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Unlocking Gridlock

The health of an economy depends importantly upon the quality of its infrastructure, especially its transportation systems. Yet there is growing concern that the transportation system of the United States is succumbing to congestion and age. In just 10 years, congestion on urban highways nationwide has increased by over 50 percent. Peak period congestion at airports is so severe that safety considerations have required cutbacks at major hubs. The manhours lost to congestion delays equal 17 percent of the average workday.

The solution does not seem to lie simply in expanding capacity; indeed, highway congestion grew just as rapidly in the U.S. between 1960 and 1970, even though real spending on highways was nearly twice what it is today. In any event, the nation already commits nearly 18 percent of its GNP to the movement of people and goods, and new transportation facilities are tremendously expensive. Providing new lane-miles for morning rush commute trips can cost $40,000 per commuter in an urbanized area.

There is, however, a solution to the transportation dilemma that follows directly from the underlying economics of transportation congestion. This solution involves charging road users the "full cost" of the road facilities. In this *Letter,* we discuss the origin and solution of transportation congestion problems. The focus is on highways, but the problems and solutions are the same for all congested facilities.

A pricing problem

Most consumers accept the principle that the price they pay for goods and services should reflect the "full" cost of providing them. If they buy goods in a shop, for example, they understand that built into the price is some compensation for the salesperson's time and the cost of the premises, in addition to the cost of the goods purchased.

Consumers also accept the principle that the price of goods and services must vary with the strength of demand relative to the available supply. Virtually everywhere in the economy, prices typically are higher during periods of peak relative demand. Telephone calls are more costly during the day; theatre tickets are more expensive at night than during the matinee; tomatoes are more expensive during the winter than in the summer.

Neither of these principles, so commonly observed in daily life, has been adopted by transportation policymakers. Indeed, highways typically are not "priced" directly at all, and are financed instead with indirect gasoline or other taxes. The exceptions are toll bridges and toll highways, which practice direct pricing. But even in those cases, the fees typically are set only to liquidate the historical cost of the facility. There is no attempt to charge the current "full cost" of the facility let alone to recognize peak versus off-peak variation in these costs.

Full cost pricing

Calculation of the true "full cost" of transportation facilities requires consideration of certain features of the cost structure of transportation. In particular, transportation facilities are beleaguered by what economists call an "externalities" problem. Specifically, on a transportation facility such as a highway, the use of the facility by an additional vehicle adversely affects the amount of time that other users must spend to make their trips. Since the driver is not compelled to compensate the other travelers for their lost time, each tripmaking decision will ignore the costly "externalities" imposed on other travelers. Of course, each driver is delayed by the extra congestion and weighs this inconvenience in the tripmaking decision. However, the problem is that the driver does not consider the costs of the delays he imposes on *other* travelers.

During commute rush hours, these incremental "externalities" can be extremely large, as engineering data show. For example, at a vehicle flow of 1900 vehicles per hour, a highway lane is very congested but still has a free-flow speed of about

14 miles per hour. If traffic increases five percent, adding just 100 more vehicles to the flow, the speed of the traffic drops 21 percent to about 11 miles per hour, increasing travel times for everyone on the facility. Put differently, each additional vehicle on such a facility imposes an aggregate delay of about 30 minutes on the other traffic. On the other hand, at typical nighttime traffic volumes of 200 vehicles per hour or so, the congestion delay imposed by an additional vehicle is negligible (less than five minutes).

Pricing roads

These congestion delays are a cost imposed on others by the individual users of the transportation facility. Therefore, the price of using the facility should reflect these time costs, as surely as prices in a shop should incorporate the cost of the shopkeeper's time. Moreover, since the extent of these externalities varies with the degree of traffic congestion, highway prices should vary sharply across peak and off-peak periods.

This proper structure of prices contrasts sharply with the way in which road pricing actually is implemented on U.S. roadways. On most highway facilities, the only usage fee is levied very indirectly through a gasoline tax. As a driver uses his vehicle, and gasoline is consumed, a tax roughly proportional to distance traveled is implicitly levied. This fee averages only about one cent per mile and, of course, does not vary significantly with the level of congestion on the facility.

