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# Smart Congestion Reductions

## *Reevaluating The Role Of Highway Expansion For Improving Urban Transportation*

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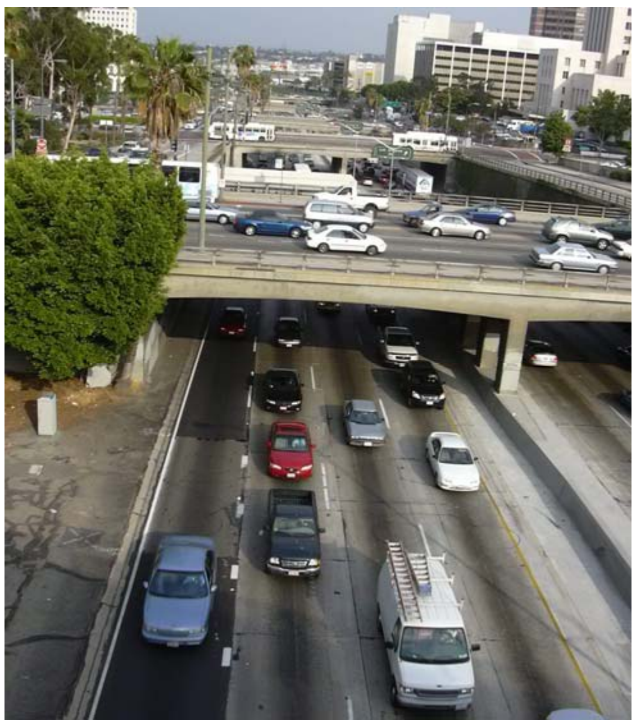
**19 June 2009**



**Summary**

This report investigates claims that highway capacity expansion is a cost effective and desirable solution to urban traffic congestion problems. It identifies errors in proponents' analysis that overestimate the congestion reduction impacts and economic benefits of roadway capacity expansion, overlook negative impacts of induced travel, and ignore more cost effective alternatives. This is a companion to the report, *Smart Transportation Reductions II: Reevaluating The Role Of Public Transit For Improving Urban Transportation* (www.vtpi.org/cong_reliefII.pdf).

## Introduction

Recent publications argue that expanding urban highways is a cost effective and desirable way to reduce traffic congestion (TDA, 2003; AHUA, 2004; Cox and Pisarski, 2004; Hartgen and Fields, 2006; Poole, 2006). They claim that highway expansion provides *congestion relief*, a seductive term since congestion is stressful and costly. People understandably want *relief*. But this may be an example of a misguided solution that exacerbates the problem it was intended to solve and has undesirable unintended consequences.

As an analogy, consider the role laxatives should play relieving constipation. Laxatives are sometimes appropriate, but it is generally best to address constipation by changing diet (more fiber and liquids) and exercise (take a walk), because laxatives' effectiveness declines with frequent use, they can hide more severe diseases, and they can exacerbate other medical problems. A physician who prescribes laxatives without investigating why the patient is constipated or considering other solutions is guilty of malpractice.

Similarly, chronic traffic congestion is often a symptom of more fundamental problems, such as inadequate mobility options that force people to drive for every trip, and dispersed land use patterns that increase travel distances. Where this is true, expanding roads may reduce symptoms in the short term but exacerbate problems over the long term.

Although roadways projects (particularly safety and surface quality improvements) can be an appropriate part of a city's transport program, continually expanding congested highways tends to be inefficient. The first highways in an area often provide large economic returns, but marginal benefits diminish as more capacity is added for the following reasons:

- The first highways projects are generally the most cost effective, because planners are smart enough to prioritize investments. For example, if there are several possible highway alignments on a corridor, those with the greatest benefits and lowest costs are generally built first, leaving less cost effective options for subsequent implementation.
- Interregional highways (those connecting cities) are generally constructed first. They tend to provide greater economic benefits and have lower unit costs than local highway expansion, due to numerous conflicts and high land costs in urban areas.
- Adding capacity tends to provide declining user benefits, since consumers are smart enough to prioritize trips. For example, if highways are congested consumers organize their lives to avoid peak automobile period trips. As highway capacity increases they travel more during peak periods, perhaps driving across town during rush hour for an errand that would be deferred, or moving further away from their worksite. Each additional vehicle mile provides smaller user benefits, since the most valued vehicle-miles are already taken.

This paper investigates claims that highway expansion is a cost effective way to reduce urban traffic congestion, and evaluates the role that roadway capacity expansion should play in improving transportation. This is a companion to the report *Smart Transportation Investments II: Reevaluating The Role Of Public Transit For Improving Urban Transportation* (Litman, 2006b).

## Context

Highway expansion advocates are responding to changes in transportation planning practices during the last two decades. Traditional transport planning is *reductionist*; individual organizations are expected to solve narrowly defined problems. For example, transport agencies (then called *highway departments*) were responsible for improving vehicle traffic flow, while transit agencies were responsible for providing mobility for non-drivers, and environmental agencies were responsible for reducing pollution emissions. This type of planning often results in organizations implementing solutions to problems within their mandate that exacerbate other problems facing society, and tends to undervalue strategies that provide multiple benefits.

Modern planning is more comprehensive, taking into account additional impacts and options. It measures transport system performance differently (Litman, 2003). Traditional planning primarily measures *vehicle traffic* using indicators such as roadway level of service (LOS) ratings, average traffic speeds, and travel time indices that only reflect roadway conditions. Planners increasingly evaluate transport based on *mobility* (the movement of people and goods) and *accessibility* (the ease of reaching desired goods, services and activities), which expands the range of possible solutions to transport problems. For example, measuring transport based on *mobility* allows improvements to alternative modes to be considered, and based on *accessibility* allows more accessible land use development to be considered as possible solutions to transport problems.

Highway expansion advocates contend that efforts to increase transport system diversity and encourage more efficient use of the transportation system have been tried and failed, or are harmful to users, and so advocate a return to older transportation planning practices that define transportation simply in terms of motor vehicle traffic.

There is an alternative narrative. During the last century the U.S. built an extensive roadway system that serves users relatively well. Motorists can drive to most destinations with relative convenience, comfort and safety, except under urban-peak conditions. The main transport problems in most urban communities are traffic congestion, inadequate mobility for non-drivers, and various external costs of motor vehicle traffic, including road and parking facility costs, accidents and pollution emissions, all problems reduced with improved travel options, more efficient travel behavior, and more accessible land use development. With a mature roadway system, it may be better to increase transport diversity and encourage efficiency rather than continuing to expand highway capacity.

