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Smart Congestion Reductions II

Reevaluating The Role Of Public Transit For Improving Urban Transportation

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Abstract

This report investigates the role public transport can play in reducing traffic congestion. The analysis indicates that high quality public transit tends to reduce congestion by attracting travelers who would otherwise drive. As transit service quality (speed, convenience, comfort and affordability) on a corridor improves, congestion levels on parallel roadways tends to decline. Transit investments become more effective at reducing congestion if implemented with complementary road pricing, mobility management strategies and smart growth land use policies. Congestion reduction is just one of many benefits provided by transit improvements. When all impacts are considered, transit investments are often cost effective. This is a companion to the report, *Smart Congestion Reductions: Reevaluating The Role Of Highway Expansion For Improving Urban Transportation* (www.vtpi.org/cong_relief.pdf).

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Introduction

Several recent articles criticize urban rail transit investments on grounds that they are ineffective at reducing traffic congestion and financially wasteful (Stopher 2004; Taylor 2004; O'Toole 2004). This paper evaluates this criticism and investigates the role that public transit can play in reducing traffic congestion and achieving other planning objectives. This is a companion to the report *Smart Congestion Reductions: Reevaluating The Role Of Highway Expansion For Improving Urban Transportation* (Litman 2006b).

Context

Most industrialized countries have high levels of motor vehicle ownership and extensive roadway systems that provide a high level of service under most conditions. Motorists can drive to most destinations with relative speed, comfort and safety, except under urban-peak conditions. The main transport problems facing most communities are urban-peak traffic congestion; inadequate mobility for non-drivers; and external costs of vehicle use, including road and parking facility costs, accident risk imposed on others, and various environmental impacts resulting from motor vehicle facilities and use.

The question facing policy makers and planners is whether these problems are best addressed by further expanding urban highways to accommodate more vehicle traffic, or instead to emphasize alternative forms of mobility, particular high quality, grade-separated rail transit designed to attract discretionary travelers (people who would otherwise drive). Many experts argue that major urban transit investments are justified.

Critics argue that transit investments are not cost effective at reducing traffic congestion due to their high cost per reduced peak-period vehicle trip (O'Toole, 2004; Stopher, 2004). This debate partly reflects differences in how congestion is defined and measured. Traditional planning evaluated transport system performance primarily based on the ease of driving, using indicators such as *roadway level of service* (LOS) ratings and *average traffic speeds*. From this perspective, transit investments are only valuable to the degree that they reduce motorist delay.

However, modern planning tends to use more comprehensive analysis methods that evaluate transport system quality based on *mobility* (the movement of people and goods) and *accessibility* (the ease of reaching desired goods, services and activities). Modern planning also tends to give more consideration to other planning objectives besides congestion reduction, and to a wider range of accessibility improvement strategies, including various mobility management strategies and smart growth land use policies. More comprehensive planning tends to place a higher value on public transit investments, particularly when implemented in conjunction with supportive policies such as road and parking pricing, commute trip reduction programs, and transit oriented land use development.

Transit Congestion Reduction Benefits

High quality public transit reduces traffic congestion costs in three ways (Litman, 2005):

1. High-quality, time-competitive transit tends to attract travelers who would otherwise drive (CTS 2009), which reduces congestion on parallel roadways (described in the box below). Various studies indicate that automobile travel times tend to converge with those of grade-separated transit (Lewis and Williams 1999; Vuchic 1999).

How Transit and HOV Reduces Traffic Congestion
When a road is congested, even small reductions in traffic volume can significantly increase travel speeds. For example, on a highway lane with 2,000 vehicles per hour a 5% reduction in traffic volumes will typically increase travel speed by about 20 miles per hour and eliminate stop-and-go conditions. Similar benefits occur from traffic volume reductions on congested surface streets.

Urban traffic congestion tends to maintain equilibrium. If congestion increases, people change route, destination, travel time and mode to avoid delay, and if it declines they take additional peak-period vehicle trips. Reducing the point of equilibrium is the only way to reduce long-term congestion. The quality of travel options available affects the level of congestion equilibrium: If alternatives are inferior, motorists will resist shifting mode until congestion becomes severe. If alternatives are attractive, motorists will more readily shift mode, reducing the level of congestion equilibrium. Improving travel options can therefore reduce delay both for travelers who shift modes and those who continue to drive.