If a more theoretically appropriate pricing system were in use, what would the fees be? In an environment in which a facility is already congested and cannot be expanded, pricing serves simply to ration the facility. The fee must signal the level of the congestion externalities plus incremental wear-and-tear costs imposed by the vehicle. During congested peak hours, such fees could be very large—perhaps as much as $4 or $5 per mile at the levels of rush-hour congestion cited earlier. In the off-peak period, though, fees would be much lower—just a few cents a mile.

Expanding capacity

In most transportation corridors, however, capacity *can* be expanded. Prices then serve not only to ration existing facilities, but also to signal appropriate investment in capacity. Specifically, if rational expansion of capacity is being undertaken, the highway user fee should rise at the incremental cost of expanding capacity (in economic parlance, the long run marginal cost). If an increment of new capacity can save more in congestion costs than it costs to build, then expansion is called for. Thus, if congestion fees are above the cost of this additional capacity, it would be a clear signal that more capacity was needed. The new capacity, then, would reduce congestion and the related fees.

A disadvantage, therefore, of not pricing highways is that they are not expanded optimally. On our currently "unpriced" highway facilities, however, congestion is not itself proof that the road needs to be expanded; it can simply be the result of inappropriate pricing of the facility. On a *priced* facility, in contrast, the existence of congestion despite appropriate fees is a clear signal that expansion of capacity would be valuable.

Moreover, a highway system priced with such user fees can be shown to be entirely self-financing. More precisely, because highway capacity costs exhibit roughly constant returns to scale, according to a National Science Foundation Study, the appropriate long-run fees would cover all long-run costs. In contrast, an unpriced highway system generates no revenue with which to finance expansions. Consequently, the decision to expand highway capacity becomes a contentious, inefficient policy debate involving general public funds.

A number of economists have attempted to calculate the appropriate level of user fees. The calculation is simple, but the fees would vary regionally because of variation in the costs of building. For California roads, the charges consistent with optimal road pricing and investment have been calculated by type of facility and use period. The peak-period fees for each automobile would be approximately 65 cents per mile in centralized urban locations, 21 cents per mile in suburban areas, and 17 cents per mile in the lower cost, fringe suburban areas. Off-peak fees would not differ very much by the location of the facility, and would be roughly three to five cents per vehicle mile.

The effects of optimal pricing

These clearly are higher out-of-pocket expenses than currently are borne by users of highways, especially during the peak period in urban and

suburban areas. However, these fees tell only part of the story. For those continuing to drive, the higher direct fees would be offset by much shorter travel times. Indeed, economist Theodore Keeler has shown that the travel speed on a properly priced and expanded California highway should average 48 miles per hour at the height of the peak period, compared to only about 15 miles per hour today.

Greater high-density use of highways (via buses and carpools) would be a likely effect of charging highway fees. These vehicles would be charged the fee as well; but because the fee is spread over more passengers, the cost per passenger would be much lower for such high occupancy vehicles. And these travelers, too, would benefit from an increase in average highway speeds.

The overall effect would be to make the performance of the highway system similar to the telephone system, which currently employs time-sensitive pricing and investment. Peak-period use would be costly, but accessible and uncongested. Such highway pricing would not be difficult to implement: cheap transponders in vehicles and wire loops in the roadway can be used to record and price usage. Much as each household now receives a bill for calls made on the telephone system, each traveler would simply receive a monthly bill for trips on the highway. Such a system was designed recently for use in Hong Kong, which plans to price vehicle travel in its central district with 18 wire loop gateways. Simpler, less precise systems, however, also can achieve most of the effects of road pricing. In Singapore, a system of permits is used to price access to congested zones.

The entire economy would benefit from a rational system of road pricing. The current system of unpriced highways, by definition, wastes important resources, particularly the time of peak-period travelers. Also by definition, therefore, proper pricing, investment, and use of highways will have the effect of *reducing* the total cost of the grind of the daily commute.

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