## Evaluating Congestion

Highway expansion advocates tend to exaggerate congestion costs and bias their analysis to favor highway expansion over other types of transportation improvements.

Traffic congestion can be measured in various ways, some of which only reflect motorists' perspective and ignore congestion reduction benefits to travelers who shift modes or from more accessible land use patterns. Table 1 compares various congestion indicators and indicates whether they are comprehensive in terms of considering impacts of alternative modes and more accessible land use.

***Table 1*** **Roadway Congestion Indicators** (Litman, 2006)

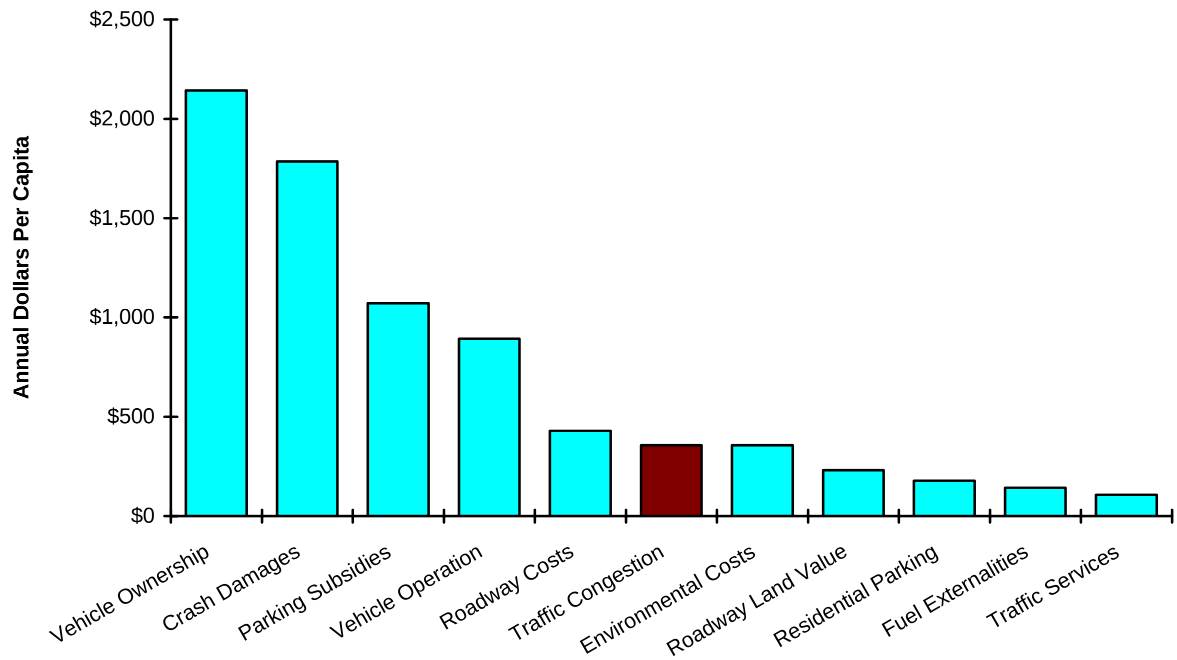
| Indicator | Description | Comprehensive? |
|---|---|---|
| Roadway Level Of Service (LOS) | Intensity of congestion delays on a particular roadway or at an intersection, rated from A (uncongested) to F (most congested). | No |
| Travel Time Rate | The ratio of peak period to free-flow travel times, considering only reoccurring delays (normal congestion delays). | No |
| Travel Time Index | The ratio of peak period to free-flow travel times, considering both reoccurring and incident delays (e.g., traffic crashes). | No |
| Percent Travel Time In Congestion | Portion of peak-period vehicle or person travel that occurs under congested conditions. | No if for vehicles, yes if for people. |
| Congested Road Miles | Portion of roadway miles that are congested during peak periods. | No |
| Congested Time | Estimate of how long congested "rush hour" conditions exist | No |
| Congested Lane Miles | The number of peak-period lane miles of congested travel. | No |
| Annual Hours Of Delay | Hours of extra travel time due to congestion. | No if for vehicles, yes if for people. |
| Annual Delay Per Capita | Hours of extra travel time divided by area population. | Yes |
| Annual Delay Per Road User | Extra travel time hours divided by peak period road users. | No |
| Excess Fuel Consumption | Total additional fuel consumption due to congestion. | Yes |
| Fuel Per Capita | Additional fuel consumption divided by area population | Yes |
| Annual Congestion Costs | Hours of extra travel time multiplied times a travel time value, plus additional fuel costs. This is a monetized value. | Yes |
| *Congestion Cost Per Capita* | Additional travel time costs divided by area population | Yes |
| Congestion Burden Index (CBI) | Travel rate index multiplied by the proportion of commuters subject to congestion by driving to work. | Yes |
| Avg. Traffic Speed | Average peak-period vehicle travel speeds. | No |
| Avg. Commute Travel Time | Average commute trip time. | Yes |
| Avg. Per Capita Travel Time | Average total time devoted to travel. | Yes |

*This table summarizes various congestion cost indicators. Some only consider impacts on motorists and so ignore congestion reduction benefits of shifts to alternative modes and more accessible land use.*

For example, indicators such as the *Travel Time Index* (*TTI*, the ratio of actual vehicle travel times over freeflow travel times) measure roadway congestion *intensity* but ignore *exposure*. They do not consider the degree to which travelers can avoid roadway congestion by shifting to alternative modes (such as grade-separated High Occupancy Vehicles and public transit, or telecommuting), nor the effects of land use patterns on trip distances. The TTI actually implies that congestion declines if vehicle mileage on uncongested roadways increases, as often occurs when urban fringe highway expansion stimulates more dispersed land use patterns. Other indicators, such as *Congestion Costs Per Capita*, are more comprehensive, because they account for alternative modes and travel distance, and so expand the range of possible solutions.