To attract discretionary riders (travelers who could drive), transit must be fast, comfortable, convenient and affordable. In particular, grade-separated transit provides a speed advantage that tends to attract motorists. When transit is faster than driving, a portion of motorists shift until the highway reaches a new equilibrium (until congestion declines so transit's time advantage attracts no more motorists). The number of motorists who shift may be small, but is enough to reduce delays. Congestion does not disappear but is never as bad as without the parallel grade-separated transit service. Several studies have found that the faster the transit service, the faster the travel speeds on parallel highways (Mogridge 1990; Lewis and Williams 1999; Vuchic 1999). Comparisons between cities also indicate that total congestion delay tends to be lower in areas with good transit service (STPP 2001; Litman 2004a).

Shifting traffic from automobile to transit on a particular highway not only reduces congestion on that facility, it also reduces vehicle traffic discharged onto surface streets, providing "downstream" congestion reduction benefits. For example, when comparing *highway* widening with transit improvements, the analysis should account for the additional *surface streets* traffic congestion that would be avoided if transit improvement attracts highway drivers out of their cars.

2. Rail transit can stimulate transit oriented development (TODs) – compact, mixed-use, walkable urban villages where residents tend to own fewer cars and drive less than if they lived in more automobile-dependent neighborhoods ("Land Use Impacts On Transport," VTPI 2005). Before-and-after studies indicate that households often reduce their vehicle travel when they move to transit-oriented locations (Podobnik 2002).

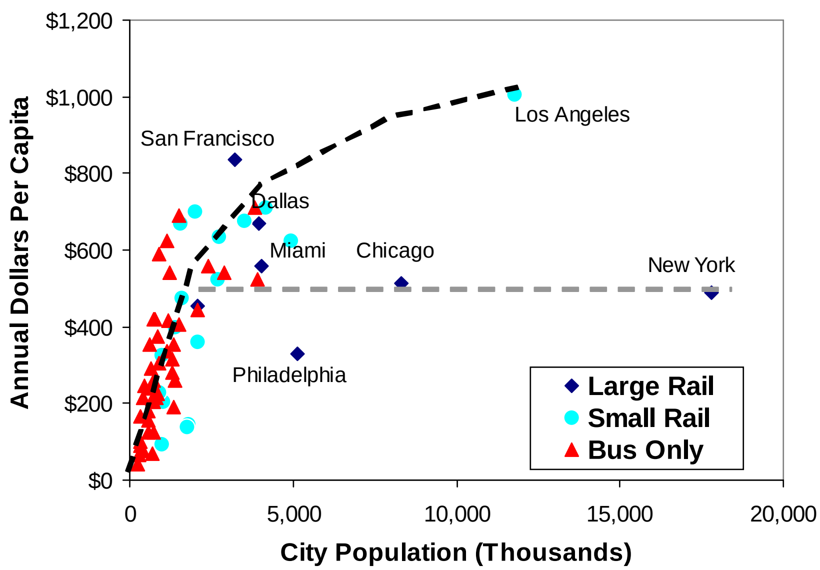
3. High quality transit service can reduce user travel time costs. Even if transit takes more minutes, many travelers consider their cost per minute lower than driving if transit service is comfortable (passengers have a seat, vehicles and stations are clean and safe, etc.) allowing passengers to relax and work ("Travel Time Costs," Litman 2006a; Litman 2007b).

Winston and Langer (2004) found that motorist and truck congestion delay declines in cities as rail transit mileage expands, but increases as bus transit mileage expands, apparently because buses attract fewer motorists, contribute to congestion, and do little to increase land use accessibility. Garrett and Castelazo (2004) found that congestion growth rates tend to decline in cities after light rail service begins. Baltimore's congestion index increased an average of 2.8% annually before light rail but only 1.5% annually after. Sacramento's index grew 4.5% annually before light rail but only 2.2% after. In St. Louis the index grew an average of 0.89% before light rail, and 0.86% after. Between 1998 and 2003, Portland's population grew 14%, but per capita congestion delay did not increase, possibly due to rail transit investments that significantly increased transit ridership during that period (TTI 2005). Other studies find similar results (LRN 2001).

