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# Congestion Pricing in Traffic Control

Marco D. Sheehan
Editor

NOVA

TRANSPORTATION ISSUES, POLICIES AND R&D SERIES

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EDITOR



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# PREFACE

Congestion costs highway users billions of dollars every year. Although policymakers have adopted a variety of strategies for reducing or mitigating congestion, relatively little attention has been paid to policies to promote more efficient use of the highway system. One such policy is congestion pricing, under which drivers are charged a higher price for use of a highway at times or places with heavy traffic and a lower price in the opposite circumstances. This book explains how congestion pricing works, reviews the best available evidence on projects that make use of such pricing in order to assess the benefits and challenges of the approach, and discusses federal policy options for encouraging congestion pricing. Congestion pricing also can be linked to strategies to improve mobility by making alternatives to the private automobile, such as subways, buses or commuter rail service, more attractive during peak periods. The revenues generated by such pricing have sometimes been used to pay for improvements in public transportation systems.This book consists of public documents which have been located, gathered, combined, reformatted, and enhanced with a subject index, selectively edited and bound to provide easy access.

Chapter 1 - Growing congestion in the U.S. transportation network poses a substantial threat to the U.S. economy and to the quality of life of millions of Americans. According to the Texas Transportation Institute (TTI), in 2003, congestion in the top 85 U.S. urban areas caused 3.7 billion hours of travel delay and 2.3 billions gallons of wasted fuel, for a total cost of $63 billion. This figure would be substantially higher (perhaps almost triple) if it accounted for the significant cost of growing system unreliability and unpredictability to drivers and businesses, the environmental impacts of idle-related auto emissions, or higher gasoline prices. In the 10 most congested areas, each rush hour traveler "pays" an annual "congestion tax" of between $850 and $1,600 in lost time and fuel and spends the equivalent of almost 8 workdays each year stuck in traffic.

Chapter 2 - Highway congestion occurs when a vehicle causes delay to other vehicles on the road, resulting in longer and less reliable travel times, the use of additional fuel, and other costs to the economy. According to one widely cited study, in 2005 highway congestion resulted in 4.2 billion hours of delay and 2.9 billion gallons of additional fuel used, at a cost of $78 billion to highway users.[1] The costs are borne not just by highway users themselves, but by households and firms throughout the nation as well. Moreover, highway congestion has been increasing and is expected to worsen in the coming years.

Policymakers have adopted a variety of strategies for reducing congestion, including building more roads, supporting public transit, and improving the efficiency with which highway capacity is used. One fundamental way of improving efficiency is through congestion pricing.

Congestion pricing reduces the number of vehicles on a highway at peak periods by charging drivers for using the highway during those periods. When successfully applied, congestion pricing makes better use of highways' capacity by allocating it more efficiently. Other strategies that are designed to allocate the existing capacity more efficiently in specific circumstances include timed traffic signals, signs that warn drivers of congestion ahead, and improved responses to accidents. Such strategies have attracted more attention as building or expanding highways has become increasingly expensive and less feasible.

Congestion pricing also can be linked to strategies to improve mobility by making alternatives to the private automobile, such as subways, buses, or commuter rail service, more attractive during peak periods. The revenues generated by such pricing have sometimes been used to pay for improvements in public transportation systems.

Chapter 3 - The purpose of this "Lessons Learned Report" is to summarize projects sponsored by FHWA's Congestion and Value Pricing Pilot Programs from 1991 through 2006, synthesizing project experience, drawing implications for federal and project level roles and looking forward to future roles for pricing strategies.

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In: Congestion Pricing in Traffic Control
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*Chapter 1*

# CONGESTION PRICING – A PRIMER*

*United States Department of Transportation*

## I. THE CONGESTION PROBLEM

### Costs of Traffic Congestion

Growing congestion in the U.S. transportation network poses a substantial threat to the U.S. economy and to the quality of life of millions of Americans. According to the Texas Transportation Institute (TTI), in 2003, congestion in the top 85 U.S. urban areas caused 3.7 billion hours of travel delay and 2.3 billions gallons of wasted fuel, for a total cost of $63 billion. This figure would be substantially higher (perhaps almost triple) if it accounted for the significant cost of growing system unreliability and unpredictability to drivers and businesses, the environmental impacts of idle-related auto emissions, or higher gasoline prices. In the 10 most congested areas, each rush hour traveler "pays" an annual "congestion tax" of between $850 and $1,600 in lost time and fuel and spends the equivalent of almost 8 workdays each year stuck in traffic.