In addition, the TTI calculates delay relative to freeflowing traffic speeds. Most economists consider this is inappropriate, since it is equivalent to suggesting that a restaurant should be sized to accommodate all the patrons it could attract if it gave food away. This methodology exaggerates congestion cost values. A more appropriate approach is to measure delays beyond a moderate level of congestion (LOS C or D), reflecting what is economically optimal (Bertini, 2005). Winston and Langer (2004) estimated that congestion costs are actually about half of those published by the Texas Transportation Institute. Through intention or ignorance, highway expansion advocates generally select the Travel Time Index and therefore exaggerate congestion problems and undervalue alternative modes and smart growth as congestion reduction strategies.

***Figure 1*** **Costs Ranked by Magnitude** ("Transportation Costs," VTPI, 2005)




*This figure compares various costs of automobile transportation. Congestion is a moderate cost, far lower than vehicle costs, crash damages, parking and roadway costs.*

Congestion is a moderate cost compared with other transportation costs, as indicated in Figure 1. Per capita vehicle expenses average about $4,000, crash costs (including lost productivity and monetized values for pain) more than $1,500, parking facilities costs more than $1,000, and roadway costs total about $400, compared with approximately $350 per capita congestion costs estimated by the Texas Transportation Institute.

Highway expansion advocates argue that because VMT grew faster than lane-miles in recent years, there is a roadway capacity “deficit.” But highway lane-miles growth rates during the Interstate Highway development period (1950s-70s) should not be compared with later periods, after the highway system was complete, when capacity expansion is only needed to address specific problems. In addition, the greatest increases in VMT involved personal and off-peak travel, and increased urban-peak travel means that more corridors achieve volume thresholds needed for efficient transit and HOV facilities. It is therefore wrong to assume that roadway lane-miles should increase with VMT.

Highway expansion advocates often extrapolate past trends to predict huge future growth in vehicle travel and traffic congestion, although demographic (aging population), economic (rising fuel prices), market (increase consumer preferences for alternative modes), transportation (declining per capita vehicle travel) and management (increased application of transportation systems management) trends are likely to reduce future traffic growth rates (Litman, 2005a). They often use older traffic models that exaggerate future congestion problems by ignoring the tendency of congestion to be self-limiting: congestion tends to limit peak-period traffic growth, as consumers respond by shifting travel time, route, mode and destination (“Traffic Model Improvements,” VTPI, 2006). Predictions that roads will reach “gridlock” are generally wrong. This indicates that congestion problems will only increase significantly in areas with rapid population or freight traffic growth, and only if they fail to implement mobility management strategies.

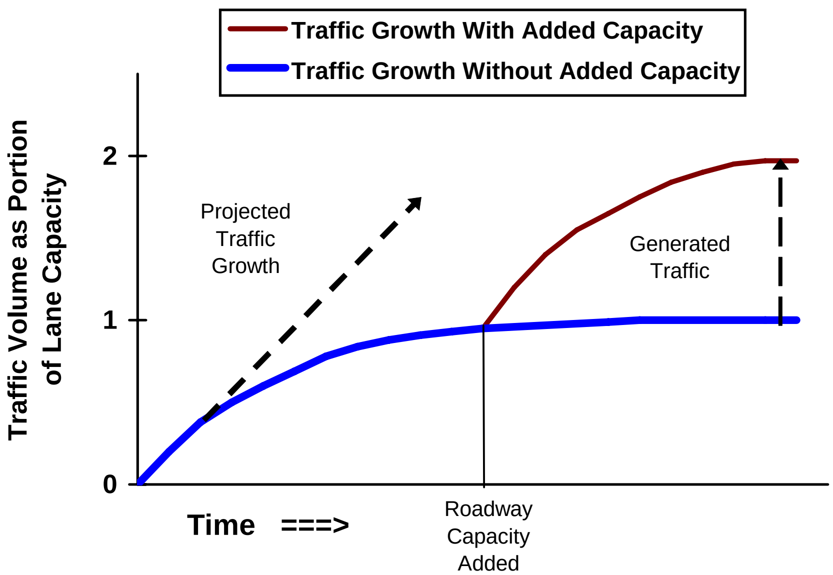
Advocates use exaggerated analysis to justify highway expansion. For example, Cox and Pisarski (2004) cite an obscure French study (Prud’homme and Lee, 1998) showing a positive relationship between employment accessibility and regional productivity to predict huge economic returns from highway capacity expansion. Although the basic concept is appropriate – urban economists find plenty of evidence that improved accessibility increases productivity (Haughwout, 2000) – the particular application is inappropriate since urban highway expansion tends to stimulate more dispersed development that *reduces* rather than *increases* accessibility (Muro and Puentes, 2004).

This is not to suggest that congestion problems should be ignored and congestion reduction efforts are unwarranted, but other costs should be considered when evaluating congestion reduction strategies. For example, it would be misguided to implement a policy or program that reduces congestion costs by 10% if doing so increased vehicle expenses, road or parking facility costs, crashes or environmental damages by just 3% each. On the other hand, a congestion reduction strategy provides far more total benefit it also helps reduce these other costs even by small amounts.

## Congestion Reduction Impacts

As mentioned earlier, traffic congestion tends to maintain self-limiting equilibrium: it grows to the point that congestion delays constrain further peak-period vehicle trips, causing travelers to shift to alternative times, routes and mode, and forego lower-value trips. For example, when roads are congested you might choose a closer destination or defer a trip until later, but if congestion is reduced you make those peak-period trips. Similarly, when considering a new home or job you might accept a maximum commute 20 miles if the main highway is congested, but up to 30 miles if the highway is widened and congestion reduced. Figure 2 illustrates this effect. As a result, congestion seldom gets as severe as worst-case predictions warn, and expanding roadways tends to *generate traffic* (increase peak-period vehicle travel, including shifts in time and route) and *induce travel* (increase total vehicle mileage) compared with what would otherwise occur (Litman, 2001).

***Figure 2*** **How Road Capacity Expansion Generates Traffic** (Litman, 2001)




*Traffic grows when roads are uncongested, but growth rates decline as congestion develops, reaching a self-limiting equilibrium (indicated by the curve becoming horizontal). If capacity is added, traffic growth continues until it reaches a new equilibrium. The additional peak-period vehicle travel that results is called "generated traffic." The portion that consists of absolute increases in vehicle travel (as opposed to shifts in time and route) is called "induced travel."*

This additional vehicle travel provides direct benefits to travelers, which can be calculated and incorporated into economic evaluation using consumer surplus analysis, and imposes various external costs (Litman, 2001).

