing possible. The opposite, however, is true in Singapore, which only had bus service when it began charging. Only after road charging began did Singapore develop its rapid transit system. Transit in Singapore didn't enable pricing, pricing enabled transit. The same would likely be true in Los Angeles or Atlanta. One of the biggest obstacles to transit use in much of the U.S. — and to meaningfully improving transit quality — is how relatively *in*expensive it is to drive. Helping transit is not congestion pricing's purpose, but it is often a side-effect.[51]

One could still argue, of course, that Singapore is sufficiently unique to not be a reliable example for the rest of the world. Singapore restricted vehicle ownership and started charging for roads just as the country was becoming affluent. In doing so it established a pattern wholly different from the rest of the world's modernization, where rising income did not move in lockstep with rising automobility. The great majority of people in Singapore never came to expect or depend on free roads, and you can't miss what you've never had. Congestion pricing in Singapore, as a result, probably looked a lot like a tax on the rich. In a typical American city, where 85% to 90% of households own a car, pricing would not seem as progressive.

To me, that concern sounds more political than practical: it's a reason pricing is hard to sell, but not a reason it wouldn't work. Nevertheless, there's no getting around the fact that the few places with congestion pricing don't look much like the rest of the world. So here's another way to think about the issue: Suppose we accept that it is practically difficult or ethically problematic to

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48. Santos, Georgina. 2008. London Congestion Charging. *Brookings-Wharton Papers on Urban Affairs*. 177-234.
49. For an overview, see Gregory Christiansen. 2006. Road Pricing in Singapore After 30 Years. *Cato Journal*, 26(1):71-88. Bids for the right to drive (Certificates of Entitlement, or COEs) in 2020 averaged between $25,000 and $32,000 US. Also see Timothy Ho. 2020. Cost of Owning a Car in Singapore over 10 Years. *Dollars and Sense*. October 19.
50. A reasonable expectation for a driver in Singapore is to pay $30 a month in tolls. Timothy Ho. 2020. Cost of Owning a Car in Singapore over 10 Years. *Dollars and Sense*. October 19.
51. Kenneth Small. 2005. Unnoticed Lessons from London: Road Pricing and Public Transit. *Access*. Spring(26):10-15.

charge for vital infrastructure that has few alternatives. We might as a result hesitate to charge for roads, at least outside the few places where walking and mass transit are excellent. But that same logic should lead us to *strongly* object to charging for electricity, water, or heating fuel.

Water, electricity and heating fuel are every bit as vital as roads, indeed more so. (A week without driving is often hard, a week without water is always death.) Like the roads, these utilities are monopoly network infrastructure with few alternatives. Substituting for these services, in fact, is probably harder than substituting for roads. Quality transit is rare. The American Public Transportation Association estimates that only 55% of U.S. households have any access to transit, and many of those probably don't have access to *good* transit.[52] But the share of households without quality transit access is nevertheless dwarfed by the share with a viable alternative to metered water or electricity. Only two-tenths of one percent of U.S. households live off the electricity grid, and even fewer are able to provide their own water in addition.[53] Few households have their own aquifers, wells or generators. Most have no choice but to pay for water or electricity from their local utility. Yet we rarely hear that water metering is unfair or ethically problematic. There are people, of course, who have trouble paying for their water and electricity, and that is a legitimate area of ethical concern. But this concern usually leads, justifiably, to calls to help those people, not calls to make all electricity or water free.

How can we tolerate water and electric metering while nevertheless insisting that priced roads would be unfair? One could answer by invoking the Singapore reasoning above: what matters is that we are all used to metering. If municipal water has always been metered, then people never got used to unmetered water, or built budgets and routines around it. That makes the situation different from one where the government takes roads that have been long been free and starts charging for them. If cities had water utilities but not water metering, and then tried to introduce meters, that would be a better analogy — but that would also create a genuine hardship.

It's an interesting argument. But the evidence we have also suggests it is wrong. There are places in California that until recently had almost no residential water meters. People in these cities had bought homes and planned their budgets on the assumption that municipal water — a vital service with no easy substitute — would not be priced by use. That expectation was dashed. These cities, like Sacramento and Fresno, were ultimately forced to start metering. They thus offer a small case study in what happens when a vital good starts getting priced by use.