### Alarming Trends

Highway congestion has increased dramatically over the past two decades. Between 1982 and 2003, U.S. highway congestion has increased in extent, duration, and intensity. In 2003, in the largest U.S. cities, highway congestion:

- Impacted 67% of travel (up from 33% in 1982);
- Lasted 7 hours per day in duration (up from 4.5 hours in 1982); and

* This is an edited, reformatted and augmented version of a U. S. Department of Transportation publication dated December 2006.

- Added an additional 37% to the length of the average rush hour driver's trip (up from 13% in 1982).

Congestion is also growing rapidly in small and medium sized metropolitan areas. Based on current trends, a medium-sized city should expect its congestion in 10 years to be as bad, or worse than, that currently experienced by a large city. The rate of congestion growth has been greater in rural than in urban areas, portending increased congestion in communities of all sizes.

### Causes of Congestion

At its most fundamental level, highway congestion is caused by the lack of a mechanism to efficiently manage use of capacity. When searching for a solution to the congestion problem, most people immediately think of adding a new lane to an overburdened highway. Construction costs for adding lanes in urban areas average $10 million per lane mile. Generally, the funding for this construction comes from the tax that drivers pay when buying gas for their vehicles. Overall, funds generated from gas taxes on an added lane during rush hours amount to only $60,000 a year. This amount is grossly insufficient to pay for the lane addition. The bargain price paid by motorists for use of expensive new capacity encourages more drivers to use the expanded highway. Introducing congestion pricing on highway facilities discourages overuse during rush hours by motivating people to travel by other modes such as car-pools or transit, or by traveling at other times of the day.

## II. What is Congestion Pricing?

Congestion pricing – sometimes called value pricing – is a way of harnessing the power of the market to reduce the waste associated with traffic congestion. Congestion pricing works by shifting purely discretionary rush hour highway travel to other transportation modes or to off-peak periods, taking advantage of the fact that the majority of rush hour drivers on a typical urban highway are not commuters. By removing a fraction (even as small as 5%) of the vehicles from a congested roadway, pricing enables the system to flow much more efficiently, allowing more cars to move through the same physical space. Similar variable charges have been successfully utilized in other industries – for example, airline tickets, cell phone rates, and electricity rates. There is a consensus among economists that congestion pricing represents the single most viable and sustainable approach to reducing traffic congestion.

Although drivers unfamiliar with the concept initially have questions and concerns, surveys show that drivers more experienced with congestion pricing support it because it offers them a reliable trip time, which is very valuable especially when they have to be somewhere on time. Transit and ridesharing advocates appreciate the ability of congestion pricing to generate both funding and incentives to make transit and ridesharing more attractive.

There are four main types of pricing strategies, each of which is discussed in more detail later in this section:

- **Variably priced lanes**, involving variable tolls on separated lanes within a highway, such as Express Toll Lanes or HOT Lanes, i.e. High Occupancy Toll lanes

- **Variable tolls on entire roadways** – both on toll roads and bridges, as well as on existing toll-free facilities during rush hours

- **Cordon charges** – either variable or fixed charges to drive within or into a congested area within a city

- **Area-wide charges** – per-mile charges on all roads within an area that may vary by level of congestion