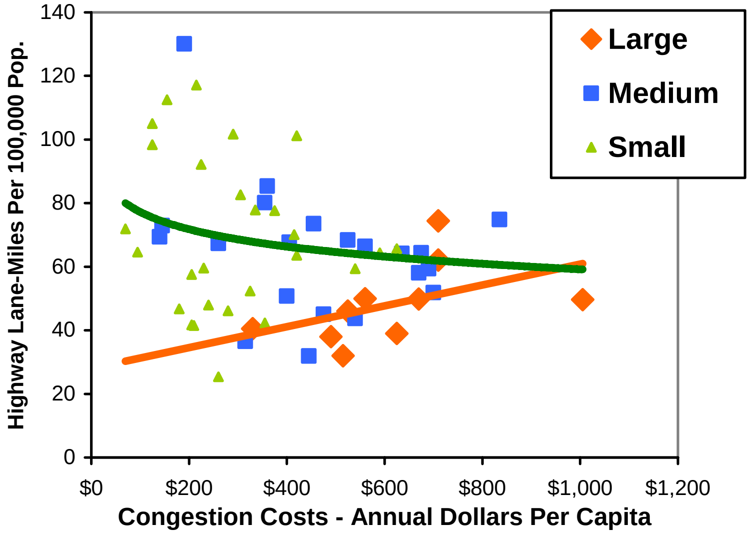
Various studies have quantified the amount of vehicle travel generated and induced by roadway expansion (TRB, 1995; Litman, 2001). Below are summaries of this research.

- Using data on California freeway expansion, traffic volumes, and various demographic and economic factors between 1980 and 1994, Cervero (2003) found the long-term elasticity of VMT with respect to traffic speed to be 0.64, meaning that a 10% increase in speed increases VMT 6.4%, so about 80% of added road capacity is filled with additional peak-period traffic.
- Time-series data indicates an elasticity of vehicle travel with respect to lane miles of 0.5 in the short run, and 0.8 in the long run (Noland, 2001). This means that half of increased roadway capacity is filled with added travel within about 5 years, and 80% of the increased capacity eventually fills. Urban roads, which tend to be most congested, had higher elasticity values than rural roads, as expected due to their greater congestion and latent demand.
- The medium-term elasticity of highway traffic with respect to California state highway capacity was measured to be 0.6-0.7 at the county level and 0.9 at the municipal level (Hansen and Huang, 1997). This means that 60-90% of increased road capacity is filled with new traffic within five years. Each 1% increase in highway lane-miles increased VMT about 0.65%.
- A major study found the following elasticity values for vehicle travel with respect to travel time: urban roads, -0.27 in the short-term and –0.57 over the long term; rural roads, –0.67 in the short term and –1.33 in the long term (Goodwin, 1996). These values are used by the U.S. Federal Highway Administration for highway project evaluation.

Because of these effects it is unsurprising that urban highway expansion provides only modest congestion reductions (STPP, 2001). As stated in the *Urban Mobility Study* (TTI, 2005), “This analysis shows that it would be almost impossible to attempt to maintain a constant congestion level with road construction alone.” Zupan (2001) found that each 1% increase in VMT in a U.S. urban region was associated with a 3.5% increase in congestion delays in that region during the 1980’s, but this relationship declined during the 1990s, so a 1% increase in VMT increases delays only 1%. This change may reflect increased ability of travelers to avoid peak-period driving, through flextime, telework and suburbanization of destinations, reducing the congestion delay caused by increased travel.

Highway expansion advocates generally ignore or severely understate generated traffic and induced travel impacts. For example, Cox and Pisarski (2004) use a model that only accounts for diverted traffic (trips shifted in time or route) but ignores shifts in mode, destination and trip frequency. Hartgen and Fields (2006) assume that generated traffic would fill just 15% of added roadway capacity, a figure they base on generated traffic rates during the 1960s and 1970s, which is unrealistically low when extremely congested roads are expanded. They also ignore the incremental costs that result from induced vehicle travel, such as increased downstream traffic congestion, road and parking costs, accidents and pollution emissions. They claim that roadway capacity expansion reduces fuel consumption, pollution emissions and accidents, because they measure impacts per vehicle-mile and ignore increased vehicle miles. As a result they significantly exaggerate roadway expansion benefits and understate total costs.

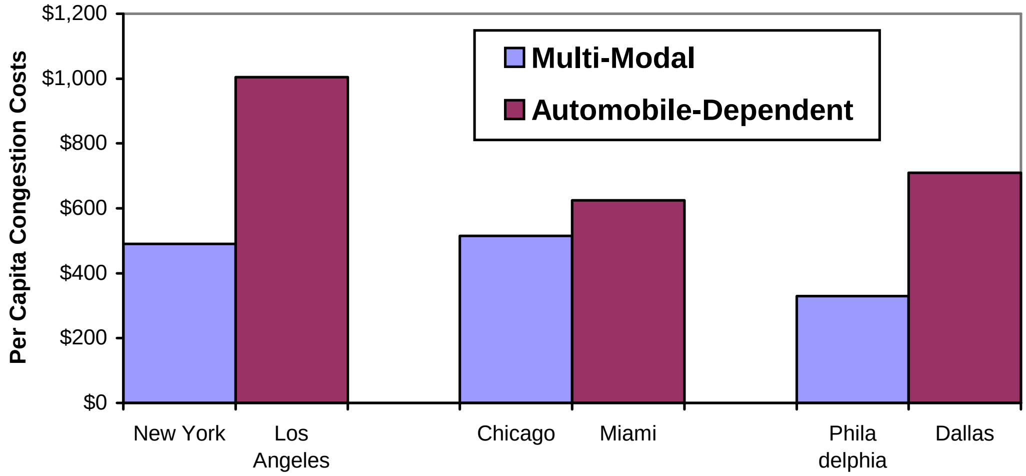
***Figure 3*** **Congestion Costs Versus Highway Supply** (TTI, 2003; FHWA, 2002)




*This figure illustrates the relationship between highway supply and congestion costs. Overall, increased roadway supply provides a small reduction in per capita congestion costs (green line), but among large cities, congestion increases with road supply (orange line).*

Figure 3 illustrates the relationship between highway lane-miles and congestion costs. Considering all cities, congestion declines with highway supply but the relationship is weak (green line): a large supply increase provides modest congestion reduction. Among the ten largest cities (orange diamonds) the relationship is negative (orange line): those with more highways tend to have more congestion. Congestion costs are significantly lower in cities with multi-modal transport systems, as illustrated in Figure 4.