We can begin by noting that there was no particularly good reason for these California cities to lack water meters. They did not, for instance, enjoy some kind of superabundance of water. California's precipitation can charitably be described as volatile. Floods are a problem, but droughts are a bigger one. The state has had at least one multiyear drought in every decade since the 1920s, and anyone who has seen "Chinatown" knows that water, its scarcity, and the resulting desire to control it have long injected anxiety and intrigue into California politics.[54] Even by California standards, moreover, the unmetered cities were dry; they were located in the state's arid interior, the Central Valley. Sacramento sits at the confluence of two rivers, which makes it flood-prone, but it also averages only 20 inches of rainfall per year — about half the U.S. average. Fresno was an even less likely candidate for unmetered water, since it is basically a desert. The city averages 11.5 inches of rain per year, putting it about 2 inches ahead of Phoenix.[55]

Sacramento and Fresno, along with a handful of smaller California Central Valley cities, were unmetered as a matter of principle. Just as many Americans today have long believed that roads shouldn't be priced, residents of these cities had long believed water shouldn't be priced. Proposing water meters, one Sacramento resident explained in 2014, was "like going to Alabama and saying

52. APTA Newsroom Public Transportation Facts, October 2020. https://www.apta.com/news-publications/public-transportation-facts/. That said, transit access is better in places where congestion is worse. Transit access is poorest in rural areas, but rural areas are unlikely candidates for congestion pricing.
53. Tim Gaynor. 2008. Pioneers show Americans How to Live Off the Grid. *Reuters*. May 25. Also Homeadvisor. 2020. Off-the-Grid Capitals. https://www.homeadvisor.com/r/off-the-grid-capitals/
54. Marc Reisner. 1993. *Cadillac Desert*. New York: Penguin.
55. National Weather Service, Annual Precipitation Data. https://w2.weather.gov/climate/local_data.php?wfo=ffc

you are going to register their guns ... People in some places view it as birthright that they will have big trees and green grass. They see the water in the river, they work alongside it and they raft on it."[56] Sacramento's voters banned meters in 1920, and in the years since showed little interest in revisiting that decision. Fresno, compared to Sacramento, was a latecomer to formal anti-meter sentiment, and didn't officially ban meters until 1992. But it had never used them either.

The bans weren't universal: they applied only to detached single-family homes. Office buildings, apartment buildings and other structures all had metered water. But single-family homes were most housing units.[57] Notably, the bans couldn't prevent a single-family home from physically including a water meter. State law saw to that: California required every home built after 1990 to have a water meter, and Central Valley builders complied. The state law did not, however, require that the meters be *read*. By 2010, as a result, Fresno had tens of thousands of older single-family homes without meters, and about 24,000 single-family homes with water meters that weren't monitored.[58]

Water in these cities wasn't completely free, just as roads today are also not costless. But as is the case with roads now, people in unmetered cities only paid for water indirectly, in a manner divorced from how much they actually used. Sacramento and Fresno both charged a flat per-household rate for water. As the Fresno Bee described it in 2010, "customers now pay the same rate whether they use 100 gallons a month or 10,000."[59] A local radio station interviewed a Fresno homeowner who paid about $30 a month for unlimited water.[60]

Because people paid *something*, and because it's easier to increase the supply of water than the supply of roads, these cities didn't have water shortages the way most cities today have the road shortages we call congestion. But there is little doubt that unmetered water exacerbated the overall anxiety about water in California, because it led people to use more water than they otherwise would.

Pricing water with a flat rate was the municipal infrastructure equivalent of going to dinner with a large group and splitting the check evenly afterward. Dinners like that can be fun, but they encourage neither efficiency nor equity. When everyone helps pay for everyone else, no single diner's bill has much relation to what they order, so everyone is subtly encouraged to order more, or to order things that are more expensive. People at the table end up eating and drinking more than they otherwise would, and they order some things no one actually wants very much. No diner has much incentive to conserve, because ordering less doesn't mean paying less. It just means paying more to benefit someone else. Food gets wasted; everyone's bill rises. The higher bill is evenly split, but the even split isn't a fair split, because the equal burden doesn't reflect equal benefits. When everyone pays the same but some people order more, an even split quietly transfers resources from those who consumed least to those who consumed most. Diners with small appetites help pay for their friends who are big eaters, vegetarians subsidize carnivores, and teetotalers subsidize drinkers.