## Technology for Congestion Pricing

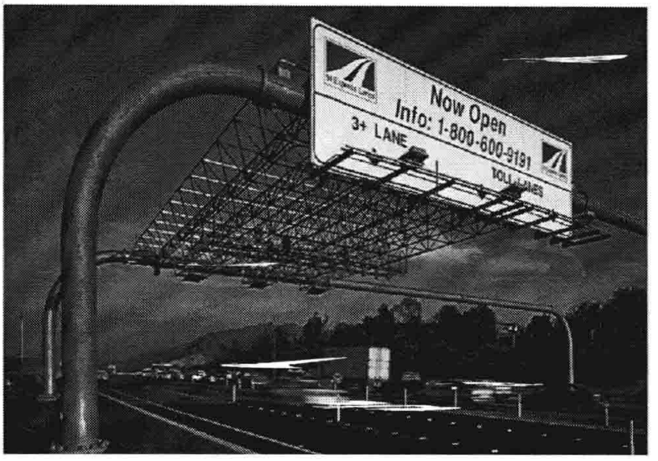
With congestion pricing, tolls typically vary by time of day and are collected at highway speeds using electronic toll collection technology. Traffic flows freely, and there are no toll booths. Vehicles are equipped with electronic devices called transponders or "tags", which are read by overhead antennas. Toll rates for different time periods may be set in advance, or they may be set "dynamically" – hat is, they may be increased or decreased every few minutes to ensure that the lanes are fully utilized without a breakdown in traffic flow.

Tags range from simple to highly sophisticated devices. Simple tags are "read-only," meaning that they can provide an identification number to overhead readers using power from incoming radio frequency energy. More sophisticated tags are battery-powered, and have processing power and memory. Tags are now the normal way tolls are collected from regular users – 70 to 80 percent of tolls are now collected this way on most urban commuter toll roads in peak hours. Simple "sticker" tags may be obtained for less than $10.

Global Positioning Systems (GPS) are used to collect truck tolls in Germany on the autobahns. In tests of such systems in the United States, an in-vehicle device records charges incurred based on its location as identified by the GPS unit in the vehicle. All location and payment information remains in the vehicle, and the vehicle owner periodically uploads the summary of charges to a processing center along with payments. The costs of such systems are currently high – as much as $500 per vehicle in Germany. Their high costs can be justified by additional services provided by the systems, such as in-vehicle navigation and commercial fleet management. Also, the need for roadside equipment for toll collection is reduced.

Cameras are an essential complement to tags and GPS units to gain a record of the identity of vehicles that don't have a working tag or GPS unit. Cameras can be used to deter toll violators. This is known as "video enforcement." In cases where a tag is required for use of a facility, camera images allow a follow-up of violators and imposition of a penalty.

Use of a toll facility may be permitted without a tag or GPS unit. In this case, a camera-based system is used to collect what is termed a video toll. This toll includes the additional costs for administration. Cameras are being improved steadily in their capabilities and some believe that very soon toll operators could rely entirely on video tolling.




Transponders are read by overhead antennas, allowing tolls to be paid without stopping

## Variably Priced Lanes

Variably priced lanes include Express Toll lanes and HOT lanes. "HOT" is the acronym for "High Occupancy Toll." On HOT lanes, low occupancy vehicles are charged a toll, while High Occupancy Vehicles (HOVs), public transit buses and emergency vehicles are allowed to use the lanes free of charge or at reduced rates. HOT lanes create an additional category of eligibility to use HOV lanes. People can meet the minimum vehicle passenger requirement – or they can choose to pay a toll to gain access to the HOV lane.

With citizens growing more frustrated with under-used HOV lanes, HOT lanes are increasingly being viewed as a solution that can reduce public opposition to HOV lanes. Surveys show that low-income commuters express a high level of support for having a priced express lane option. This is valuable when they absolutely must get somewhere on time. In places like San Diego, support from low-income travelers is over 70 percent. Low-income commuters also benefit from toll-financed transit improvements.

Express Toll lanes are similar to HOT lanes. The difference is that all vehicles are required to pay a toll–HOVs do not get free service. This makes enforcement of toll cheaters much easier. However, many travelers still have an incentive to carpool. By sharing the ride, each person in a two-person carpool pays only half the price, while each commuter in a four-person carpool only pays one-fourth.