***Figure 4*** **Congestion Costs Compared** (Litman, 2004)

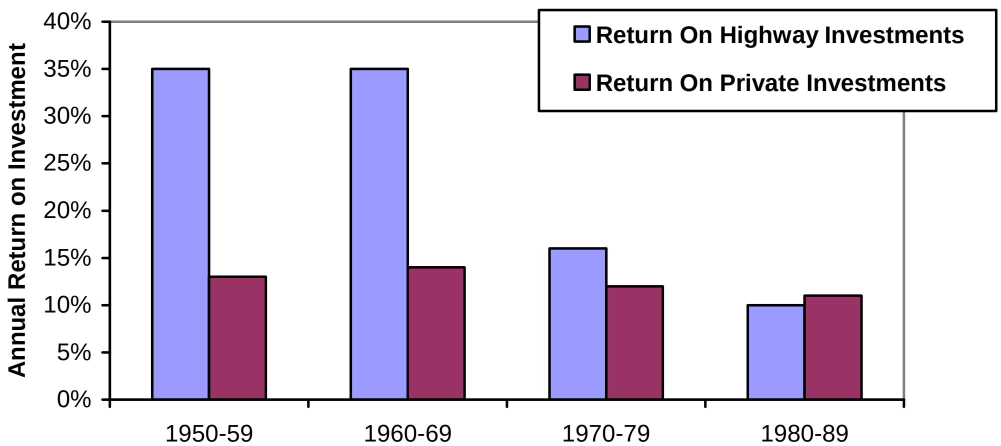



*This matched pair analysis indicates that multi-modal cities have much lower per capita congestion costs than automobile-dependent cities with comparable population size.*

## Economic Value of Roadway Expansion

Advocates claim that highway expansion provides huge economic benefits, but their economic analysis is faulty. If roadway capacity expansion significantly increased economic productivity this effect would be easy to measure, but numerous studies show that economic returns on highway expansion investments are modest and declining (Boarnet and Haughwout, 2000; Shirley and Winston, 2004, "Economic Development Impacts," VTPI, 2006). Figure 5 shows how highway investments provided high annual economic returns during the 1950s and 60s, far higher than returns on private capital, but these declined to below that of private capital investments by the 1980s. This is what economic theory would predict, since the most cost-effective investments have already been made, so more recent projects provide less value at a higher cost.

***Figure 5*** **Annual Rate of Return** (Nadri and Mamuneas, 1996)




*During the 1950s-70s, highway expenditures provided a high return on investment, but this has declined over time as economic theory predicts.*

To the degree that highway expansion induces additional vehicle travel and stimulates sprawl it tends to be economically harmful since this increases public infrastructure and service costs ("Land Use Evaluation," VTPI, 2006) and shifts consumer expenditures to goods that provide relatively small regional business activity and employment, as indicated in Table 2. Other congestion reduction strategies provide more positive economic impacts ("Economic Development Impacts," VTPI, 2006).

***Table 2*** **Economic Impacts of $1 Million Expenditure** (Miller, Robison and Lahr, 1999)

| Expenditure Category | Regional Income | Regional Jobs |
|---|---|---|
| Automobile Expenditures | $307,000 | 8.4 |
| Non-automotive Consumer Expenditures | $526,000 | 17.0 |
| Transit Expenditures | $1,200,000 | 62.2 |

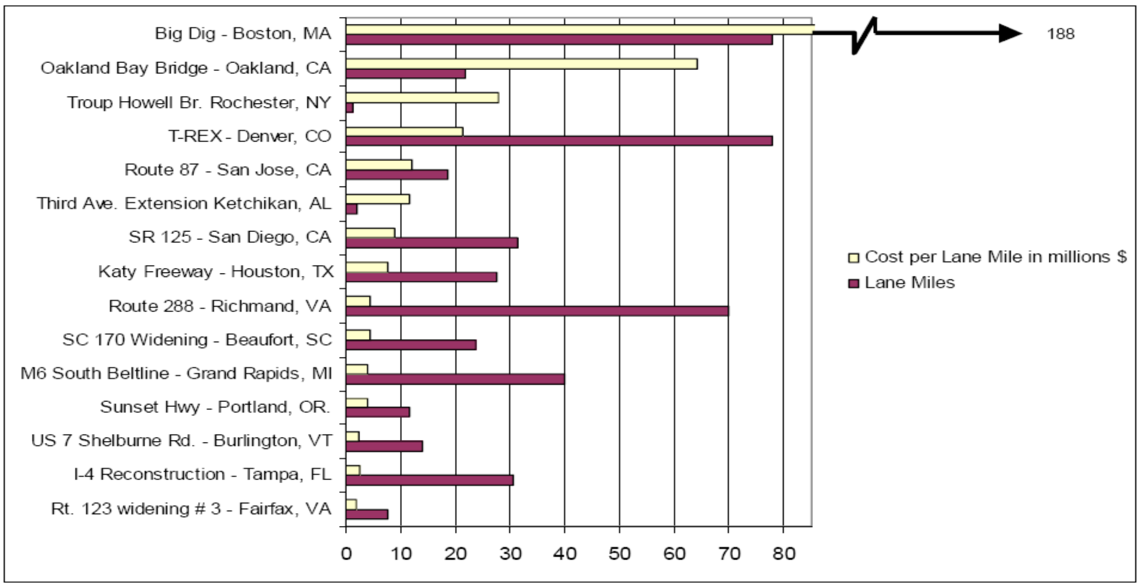
*This table shows economic impacts of consumer expenditures in Texas.*

## Urban Highway Expansion Costs

Highway expansion advocates understate the true costs of the projects they propose. For example, Cox and Pisarski (2003) assume that highway widening costs would average $3 million per lane-mile for arterials and $6 million per lane-mile for freeways, and Hartgen and Fields (2006) assumes that severely congested highways could be expanded for $3.8 million per lane-mile on average, although these projects are mostly in dense urban areas, often requiring land acquisition, complex intersections, bridges, tunneling and community mitigation, plus the delay costs during project construction.

Many recent urban highway projects have much higher unit costs, as illustrated in Figure 6. Of 36 highway projects studied by the Washington State Department of Transportation 13 of them had costs in excess of $10 million per lane mile (WSDOT, 2005). Future projects are likely to have higher unit costs since most jurisdictions have already implemented the cheapest highway projects, and both construction costs and urban land values have increased much faster than inflation in recent years.