Something similar happened with water in Sacramento and Fresno. Without meters, people used a *lot* more water. If your bill would be the same regardless of whether you used 100 gallons or 10,000, you probably wouldn't go out of your way to use more water, but you also probably wouldn't think twice about it. (If that sounds familiar, it describes the incentives many of us face when we decide to drive). In 2003, Sacramento households were consuming an average of 17,000 gallons of water per month, well above the average in nearby metered cities like Davis, Stockton, and Vacaville (closer to 12,500 gallons).[61] By 2010, the Central Valley's unmetered cities were using 39% more water per person than its metered cities.[62] Fresno's residents averaged 300 gallons of water per day; in the nearby metered town of Clovis, residents averaged 230 gallons.[63] In the tiny unmetered town of Folsom, renowned

56. Rogers, P. 2014. California Drought. Water Meters Absent from more than 250,000 homes. *Los Angeles Daily News*. March 9.
57. The Census shows, for example, that in 2018 detached single family homes were 60 percent of Fresno's housing units.
58. Hostetter, George. 2010. Fresno Turns Page on New Water Meters. *Fresno Bee*. July 10.
59. Hostetter, George. 2010. Fresno Turns Page on New Water Meters. *Fresno Bee*. July 10.
60. Yuriar, N. 2010. Fresno Installs Water Meters. *KMPH FOX 26*. July 13.
61. Vogel, N. 2003. Sacramento May Finally Go With the Flow. *Los Angeles Times*. May 6.
62. Rogers, 2014.
63. Boyles, D. 2008. City Sifts Water Meter Options. *Fresno Bee*. June 10. Also Khoka, S. 2009. Without Meters, Fresno Water Beyond Measure. *NPR*. May 26.

for its prison blues, residents consumed an astonishing 429 gallons of water per day.[64] Some of that water was important to those residents, some was not, and some, probably, was used without residents even knowing it. "Without meters," one analyst observed, "homeowners can't even figure out if they have leaks."[65]

To be clear: metered cities like Stockton and Clovis were not models of conservation. Water in California, almost *all* of California, is appallingly mismanaged. Most of California is naturally brown, but many of its residents want green lawns. California's elected leaders, to their great discredit, cater to that desire, and water use ends up high. The metered residents of Clovis, with their 230 daily gallons of use, still consume more than twice the U.S. daily average of 100 gallons.[66] So the point is not that all cities should emulate Clovis. It's only that pricing has an impact. Controlling for California's overall profligacy, metering reduces use.

This proposition becomes more evident when we look at what happened next. When droughts became more frequent and severe in the early 2000s, the Central Valley's free-flowing ways started to seem less acceptable. The unmetered cities themselves remained firm, but in 2009 the state legislature, with some prodding from the federal government, forced the issue. California passed a law saying that any city not fully metered by 2013 would lose access to water from dams operated by the federal Bureau of Reclamation.[67] Reclamation dams hold a lot of California's water — Fresno relied on them for about 40% of its annual consumption — so this got people's attention. Reluctantly but steadily, the unmetered cities began preparing to price water by use. They launched educational and outreach campaigns, and started to install meters in houses that lacked them. By 2013, metering had begun.

When metering started, water use plunged. In Fresno, by 2014, water consumption had fallen 27%, to 200 gallons a day.[68] Meter installation was slower in Sacramento, and by 2014 it was only half complete, but water use had still fallen 12%.[69] By 2018, 70% of the city's households were metered, and water use had fallen 24%, from over 17,000 gallons per month to just under 13,000, putting it squarely in line with Davis and Stockton.

This reduction did *not* occur because the cities charged prices that were punitively high. The Central Valley cities took baby steps toward water pricing. Sacramento and Fresno started out by charging $45 and $42 per 100 cubic feet, respectively, well below the $125 per 100 cubic feet charged in San Francisco and the $92 per 100 cubic feet in Los Angeles. Even these modest prices, however, hauled consumption down. And did so without mass hardship. People weren't thrilled to be paying more for water, but no crisis of access emerged. The sky didn't fall.