## Variable Tolls on Roadways

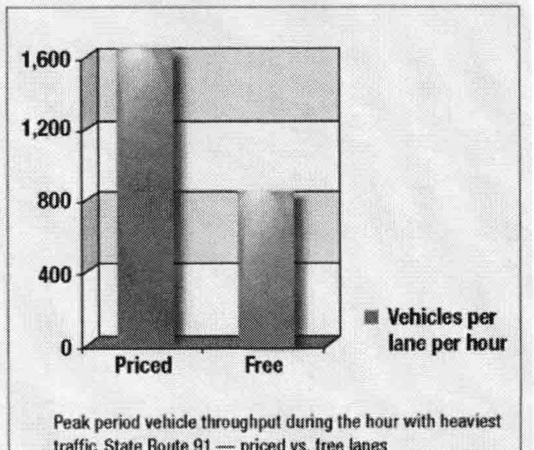
With this type of pricing, flat toll rates on existing toll roads are changed to a variable toll schedule so that the toll is higher during peak travel hours and lower during off-peak or shoulder hours. This encourages motorists to use the roadway during less congested periods, and allows traffic to flow more freely during peak times. Peak toll rates may be high enough to guarantee that traffic flow will not break down, thus offering motorists a reliable and congestion-free trip in exchange for the higher peak toll.

Variable tolls can also be introduced on existing toll-free facilities to manage traffic flow. Again, tolls vary by time of day and are charged *only on congested highway segments* to manage traffic flow and recover the highway's capacity to carry the number of vehicles it was designed for. The most efficient way to operate our freeways is to prevent congestion and keep traffic moving freely. When traffic flow collapses under congested conditions, capacity is lost *(see box at right)*. By preventing congestion, pricing recovers this daily waste of public investment that occurs on congested highways.

## EFFECTS OF PRICING ON VEHICLE THROUGHPUT

Vehicle "throughput" on a freeway is the number of vehicles that get through over a short period such as an hour. Once freeway traffic exceeds a certain threshold level, both vehicle speed and vehicle throughput drop precipitously. Data show that maximum vehicle throughput occurs at free flow speeds ranging from 45 mph to 65 mph. The number of vehicles that get through per hour can drop by as much as 50 percent when severe congestion sets in. At high traffic levels, the freeway is kept in this condition of "collapse" for several hours after the rush of commuters has stopped. This causes further unnecessary delay for off-peak motorists who arrive after rush hour.

With peak-period highway pricing, a variable toll dissuades some motorists from entering freeways at those access points where traffic demand is high, and where such surges in demand may push the freeway over the critical threshold at which traffic flow collapses. Pricing prevents a breakdown of traffic flow in the first instance, and thus maintains a high level of vehicle throughput throughout the rush hours. As shown in the graph above, each variably priced lane in the median of State Route 91 in Orange County, California, carries twice as many vehicles per lane as the free lanes during the hour with heaviest traffic. Pricing has allowed twice as many vehicles to be served per lane at three to four times the speed on the free lanes.




Peak period vehicle throughput during the hour with heaviest traffic, State Route 91 — priced vs. free lanes

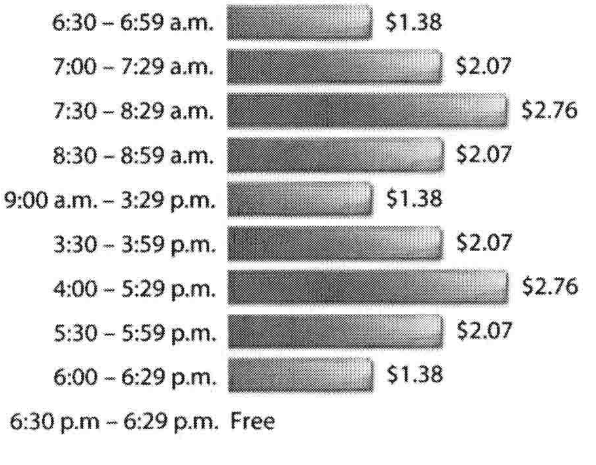
Real life examples show the impacts of pricing. In Ft. Myers, Florida, a 50 percent discount on the toll was offered on the Midpoint and Cape Coral bridges for a short period of time before and after the rush hours. Survey data revealed that, among those eligible for the discount, there was an increase in traffic of as much as 20 percent during the discount period before the morning rush hours, with corresponding drops in the rush hour itself.