***Figure 6*** **Urban Highway Expansion Costs** (WSDOT, 2005)




*This figure illustrates costs per lane-mile for recent U.S. highway projects.*

## Economic Principles

Economic principles require that costs be borne directly by users unless subsidies are specifically justified ("Market Principles," VTPI, 2006). This means that roadway expansion is only efficient and equitable if projects are fully financed by peak-period tolls. Few highway expansion projects could meet this test. Current U.S. road user revenues (fuel taxes, vehicle registration fees and road tolls) only finance about two-thirds of roadway expenditures – a growing portion of roadway funding comes from general taxes (Wachs, 2003; Litman, 2006a). Highway expansion advocates recommend increasing these taxes to finance their proposed projects. This is inefficient and unfair.

Proponents argue that roadway expansion would only cost a few cents per vehicle-mile, but only about 20% of total vehicle travel occurs under urban-peak conditions, only about half of this (10%) takes place on highways (as opposed to surface streets), less than half of this (<5%) experiences congestion, and less than half of this (approximately 2%) experiences severe congestion. Highway expansion proposals therefore significantly increase taxes on all consumers (even non-motorists would pay increased general taxes) to finance projects that only improve approximately 2% of vehicle mileage.

Assuming, as proponents optimistically claim, that urban highway expansion costs average just $3.8 million per lane-mile, or $140,000 annualized (assuming 7% interest over 30 years), that such lanes normally carry up to 2,000 vehicles per hour, and each lane is congested two hours daily, 300 days a year, the costs would average 12¢ per peak vehicle-mile, or about $1.00 per 8-mile trip. This is the minimum toll needed to efficiently finance the project. Of course, motorists would sometimes willingly pay such a fee for uncongested travel, but experience indicates that tolls exceeding 10¢ per vehicle-mile cause demand to decline significantly as travelers shift time, mode, route or destination to save money ("Road Pricing," VTPI, 2006).

The most effective and efficient solution to congestion is to apply variable pricing on existing highways, with tolls that increase under congested conditions, to manage demand and test users' willingness to pay for roadway improvements, called *congestion pricing* or *value pricing* ("Road Pricing," VTPI, 2006). This gives motorists an incentive to reduce peak period vehicle trips to the level a roadway can accommodate. This is more efficient than letting congestion limit traffic, as we do now, because it allows higher-value trips to outbid lower-value trips (for example, an emergency vehicle, bus with numerous passengers, or truck with valuable cargo can outbid trips that are lower value or could more easily shift to another time or mode), and provides revenue. Such pricing has proven successful in several cities, including Singapore, London and Stockholm.

In practice, revenues are seldom sufficient to finance major highway expansion since pricing reduces travel demand. Tolls can generally only finance a minor portion of total expansion costs. This represents an economic trap, since highway expansion is justified when road use is underpriced but demand is insufficient to finance expansion. Current proposals to fund highway expansion using other funding sources will be ineffective at reducing traffic congestion, are economically inefficient and unfair.

**Road Pricing Traps**

*Road pricing* (road tolls) can help reduce traffic congestion in two different and sometimes conflicting ways. In some cases, road pricing policies can create a trap, resulting in inefficient and unfair tolls. It is important that decision-makers understand these differences and their ultimate impacts when evaluating road pricing options.

*Congestion pricing* refers to tolls structured to reduce peak-period vehicle traffic, and therefore congestion, with higher rates during peak periods and lower rates during off-peak periods, plus features to encourage travelers to shift to alternative routes and modes. Congestion pricing and public transit improvements are complements since improved transit service reduces the fee needed to convince some travelers to shift from driving to public transit, therefore reducing the congestion toll needed to achieve a given reduction in traffic congestion. As a result, congestion pricing revenues are often used to improve public transit services.

Roadway financing tolls are designed to fund highway expansion projects. This type of road pricing is designed to maximize revenue, and so tolls are applied during both peak and off-peak periods (even though off-peak travelers do not benefit from roadway expansion), and sometimes include provisions that intentionally discourage development of alternative routes or modes, in order to force travelers to pay tolls.

Congestion pricing is a preventive strategy: it reduces congestion on existing roads and avoids the need to expand highways. It is comparable to a healthy diet, exercise and cholesterol reduction medicine, which prevent medical problems. Highway tolling to finance roadway capacity expansion is a more difficult and costly treatment, comparable to major heart surgery. Because highway capacity expansion projects have high costs, require maximum revenues (so tolls are applied to off-peak travel, and are often augmented by general taxes), sometimes include provisions that reduce route and mode options, and tend to induce additional travel that imposes additional downstream external costs, using tolls only for highway expansion is inefficient, unfair and generally undesirable.

However, there is often institutional and political resistance to pricing existing roadways. This creates a trap: efficient pricing can only be implemented after problems develop and high costs are incurred, rather than as a preventive strategy to avoid major costs. The result is comparable to a medical system that only major surgery, but not cost-effective preventive health programs.

Only if peak-period toll revenues can fully fund roadway capacity expansion can such projects be considered efficient and equitable. In practice, peak-period road toll revenues are seldom sufficient to fully fund roadway capacity expansion, typically they can finance only 20-40% of project costs. As a result, additional funds are needed from off-peak users or general taxes. The result is inefficient and unfair highway expansion projects.

If highways expansion projects are to be implemented, it is more efficient and equitable to fund them through tolls as much as possible, to prevent induced demand from quickly filling the additional capacity and creating downstream traffic problems, and so that the costs are born directly by users. But it is even more efficient to apply congestion pricing on existing highways *before* implementing expansion projects, in order to avoid or defer the need to expand highways, and test motorists willingness-to-pay for additional capacity. Efficient congestion reduction therefore requires reforms to allow congestion pricing on existing roadways.

## Efficient Investment Example

Here is a simple example illustrating "smart" congestion reduction investments. Imagine a four-lane highway is on a corridor with demand of 5,000 peak period trips at zero price (if use of the road is free). Because the road can only accommodates a maximum of 4,000 peak period users (2,000 vehicles per lane) it experiences congestion that causes 1,000 potential peak-period travelers to shift to other times, routes or modes.