"Essential" Roads, and How to Price Them

The ease with which the Central Valley cities started charging for water suggests the ease with which US cities might charge for roads. But that ease *is* surprising. How can we allocate something that we all agree is vitally important, and so with relatively modest prices? That question, or at least a version of it, is actually very old. In his 1776 book "The Wealth of Nations," sometimes considered the first book of economics, Adam Smith discussed what was known as the diamond-water paradox, which today is sometimes

64. Rogers, 2014.
65. Vogel, 2003.
66. Khoka, 2009.
67. Khoka, 2009.
68. Berstein, S. 2015. In drought, Californians Lacking water meters let it flow. *Reuters.* April 8.
69. Reese, P. 2014. How Much Water a Community Gulps Varies Across the Sacramento Region. *Sacramento Bee.* March 8.

called the paradox of value. The paradox is this: water is extraordinarily useful, a good without substitutes, and essential for human life. Diamonds are baubles; vanities with no real purpose. Yet diamonds are consistently expensive and water is consistently cheap. Why?

Smith, by his own admission, couldn't offer a satisfying answer. Solving the puzzle fell to later economists. The solution involves what economists now call the *marginal* value of diamonds and water. The essential insight of marginalism, which has since become a bedrock principle of economics, is that a good's value is subjective, and often depends crucially on how much of it people already have. The value of a small amount of water, if you have no water at all, is almost infinite. A man who has spent days dragging himself across a desert will pay more for a drink from the tap than he would for the most ornate of diamonds. Yet that same man, if his basement has flooded, might pay someone handsomely to take water away.[70] The water itself hasn't changed between those situations. It's still just water. What's changed is how much of it the person has.

Most people, fortunately, aren't in a situation where they have no water at all (although too many, tragically, are), and for that reason the *typical* water purchase carries little urgency. The next gallon of water, for most of us, is not a matter of life or death. It's a matter of watering the lawn, filling the pool, taking a longer shower, or running the washing machine and dishwasher a bit more frequently. Some uses of water are essential, but many are frivolous, and the price reflects both.

Diamonds are different. Many people do find themselves in a situation (called "getting engaged") where they have no diamonds and really need one. This situation and others like it, moreover, describe most diamond purchases. Engagement rings are about 30% of U.S. diamond purchases, while gifts for weddings, anniversaries and the like account for another 20% to 30%.[71] Whatever one thinks of these rituals, their prevalence means that buying a diamond, unlike buying a gallon of water, is almost always a special occasion, and often a once-in-a-lifetime occasion.[72] The typical diamond purchase, as a result, carries more subjective urgency than the typical water purchase. It's easier for people to give up the next increment of water, and that fact is reflected in the price.

Roads are more like water than diamonds. For most people, some minimum level of driving on roads is extremely important, and we don't want pricing to deny anyone that level of access. But the fact that some driving is essential should not blind us to the fact that lots of it isn't, and the fact that a good has a price above zero doesn't mean no one will ever use it. If roads were priced, most of us could afford the proportion of our driving that is absolutely necessary, just as most of us can now afford the gasoline, water and electricity we require. Some people, of course, could not afford the tolls, and helping those people would be an essential part of any road pricing program. (Some toll revenue cand and should be dedicated to helping those people out). But leaving roads free, like leaving water unmetered, is a wildly inefficient way to make sure people have what they need. After a certain point "need" becomes a subjective concept, and one highly dependent on price. I often find that I "need" more beer when I am at a happy hour, and more sausage when I am at a breakfast buffet. When happy hour ends, or I have to order breakfast a la carte, my needs get recalibrated.

This point also gives the lie to the idea that roads have "no substitutes." The tried-and-true alternative to using a given amount of a certain good is not to give up that good completely, but to *use less of it*. For most people, the best alternative to driving a lot on busy roads at busy times is to drive a bit less on busy roads at busy times. It's true that there's only one 405 Freeway. But congestion pricing would not take the 405 down. It would not ban driving, just as metering didn't ban water. Priced roads would only require that people find a substitute for *some trips* at *some times*, not a substitute for getting around by car. For that reason pricing does not require, as a precondition, a vast system of public transportation, any more than water or electric or heating fuel metering require, as a precondition, alternative ways to get water or power.

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70. I borrow this example from Thomas Sowell, 1990. *Knowledge and Decisions*. New York: Basic Books.
71. DeBeers Co. "Diamonds and Love in the Modern World." *Diamond Insight Report 2019*. DeBeers Group.
72. Given divorce statistics, maybe twice-in-a-lifetime.