Baum-Snow and Kahn (2005) found significantly lower average commute travel times in areas near rail transit than in otherwise comparable locations that lack rail, due to the relatively high travel speeds of grade-separated transit compared with automobile or bus commuting under the same conditions. They estimate these savings total 50,000 hours per day in Washington DC, and smaller amounts in other cities. Nelson, et al (2006) used a regional transport model to estimate transit system benefits, including direct users benefits and the congestion-reduction benefits to motorists, in Washington DC. They found that rail transit generates congestion-reduction benefits that exceed subsidies.

Texas Transportation Institute data indicate that congestion costs tend to increase with city size, but not if cities have large, well-established rail transit systems, as illustrated in Figure 1. As a result, New York and Chicago have far less congestion than Los Angeles.

Figure 1 **Congestion Costs** (Litman 2004)



In Bus Only and Small Rail cities, traffic congestion costs tend to increase with city size, as indicated by the dashed curve. But Large Rail cities do not follow this pattern. They have substantially lower congestion costs than comparable size cities.

The TTI report also calculates the congestion cost reductions provided by transit services. These savings average $279 annually per capita in *Large Rail* cities, $88 in *Small Rail* cities, and only $41 in *Bus Only* cities, and total more than $21 billion, over two-thirds of total U.S. public transit subsidies. Another indicator of transit's congestion reduction benefits is the increased traffic delay that occurs when transit service fails due to mechanical failures or strikes. For example, Lo and Hall (2006) found highway traffic speeds declined as much as 20% and rush hour duration increased significantly during the 2003 Los Angeles transit strike, although transit has only a 6.6% regional commute mode share. Speed reductions were particularly large on rail transit corridors.

The *Traffic Choices Study*, a Puget Sound (Seattle, Washington area) congestion pricing pilot project, observed the driving patterns of 275 volunteer households with GPS-equipped vehicles before and after hypothetical tolls were charged for driving on major arterials and highways (PSRC 2008). The results indicate that financial incentives can cause motorists to make significant changes in travel activity (how, when and where they drive). The study found that commuters responsiveness to congestion tolls is significantly affected by the quality transit services available: the elasticity of Home-to-Work vehicle trips was approximately -0.04 (a 10% price increase causes a 0.4% reduction in commute trips), but increased to -0.16 (a 10% price increase causes a 1.6% reduction in commute trips) for workers with the 10% best transit service. This indicates that high quality public transit service significantly reduces the price (road toll or parking fee) required to achieve a given reduction in traffic congestion, a reflection the smaller incremental cost to travelers (i.e., less loss of consumer surplus) when they shift from driving to high quality public transit.

Guo, et al. (2011) analyzed data from the 2006-2007 Oregon Road User Fee Pilot Program, which charged motorists for driving in congested conditions. The study found that households in denser, mixed use, transit-accessible neighborhoods reduced their peak-hour and overall travel significantly more than comparable households in automobile dependent suburbs, and that congestion pricing increase the value of more accessible and multi-modal locations.

Kim, Park and Sang (2008) studied traffic volumes on Twin City highways. They found that I-94 traffic volumes grew steadily between 2000 and 2004, when the Hiawatha LRT line was completed. In 2005 traffic volumes on this corridor decreased 2.1% and in 2006 they decreased 4.3%, with particularly large reductions during peak periods, although overall regional vehicle traffic grew during this period. This indicates that LRT service can significantly reduce automobile traffic volumes on parallel highways.

A Congressional Budget Office study (CBO 2008) found that increased fuel prices reduce urban highway traffic speeds and volumes. Each 50¢ per gallon (20%) gasoline price increase reduced traffic volumes on highways with parallel rail transit service by 0.7% on weekdays and 0.2% on weekends, with comparable increases in transit ridership, but no traffic reductions where found on highways that lack parallel rail service.

Aftabuzzaman, Currie and Sarvi (2010 and 2011) analyze the role that public transit can play in reducing roadway traffic congestion. Using factor analysis they identify and quantify three ways that high quality public transit reduces traffic congestion: (1) transit-oriented factor, (2) car-deterrence factor, and (3) urban-form factor. Regression analysis indicates that the car-deterrence factor makes the greatest contribution to reducing traffic congestion, followed by transit-oriented factor and urban-form factor. They conclude that high quality public transit provides $0.044 to $1.51 worth of congestion cost reduction (Aus$2008) per marginal transit-vehicle km of travel, with an average of 45¢, with higher values for circumstances with greater degrees of traffic congestion, and if both travel time and vehicle operating costs are considered.