The efficient solution to this congestion is to price peak-period use of the highway with tolls set to maintain optimal traffic flow. This also causes 1,000 potential peak period trips to shift, preventing congestion and providing revenue. The optimal toll would vary from minute to minute and day to day to reflect demand, perhaps 2¢ per vehicle-mile for most of the commute period (such as 7:00 until 9:00 in the morning, and 4:00 until 6:00 in the evening), but up to 10¢ per vehicle-mile at the maximum peak (such as 7:50 until 8:00 in the morning, and 5:10 until 5:20 in the evening).

Expanding the highway would only be efficient if peak-period revenues are sufficient to repay all additional costs, which tests users' willingness-to-pay. Highway expansion advocates often violate efficiency principles by requiring off-peak highway users to also pay for such projects, but it is inefficient and unfair to force them to pay for projects that provide them no benefit. Off-peak users should only be required to pay for project features that benefit them, such as improved safety guards.

Assume that highway expansion would cost $8 million per lane-mile, which equals approximately $300,000 per lane-mile in annual costs, or $1,000 per day if there are 300 congested days per year. Since the expanded highway can efficiently carry up to 6,000 vehicles per hour, tolls would need to average at least 17¢ per vehicle-mile ($1,000/6,000 = $0.17) if each lane is only congested and priced one hour per day (inbound in the morning, outbound in the evening), or 8.5¢ per vehicle-mile if congested and priced twice daily. If tolls high enough to recover costs would reduce peak-period travel below 4,000 vehicles the project would not be cost effective; users would be better off with a four-lane highway and lower tolls than a six-lane highway with higher tolls.

It may be efficient to use some toll revenue to improve travel options on the corridor, such as subsidizing vanpool and bus service, contributing to construction of a rail-transit line, or supporting commute trip reduction programs (VTPI, 2006) if doing so reduces peak-period automobile travel demand and therefore highway congestion (Litman, 2006b). Many factors affect the degree to which such services reduce congestion, including their quality and speed, the ease of accessing destinations (such as worksites) by these modes, and community attitudes about their use. In some situations, alternative modes may attract few motorists and do little to reduce congestion, so highway widening is more cost effective. On the other hand, improving alternative modes provides other benefits besides highway congestion reduction, including improved mobility for non-drivers, reduced downstream congestion, parking cost savings, consumer cost savings, accident reductions, energy conservation and reduced pollution, and so may be the preferred solution even if highway widening is cheaper (Litman, 2005b).

## Comparing Roadway Expansion With Alternatives

There are various possible congestion reduction strategies ("Congestion Reductions," VTPI, 2006). The best is the one with the largest net benefits per dollar invested ("Least Cost Planning," VTPI, 2006). Highway expansion advocates often fail to compare their proposals with alternatives so it is impossible to determine which is truly optimal.

*Public transit improvements* can reduce congestion and provide other benefits (Litman, 2006b). Virtually any corridor with enough travel demand to experience congestion has enough to support high quality vanpooling and public transit services. High quality public transit services cost about $100 annually per capita in additional subsidies but reduce consumer costs about $500 annually per capita, reduce congestion 30-50% (Figure 4); and reduce traffic fatality rates 36% compared with peer cities (Litman, 2004).

*Road pricing* reduced congestion in Singapore, London and Stockholm ("Road Pricing," VTPI, 2006). Reduced traffic volumes provide proportionately larger reductions in delay: pricing in London and Stockholm reduced vehicle traffic about 20% and congestion delays about 30%. Harvey and Deakin (1996) predicted that in Southern California:

- A 1¢ per vehicle-mile congestion fee reduces VMT 2.3% and congestion delay 22.5% (a 9.8 ratio).
- A $3.00 (1991 dollars) daily parking fee reduces VMT 2.7% and delay 7.5% (a 2.8 ratio).
- A 2¢ per vehicle-mile VMT fee reduces VMT 4.4% and congestion delay 9.0% (a 2.0 ratio).

*Smart growth* development tends to increase the *intensity* of costs such as congestion and roadway construction, due to increased density, but reduces per capita *costs*, since residents drive less and have better travel options.

As more impacts and options are considered, the value of roadway capacity expansion tends to decline and the relative benefits of alternative congestion reduction strategies increases (IEDC, 2006; VTPI, 2006), as illustrated in Table 3.

***Table 3*** **Roadway Expansion and Mobility Management Benefits** (Litman, 2006a)

| Planning Objective | Expand Road Capacity | Public Transit Improvements | Mobility Management | Smart Growth Land Use |
|---|---|---|---|---|
| Congestion reduction | ✓ | ✓ | ✓ | ✗/✓ |
| Roadway cost savings | ✗ | ✓ | ✓ | ✗/✓ |
| Parking savings | ✗ | ✓ | ✓ | ✗/✓ |
| Consumer cost savings | ✗ | ✓ | ✓ | ✓ |
| Transport diversity | ✗ | ✓ | ✓ | ✓ |
| Improved traffic safety | ✗ | ✓ | ✓ | ✓ |
| Reduced pollution | ✗ | ✓ | ✓ | ✓ |
| Energy conservation | ✗ | ✓ | ✓ | ✓ |
| Efficient land use | ✗ | ✓ | ✓ | ✓ |
| Improved fitness & health | ✗ | ✓ | ✓ | ✓ |

*(✓ = helps achieve that objective. ✗ = Contradicts that objective.) Roadway capacity expansion helps reduce congestion but by inducing additional vehicle travel it exacerbates other transport problems. Transit improvements, mobility management and smart growth help achieve many objectives.*

## What Does Modeling Indicate?

Older four-step traffic models are not very accurate at predicting long-term traffic congestion effects because they have fixed trip table which assume the same number of trips will be made between locations regardless of the level of congestion between them. As a result, they account for shifts in route and mode, and sometime in time, but not in destination or trip frequency ("Model Improvements," VTPI, 2006).

Newer models incorporate more factors and so are more accurate at predicting impacts of specific transportation and land use policies. Johnston (2006) summarizes results from more than three dozen long-range modeling exercises performed in the U.S. and Europe using integrated transport, land use and economic models. These indicate that the most effective way to reduce congestion is to implement integrated programs that include a combination of transit improvements, pricing (fuel taxes, parking charges, or tolls) and smart growth land use development policies. These studies indicate that a reasonable set of policies can reduce total vehicle travel by 10% to 20% over two decades, maintain or improve highway levels-of-service ratings (i.e., they reduce congestion), expand economic activity, increase transport system equity (by distributing benefits broadly), and reduce adverse environmental impacts compared to the base case. Many studies indicate that roadway expansion increases long run congestion by stimulating vehicle travel, dispersed development, and reduced travel options. Expanding road capacity, along with transit capacity, but without changing market incentives to encourage more efficient use of existing roads and parking, results in expensive transit systems with low ridership.