When the price of heating fuel goes up, the typical household in the Northeast doesn't disconnect from the gas company and freeze. They put on sweaters, install insulation, maybe seal off a room they don't use much. When water meters arrived in central California, many people were not happy, but no one worried about the absence of alternative, parallel ways to get water. No rash of well-digging occurred, and sales of bottled water didn't spike. People just used less water, which in practice often meant reducing or eliminating the water consumption that they personally valued less. In 2010, as meters were first being piloted in Fresno, the Fresno Bee conducted a variety of interviews with residents, showing how the prices had led people to find small and large opportunities to conserve. One resident was washing his truck in the street, and "handling the hose with such skill the gutter barely got wet." Another had replaced water guzzling plants in her backyard with native grasses that needed less water. A third, in contrast, couldn't quite bring himself to part with his lawn. "I'd rather keep my yard nice and green. If it costs me another $20, I'll pay it."[73]

These were the tradeoffs that meters brought, and that brought water use down. Some people, when water was priced by use, realized it wasn't quite as important to them as they had previously thought — they didn't "need" as much. Others didn't. The latter group paid, and the former group conserved. Everyone adjusted in the manner easiest for them, and the city used less water, but not *no* water. "People in Fresno have always loved their yards," the city's water director said in 2019. "We used to have so much water — and we still do. We just can't use it as profligately."[74]

Charging for road use would create the same incentives, and illuminate the same overlooked opportunities to conserve. People often think they have no choice but to drive for almost all their trips, but many people who hold that belief have never been forced to seriously examine it. A price could trigger that examination. Even in the most car-oriented of landscapes, it is possible that the next time you feel impelled to travel it may not be absolutely imperative that you make your trip right then, by car, by yourself, and via roads that many other people want to use. Sometimes — not every time — you'll have some flexibility. And once you have flexibility, you have ways to avoid or reduce toll charges. Maybe you can carpool, or drive at a slightly different time, or walk or bike. You might learn, depending on where you are, that even your subpar transit service can pull its weight for some trips.

All these adjustments might sound like inconveniences. Yes, they let you avoid the toll, but they're still *costs*. Often that's true. But if you choose them, then presumably they are *less* costly than paying a toll to get on a high-performing road. And remember that when you pull onto a busy unpriced road you are inconveniencing *others*. Someone, no matter what, is likely to be inconvenienced. It's natural to think that shouldn't be you, but what makes you so special?

Furthermore, it isn't always the case that adjustments made to avoid tolls will be inconveniences. Arguing that *any* changes to people's travel habits makes those people worse off implicitly assumes that their current travel habits are fully optimal — that the current routine allows no room for improvement. That idea strains credulity. Most of us are not relentlessly optimizing how we travel. We instead settle into a routine that works well enough, and leave it at that. We don't re-examine our routine unless something forces us to, which means many of us might not be traveling in the most convenient way. A remarkable study from 2017 used a London Tube strike to illustrate this idea. The strike, which only lasted a few days, nevertheless forced London commuters to re-evaluate how they got to work. Using data that let them follow individual commuters over time, researchers showed that after the strike ended, 5% of travelers kept the new route they had developed during the stoppage. The strike had created "forced experimentation" and a small but real share of commuters had learned that they had been stuck in suboptimal habits.[75]

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73. Hostetter, 2010. Also Orozco, Ron. 2010. Meters Spur Makeover of Fresno Backyard. July 10. *Fresno Bee*.
74. Interview with Ron Simons, Supervisor of City of Fresno Water District.
75. Shaun Larcom, Ferdinand Rauch, and Tim Williams. 2017. The Benefits of Forced Experimentation: Striking Evidence from the London Underground Network. *Quarterly Journal of Economics*. 2019–2055.

Five percent is not a huge amount, and one could argue that drivers might be less likely than transit riders to suffer from inefficient routes. Onboard navigation systems regularly help us use the best routes to get where we are going. But a navigation system optimizes a route once you've chosen a destination and a mode. It doesn't tell you where you want to go, and if you automatically look for driving directions (which many people do) you might miss the fact that another mode is faster or more reliable. That leaves lots of room for improvement. I live in Los Angeles, which is, as its reputation suggests, set up for cars. Nevertheless, the most reliable way for me to get from home to my office — by "most reliable" I mean the way with the least variance in travel time — is by bike. The easiest way, by far, for me to get from home to a Dodgers game is via bus. (The bus is slower than driving, but it doesn't trap you in the stadium parking lot after the game).

Those are examples where a different mode offers a better way to a destination I don't have much choice over. (If I want to go to work, there's only one UCLA, and the Dodgers only play home games at Dodger Stadium). There are many other instances where travelers can pick different destinations. Maybe you've always liked the coffee shop two miles away. But have you ever actually tried the one two blocks away, which opened after you fell into your initial habit? It is possible, in short, for pricing to spur some people, at least some of the time, into *more* convenient behavior.