This leaves little doubt that high quality transit services reduce per capita congestion costs. This does not mean that cities with quality transit lack congestion. In fact, congestion, measured as roadway level-of-service or average traffic speeds, tends to be particularly intense in these cities. However, people in these cities have travel alternatives available on congested corridor, and tend to drive fewer trips and shorter distances, and so they experience fewer annual hours of congestion delay.

Major transit system expansions generally occur in large and growing urban areas that experience increasing congestion. As a result, simplistic analysis often shows a positive correlation between transit service and congestion. Some critics exploit this relationship to "prove" that rail transit increases congestion (O'Toole 2004), but such analysis confuse correlation with causation. Critics often use indicators, such as the *Travel Time Index* (TTI), which only measure delay to motorists and so ignore delay reductions when people shift to transit and from more compact development that reduces travel distances. The TTI actually implies that congestion declines if residents *increase* their vehicle mileage and total travel time, for example, due to more dispersed land use, provided the additional driving occurs in less congested conditions (Cortright 2010).

On average, transit travel is slower than automobile travel, but this does not necessarily make transit uncompetitive. Average travel speeds are irrelevant, what matters is travel speeds under specific conditions. Transit service is concentrated on major urban corridors where automobile traffic speeds are low. The criticism that transit is slower than driving can be considered an argument for further improving transit service to increase its speeds rather than an argument against transit.

Of course, each trip is unique. For some trips transit is not an option because it does not serve a destination, or to carry passengers or heavy loads. Some travelers prefer driving because they want to smoke or have difficulty walking to transit stations. Some people enjoy driving even in congested conditions. But that does not negate the value of transit: if quality transit is available, travelers will self-select the mode that best meets their needs and preferences for each trip. This maximizes transport system efficiency (since shifts to transit reduce traffic and parking congestion) and consumer benefits (since it allows consumers to choose the optimal option for each trip).

Comprehensive Analysis

Critics often argue that transit investments are cost ineffective due to their relatively high cost per unit of congestion reduction, assuming that traffic congestion is the only significant transport problem. More comprehensive analysis considers other benefits, such as those listed in Table 1. As more planning objectives are considered the value of transit investments tend to increase.

Table 1 **Transit Benefits** (Litman 2005)

Benefits	Description
User benefits	Improved traveler convenience and comfort.
Congestion reduction	Reduced traffic congestion.
Facility cost savings	Reduced road and parking facility costs.
Consumer savings	Reduced consumer transportation costs.
Transport diversity	Improved transportation options, particularly for non-drives.
Road safety	Reduced per capita traffic crash rates.
Environmental quality	Reduced pollution emissions and habitat degradation.
Efficient land use	More compact development, reduced sprawl.
Economic development	Efficiencies of agglomeration, increases productivity and wealth.
Community cohesion	Positive interactions among people in a community.
Public health	More physical activity (particularly walking) increases fitness and health.

Rail transit tends to reduce per capita vehicle ownership and use, and encourage more compact, walkable development patterns, which can provide a variety of benefits to society.