Recent traffic modeling of Puget Sound region transportation improvement options reached similar conclusions (WSDOT, 2006). It found that neither highway widening nor transit investments are by themselves cost effective congestion reduction strategies (although the model has fixed trip tables so it exaggerates highway expansion benefits and underestimates transit improvement benefits). The most effective congestion reduction program includes both transit service improvements and road pricing to give travelers better options and incentives. Table 4 summarizes estimated congestion reduction benefits and project costs. Both have costs that exceed congestion reduction benefits, but transit improvements are more cost effective overall since they provides many additional benefits including road and parking cost savings, consumer cost savings, crash reductions, improved mobility for non-drivers, energy conservation, emission reductions, and support for strategic land use.

***Table 4*** **Congestion Reduction Economic Analysis** (WSDOT, 2006)

| | Congestion Reduction Benefits | | Direct Project Costs | |
|---|---|---|---|---|
| | Lower Estimate | Higher Estimate | Lower Estimate | Higher Estimate |
| Highway Expansion | $1,500 | $2,200 | $2,500 | $3,700 |
| Transit Improvements | $480 | $730 | $1,200 | $1,500 |

*This table indicates estimated highway and transit congestion reduction benefits and costs, in millions of annualized dollars. Neither approach provides congestion-reduction benefits that exceed costs, but transit provides many additional benefits.*

## Have Alternatives Failed?

A common theme among highway expansion advocates is that alternatives, such as transit service improvements and mode shift incentives, have been tried but have failed and so should be abandoned in favor of highway expansion. They are wrong.

Only a small portion of total transportation funding is devoted to alternative modes and mobility management programs. For example, in 2004 governments in the U.S. spent about $140 billion on roads and about $26 billion dollars to support public transit. Transit therefore receives about 16% of the total (FHWA, 2005). About half of transit funding is intended to provide basic mobility to non-drivers, such as special mobility services and bus services in suburban and rural areas, so only about 8% of surface transportation budgets are spent on transit services to attract discretionary travelers (people who have the option of driving). In addition, U.S. consumers, businesses and governments devote more than $300 billion in resources to off-street parking, so only about 3% of total investment in surface transport is devoted to transit services intended to attract discretionary users. Nonmotorized transport receives an even small portion of transportation budgets, probably less than 1%, although it represents 5-10% of total trips ("Evaluating Walking and Cycling," VTPI, 2006). This does not include other external costs, such as accidents and pollution impacts, which are often reduced when travel shifts from automobile to transit (Litman, 2006).

Similarly, it is wrong to claim that mobility management strategies, such as commute trip reduction programs, HOV priority and parking pricing have been tried and failed. Although many communities have implemented some mobility management programs, most efforts are modest, representing a minority of employees, roads and parking facilities. Where appropriately implemented such programs have been successful, typically reducing vehicle trips by 10-30% among affected travelers, usually with lower total costs than accommodating an additional urban peak trip, taking into account road, parking and vehicle costs (USEPA, 2005; VTPI, 2006).

Highway expansion advocates exaggerate the portion of transportation resources devoted to alternative modes and mobility management programs because they focus on particular budgets, such as regional capital investments in cities developing major new transit systems, where more than half of total expenditures may be devoted to alternative modes for a few years. However, when all transportation budgets are considered, including parking facility expenditures, and averaged over a longer time period, the portion devoted to alternative modes is generally reasonable. Proportionately large investments in alternative modes can be justified in most communities to offset decades of planning and investments skewed toward automobiles.

Highway expansion advocates argue that it is unfair and inefficient to devote significant resources to improve public transit that carry only a small portion of total trips. But transit carries a much greater portion of travel on major urban corridors, where roadway expansion is costly and transit demand is high, and so is often the most cost effective way of reducing congestion and improving mobility.

## Conclusions

Modern transportation planning considers a wider range of impacts and options than was previously common, which supports policies and programs that improve transport options, encourage more efficient travel patterns, and increase land use accessibility. These provide multiple benefits. Some people want to return to traditional planning practices that favor automobile travel and ignore other planning objectives. They advocate highway expansion to reduce congestion. Their analysis tends to:

- Exaggerate highway expansion congestion reduction impacts and economic benefits.
- Ignore or understate generated traffic and induced travel effects.
- Overlook many economic, social and environmental costs of wider highways, increased vehicle traffic and sprawled land use.
- Underestimate the true costs of expanding major urban highways.
- Fail to compare highway expansion with other transportation improvement options.

Some of these errors are subtle, technical, and even counter-intuitive. It is therefore important that decision makers and the general public become informed about issues such as the implications of different congestion indicators, the impacts of generated traffic and induced travel, the economic returns on roadway capacity expansion, and more comprehensive planning techniques.

Such projects are only cost effective if they can be funded by peak-period users. Even based on proponents' optimistic projections, highway expansion projects would cost $200 to $400 annually per urban commuter. When faced with such tolls motorists often prefer to shift route, mode or destination, so such projects cannot recover their costs. As a result, they would require funding from people who do not directly benefits, which is inefficient and inequitable. Described differently, traffic congestion results from market distortions that underprice driving and stimulate sprawl, resulting in economically excessive motor vehicle travel ("Market Principles," VTPI, 2006). Under such circumstances, expanding highways cannot reduce long term congestion, and would increase other transport problems such as downstream congestion, parking demand, accidents, pollution emissions, sprawl, and inadequate mobility for non-drivers.

Alternative strategies can reduce traffic congestion and provide other benefits. Advanced modeling indicates that the most cost effective solution to traffic congestion reduction includes a combination of transit improvements, road pricing and smart growth land use policies. This is most efficient and equitable overall because it reflects market principles, including viable consumer options, cost-based pricing and more neutral public policies.

This is not to suggest that driving is bad or that highways should never be improved. However, when all impacts and options are considered, highway expansion is significantly more costly than advocates claim and provides less overall benefit than many alternative policies and programs.

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