## Cordon Pricing

Cordon pricing involves charging a fee to enter or drive within a congested area, usually a city center. Singapore introduced the first such pricing scheme in 1975 using low-tech daily charges. In 1998, the city shifted to a fully automated electronic charging system. In 2003, a cordon pricing scheme was introduced in central London. A similar scheme functioned in central Stockholm on a trial basis in 2006 from January through July.

## Area-Wide Pricing

The State of Oregon is currently testing a pricing scheme involving per-mile charges, which it will consider using as a replacement for fuel taxes in the future. A congestion pricing component is being tested, with higher charges during congested periods on high traffic road segments. The Puget Sound Regional Council has been testing the travel behavior impacts of a similar charging system in the Seattle metropolitan area during 2005-2006. Charges are based on the type of facility being used and its level of congestion.




Source : Stockholm Trial Expert Group.

Fees for travel within Stockholm varied according to time of day, with higher fees during rush hours (*dollar rates converted from Swedish krona at current rates*)

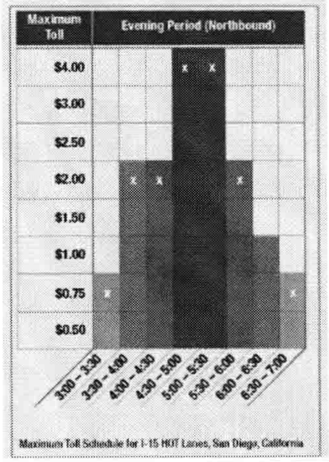
## Use of Revenues from Pricing

Congestion pricing can generate substantial revenues from tolls. A portion of the revenues generated will be needed to operate the toll collection and traffic management systems. Net revenues after payment of operating costs can be used to pay for expansion of roadway facilities, to support alternatives to driving alone such as public transit, to address impacts on low-income individuals by providing toll discounts or credits, or to reduce other taxes that motorists pay for highways such as fuel taxes, vehicle registration fees or sales taxes.

### FLAT TOLLS, "STEPPED" VARIABLE TOLLS, AND "DYNAMIC" TOLLS

The first roads in the United States and in many other countries were toll roads. In these cases, toll rates were fixed at a flat rate, since their purpose was to raise revenue, not to manage demand. If tolls are to be used to manage demand, they must vary by the level of demand. They may be set in advance by time of day, based on traffic volumes observed – during the past week, month, or quarter. In each case, the toll schedule may appear as a "stepped" form, as shown below.

Tolls to manage demand may also be set "dynamically." Under this approach, a maximum toll rate may be specified in advance for selected time periods (*see schedule for I-15 HOT lanes shown below*), but actual tolls typically vary below the maximum based on real-time traffic observed on the facility. While a driver knows the maximum rate that can be charged, actual rates (which are generally lower) are known to him or her only a few minutes in advance of approaching the priced facility. The driver can then choose to use the priced facility or continue to use toll-free facilities.