Most of the time, admittedly, tolls will force people to choose between a little less money and a little less convenience, and sometimes the best course of action will be to pay the toll. Here again is an opportunity for skeptics to pounce. One could argue that *any* additional expense for American households would be unfair. Incomes for the typical U.S. household have grown only sluggishly since the 1980s; tolls would just be one more burden. That's a reasonable concern. Of course, many American households also feel chronically short of time, and some evidence suggests that these feelings of time scarcity are also worsening.[76] By this logic *not* charging for roads, and letting congestion persist, imposes an unfair burden of its own. One could even contend, moreover, that if the government is going to force you to spend a resource, money is better than time. Money, when it is spent, does not disappear. It goes from you to the government, and the government can then redistribute or reinvest it. The government can also, when push comes to shove, make more of it. Time, once spent, is gone forever.

For the sake of argument, however, let's assume that most people would prefer more money over more time (this assumption is probably realistic). Would this assumption rule out congestion charging? It would not, because making the *roads* more expensive does not have to mean making *life* more expensive. For one, some of the increased spending on tolls would be counterbalanced by reduced spending on gas. Cars burn more gasoline per mile when they are bumping along in traffic than when are driving smoothly at 45 to 55 mph (that's why fuel economy is measured separately for "highway" and "city" driving)[77], so drivers who pay for higher, more consistent speed would see some money come back to them via fewer trips to the pump.

Would those savings completely erase the impact of tolls? Probably not. And certainly if congestion pricing were imposed overnight, and by surprise, the price of driving would rise, and many households would need to cut back in other parts of their budgets. Yet nothing about congestion pricing suggests it needs to be done overnight and by surprise. Water meters didn't arrive in Fresno with a snap of the fingers — they were activated after years of planning and outreach. Priced roads can follow a similar trajectory. Indeed, it will probably be easier to gradually price roads than to gradually price water. Each household has its own meter, so gradually introducing meters would mean charging some households for all of their water use while charging other households for none. Households *share* access to roads, however, so gradually pricing a road does not single out particular households.

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76. See Juliet Schor. 2003. *The Overworked American*. New York: Basic Books. Also Matt Saccaro. 2015. America's Free Time Problem. Salon. February 4. And Derek Thompson. 2019. Three Theories for Why You Have no Time. *Atlantic*. December 23.
77. See EPA. 2020. *Fuel Economy Guide*. https://www.fueleconomy.gov/feg/pdfs/guides/FEG2020.pdf

Gradual pricing could take a number of forms. But much of the congestion in America's urban areas occurs on its freeways, and many of those urban freeways are extremely wide. So imagine a program where — after substantial outreach — the government began pricing freeways lane-by-lane.[78] Where I live in Los Angeles, for instance, the government could take the busiest freeways and convert two lanes in each direction into congestion-priced lanes. That would leave at least two and sometimes three lanes free. In this situation anyone willing to pay for a faster ride could so do — and some of the revenue could be used to help the lowest-income drivers afford tolls — while anyone unwilling to pay would still have free lanes to choose from. Those in the free lanes, moreover, could see a demonstration of pricing in action.

After a period of time (maybe a year, maybe 18 months) the government could convert a third lane to prices. Then after another year it could convert the fourth lane. Pricing could be slowly rolled out, over the better part of five years. As more of the road became priced, there would be fewer free options, but there would also be more revenue available to help offset the burden for lower-income drivers.

More people, furthermore, would have had time to prepare. New expenses are more burdensome when they are sudden. Time is the mother of substitution. People with time can figure out how to complete some trips by other modes, or at other times. As time goes on, rental leases expire. Some people who were going to move anyway can relocate to neighborhoods where they can reach more destinations without driving, or driving as far.

Time would also let households adjust by spending less on cars. "Spending less on cars", I should emphasize, does not mean "giving up cars." It just means spending less — as in, buying a cheaper car. And there is ample room for many households to do so. Motor vehicles, in addition to being utilitarian instruments for moving around, have long been expressions of personal identity. Much of the "culture" in American car culture arises less from the undeniable need to move from point A to point B, and more from a tendency, thoroughly encouraged by automakers, to imbue in cars a series of deeper meanings, about status and identity, that far transcend transportation.[79] There's nothing wrong with that, but consumers often pay handsomely for these identity-driven aspects of automobility, and as a consequence many people, in pursuit of a vehicle that truly "fits" them, spend more on cars than they absolutely must.