Maximum Toll Schedule for I-15 HOT Lanes, San Diego, California

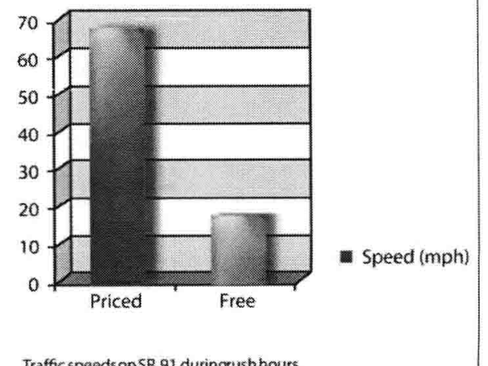
# III. BENEFITS OF CONGESTION PRICING

Congestion pricing benefits drivers and businesses by reducing delays and stress, by increasing the predictability of trip times, and by allowing for more deliveries per hour. It benefits mass transit by improving transit speeds and the reliability of transit service, increasing transit ridership, and lowering costs for transit providers. It benefits State and local governments by improving the quality of transportation services without tax increases or large capital expenditures, by providing additional revenues for funding transportation, by retaining businesses and expanding the tax base, and by shortening incident response times for emergency personnel and thus saving lives. By preventing the loss of vehicle throughput that results from a breakdown of traffic flow, pricing maximizes return on the public's investment in highway facilities. And it benefits society as a whole by reducing fuel consumption and vehicle emissions, by allowing more efficient land use decisions, by reducing housing market distortions, and by expanding opportunities for civic participation.

## Benefits to Transit Riders and Carpoolers

Pricing in combination with transit services provides bus riders with travel time savings equivalent to those for drivers, and reduces waiting time for express bus riders due to more frequent service. Introduction of pricing in central London and Stockholm has resulted in significant shifts of commuters to transit, particularly buses. Bus delays in central London dropped by 50 percent after the pricing scheme was introduced. There was a 7 percent increase in bus riders. In Stockholm, 200 new buses were put into service in August 2005, several months in advance of the pricing trial, which began in January 2006. After the pricing scheme was implemented, daily public transportation use compared to the same month in 2005 was up by 40,000 riders daily. Ridership on inner-city bus routes rose 9 percent compared with a year earlier.

Within three months of the opening of the priced express lanes on California's SR-91, a 40 percent jump occurred in the number of vehicles with more than three passengers. Ridership on buses and a nearby rail line have remained steady. On San Diego's I-15 HOT lanes, revenues generated by toll-payers financed transit improvements that contributed to a 25 percent increase in bus ridership.




Traffic speeds on SR 91 during rush hours

After the HOV lanes were converted into HOT lanes on I-15 in San Diego, carpooling increased significantly, even though there was no change in incentives to carpool – carpoolers continued to use the lanes free of charge, as they did before the lanes were converted. Similar effects were observed when the HOV lanes on I-25 in Denver were converted to HOT lanes in June 2006. It's not clear why carpooling increases – it could be a result of the extra publicity by the media.

### Benefits to Drivers

On the State Route 91 priced lanes in Orange County, California, traffic during rush hours moves at over 60 mph, while the traffic in adjacent lanes crawls at average speeds of 15 mph or less. Commuters on the priced express lanes thus save as much as half an hour each way on the 10-mile trip, or as much as an hour a day.

If we could use pricing to restore free-flowing traffic conditions on other metropolitan freeways during rush hours, similar results could be achieved. An average commuter using a 5-mile freeway segment twice each day (i.e., once in each direction) would save about half an hour each day, or 120 hours annually – equal to three weeks of work or leisure time!

The day-to-day variation in travel times is now understood as a separate component of the public's and business sector's frustration with congestion. An important benefit of pricing is that it guarantees toll-paying vehicles a reliable trip speed and travel time.

### Benefits to Businesses

Growing congestion and unreliability threatens truck transportation productivity and ultimately the ability of sellers to deliver products to market. Additionally, when deliveries cannot be relied on to arrive on time, businesses must keep extra "buffer stock" inventory on hand. This can be expensive. Pricing of the nation's major thoroughfares to guarantee free flow of traffic will ensure that reliability is restored to the transportation system, keeping business and transportation costs low. Lower costs will increase the competitiveness of U.S. businesses in international markets and boost the U.S. economy.

## IV. Examples in the U.S.

### HOT Lanes on I-15 in San Diego

Since 1998, single-occupant vehicles pay a per-trip fee each time they use the I-15 HOT lanes. Tolls vary "dynamically" with the level of traffic demand on the lanes. Fees vary in 25-cent increments as often as every six minutes to help maintain free-flow traffic conditions on the HOV lanes. The project generates $2 million in revenue annually, about one-half of which is used to support transit service in the corridor.