In 2018 the average purchase price of a new car was $34,000, and of a used car $20,000. These aren't trivial sums, and since relatively few of these cars were bought with cash — indeed, about two-thirds of all vehicles are financed in some way — many households actually pay substantially more, because they borrow the majority of the purchase price and pay interest on that amount for years.[80] In 2019, among households with a car loan, the mean payment was almost $400 per month.[81]

Since you can buy a perfectly good and marvelously safe new car for $30,000, $20,000, or less, some households could adjust to pricing's arrival by buying slightly cheaper cars and re-allocating what they save to spend on road charges. I'm not suggesting, of course, that households should run out and buy new cars in response to pricing. That's obviously not a way to save money. But the typical U.S. household replaces a car roughly every seven years. If pricing were phased in over a few years, many households would be buying a new car anyway while pricing was coming online, and some lanes were still free. Many more households would reach a point where they'd be replacing a new car a few years after that. Spending a bit less when the time for a new car arrives could free up money for tolls.

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78. This idea was first laid out (to my knowledge) in Daniel Klein and Gordon Fielding. 1997. HOT Lanes: Introducing Congestion Pricing One Lane at a Time. *Access*. 11(Fall):11-15. A version of the idea has since been formalized in two papers: Hall, Jonathan D. (2018). "Pareto Improvements from Lexus Lanes: The Effects of Pricing a Portion of the Lanes on Congested Highways." *Journal of Public Economics*, 158, 113–125. Jonathan Hall, 2020 (forthcoming). Can Tolling Help Everyone? *Journal of the European Economic Association.*

79. See, for instance, Cotton Seiler. 2008. *Republic of Drivers*. University of Chicago Press.

80. Board of Governors of the Federal Reserve System.2016. *Report on the Economic Well-Being of US Households 2015.* May 2016. Also Alicia Adamcyzk. 2019. Map Shows the Average Auto Loan Payment in Every US State. *CNBC.com*. December 9.

81. Tabulated from the 2019 Survey of Consumer Finances.

Suppose a household had budgeted to buy a $35,000 car. It has $10,000 for a down payment, and borrows the remaining $25,000 for 60 months at 3% interest, giving it a monthly payment of $450 per month for five years. Now suppose, because pricing is coming, the household buys a $30,000 car instead, and after the $10,000 down payment borrows only $20,000 for the same duration and interest rate. The monthly payment falls to $360. That's almost $100 a month to spend on tolls, and the household's transportation budget hasn't changed.[82]

If people react to pricing by buying less expensive cars, congestion charges would shift some current transportation spending away from vehicles and toward driving, meaning it would not so much raise the costs of automobility as it would change their composition. Society should want such a change in composition, for two reasons. First, right now cars are much more reliable than roads, so money spent improving roads yields a bigger return than money spent improving cars. An ongoing absurdity of American surface transportation is the sheer amount of money people spend on high-performing cars that they then are forced to operate on low-performing roads. Most people wouldn't notice if their car became 10% more reliable. But the roads are so bad, as a result of congestion, that even modest improvements from congestion pricing would make travel dramatically better. Think of it this way: if you were considering a $30,000 car and could spend $4,000 more on the car itself, or $4,000 to dramatically reduce the congestion you'd face over the next few years, which would be more valuable?

Second, shifting some driving costs from vehicles to roads would be good for the environment, because it converts a fixed cost to a marginal cost. When you spend thousands of dollars to buy a car, that money is sunk. You won't get any money back if you decide to drive less, or even drive not at all. If, on the other hand, you spend a bit less when you purchase a vehicle, and reserve that money instead for spending on roads, then that same money *is* malleable. It hasn't been converted into a car, so if you suddenly become an ardent bicyclist, or decide you have new priorities for your spending, cutting back on your driving essentially gets you extra cash. That prospect functions as a small but constant incentive to economize on vehicle trips. Driving less becomes not just good for the world, but good for your wallet.

Conclusion

Outside of transportation professors, few people get excited by the idea of congestion pricing. Most people like free things, and it is pretty to think that there must be some way for roads to flow uncongested even without a price. But there isn't. We know because we have tried, and tried again, to build our way out of traffic, and it has never worked. This lesson is slow to sink in. We are prone to thinking that a solution is just around the corner, or that we just haven't done enough — that it's the *next* mile of track or lane or tunnel that will finally turn the tide. Charlie Brown thought that way too, every time he lowered his head and charged toward a football that Lucy would reliably pull away.

When it comes to congestion, we all have a bit of Charlie Brown in us. We think this time is different. When Elon Musk was asked about triple convergence, he shrugged it off. "I think it's a red herring," he said. "No matter how much demand there is, you can satisfy it with a network of 3D tunnels ... If you have 20, 30, 40 tunnels, eventually you run out of people to use them."[83] It's tempting to think that on some level, that's true. After all, a city totally converted to road space would have no congestion — in part because

82. If those numbers sound a bit rich to you, crank them down. The same logic holds. Imagine thinking that you were going to borrow $10,000 for 60 months at 3 percent interest, and decided instead to borrow $8,000. That still frees up about $36 per month for tolls.
83. Alissa Walker. 2018. Elon Musk Debuts Test Tunnel in Hawthorne. *Curbed LA*. December 18.

there would be so much road, and in part because there'd be so little of anything else. Why drive on roads when there's no place to go? The benefit of easy travel would come at the cost of no destinations. Musk's idea, essentially, is that a truly vast network of tunnels would avoid that tradeoff. You could have your cake and eat it too: a vibrant city above ground, and massive infrastructure below.

Even if this proposal was technically feasible, the costs would be stratospheric. Tunneling is expensive, and while Musk is never clear about just how many tunnels would be needed to remove congestion, it would certainly be a lot. London has over 100 miles of subway tunnel; 443 miles of New York's rail tracks are underground. Both city's streets are still clogged with traffic.[84] Would Los Angeles need 800 miles of tunnel? A thousand miles?

And suppose the city did it: it built a wild, ant farm-esque maze of tunnels below its streets and buildings. Suppose the tunnels, moreover, worked. On day one they pulled all the traffic off the city streets and moved it underground. What would happen? The next person thinking of going for a drive in L.A. would consider the busy tunnels, where elevators would lower them into the underbelly of the earth and then fire them through the darkness, and then consider the city streets — dappled in sunlight, conveniently close to destinations, and now (thanks to the tunnels) empty of traffic. What would this prospective traveler do? She would choose, of course, to drive on the city streets. And so would others after her. Soon the streets would be congested. The tunnels would be self-undermining. The tunnels would not empty the streets, because people wouldn't choose the tunnels until the streets were full. There would be no "enough." There would be triple convergence. It wouldn't matter that the tunnels were an option, because the streets would be *better,* and they would also be *free*.

Would this outcome be inevitable? No. You could get a different outcome by (wait for it) pricing the streets. But if you're going to price the streets, why spend the time and effort to build the tunnels?

There is no escaping scarcity. The first rule of economics, Thomas Sowell famously said, is that the sum of what everyone wants is more than what there is. In busy regions, more people want to use the roads than there are roads to hold them. The question is not whether but how we will deny some of those people what they want. Right now we do it by letting our roads get congested. We discourage driving by making it miserable and unreliable. We charge people in the one currency they can never earn back — time — and in doing so we give ammunition to those who believe the government is intrinsically incompetent. A better alternative is to offer excellent service in exchange for money, and use some of that money to help drivers for whom the price would represent a real barrier to access.

Opponents can and do call pricing anti-car. That makes little sense. Pricing can be a barrier to driving, but so can congestion, and since an uncongested road carries more people than a congested one, congestion, not pricing, would seem to be would seem to be driving's bigger enemy. Maybe there is something particularly antagonistic about a price, but if we are consistent about that logic we are going to end up in some weird places. Starbucks charges over $4 for some of its lattes. Is Starbucks anti-coffee? Ford charges for its cars. Is *Ford* anti-car? Do we think electric utilities would be more "pro-electricity" if they turned off their meters and let blackouts do the work instead? Or turn the example around. In Venezuela, gasoline is free, which has led to massive gasoline shortages. Is Venezuela, a place where if you want to drive you probably can't, because you can't find any gas, "pro-car" simply because the gas has no price?

Our roads, right now, are worth what we pay for them. Pricing can change that, and get us closer to a fairer, more efficient transportation system, where most of us drive a little less, but get a better experience when we do.

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84. Except, of course, for the one part of London with a congestion charge.