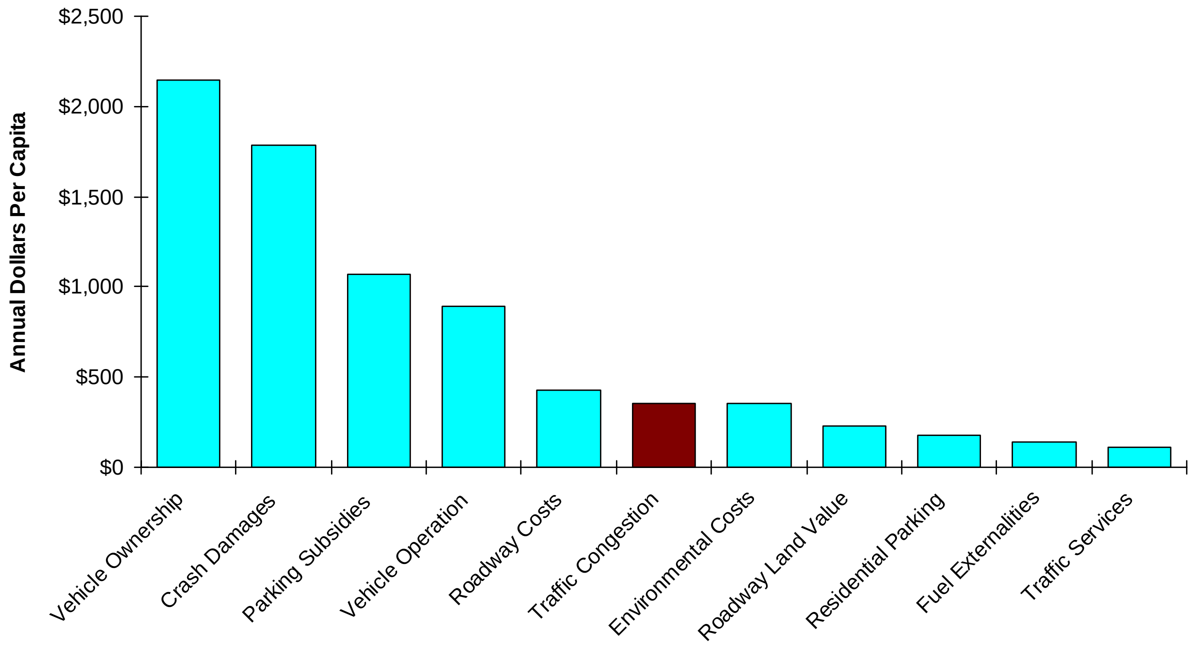
For example, comparing U.S. cities according to their rail transit service quality found that those with large rail transit systems have (Litman, 2004):

- 400% higher per capita transit ridership (589 versus 118 annual passenger-miles).
- 21% lower per capita motor vehicle mileage (1,958 fewer annual miles).
- 887% higher transit commute mode split (13.4% versus 2.7%).
- 36% lower per capita traffic fatalities (7.5 versus 11.7 annual deaths per 100,000 residents).
- 14% lower per capita consumer transportation expenditures ($448 average annual savings).
- 19% smaller portion of household budgets devoted to transportation (12.0% versus 14.9%).
- 33% lower transit operating costs per passenger-mile (42¢ versus 63¢).
- 58% higher transit service cost recovery (38% versus 24%).
- Transit-oriented development residents are more likely to achieve recommended levels of physical activity through daily walking than residents of automobile-oriented communities.

From a household’s perspective, rail transit provides a positive return on investment. Quality rail transit requires on average about $100 annually per capita in additional tax funding but provides about $500 annually per capita in direct consumer transport cost savings. In addition, rail transit tends to increase regional employment, business activity and productivity, plus it improves mobility for non-drivers, reduces the need for motorists to chauffeur non-drivers, improves community livability and improves public health.

Figure 2 illustrates the estimated magnitude of various automobile costs, including vehicle ownership and operation costs, road and parking facilities, traffic services, accidents, environmental damages, and congestion. Congestion costs are relatively modest overall. It would not be cost effective to implement a policy that reduces traffic congestion costs by 10% if it increased other transportation costs, such as vehicle expenses, roadway expanses, crashes or environmental damages, by just 3% each. On the other hand, a congestion reduction strategy provides far more benefit to society if it helps reduce these other costs, even by a small amount.

Figure 2 **Costs Ranked by Magnitude** ("Transportation Costs," VTPI, 2005)



This figure shows Average Car costs per vehicle mile, ranked by magnitude.

Alternative Transportation Improvement Strategies

Critics often suggest that other strategies are more cost effective at achieving specific planning objectives than rail transit projects. Depending on ideology they may recommend roadway capacity expansion, bus improvements, road pricing, or some type of mobility management program to encourage alternative modes such as cycling, ridesharing, public transit or telework. These are all legitimate ways of reducing congestion but are often poor substitutes for improving public transit service.

Roadway expansion can reduce traffic congestion in the short-run, but this benefit tends to decline over time due to generated traffic, and the additional vehicle travel tends to increase other costs such as downstream traffic congestion and parking demand, total accidents, energy consumption and pollution emissions (Litman, 2006b). Advocates generally exaggerate the benefits and underestimate the full costs of highway expansion.

A major study evaluating congestion reduction options for the Puget Sound region concluded that neither highway expansion nor transit improvements alone are cost effective, considering just congestion reduction benefits, but both become cost effective if implemented with roadway pricing (WSDOT 2006), and transit improvements provide co-benefits. Table 2 compares the estimated congestion reduction benefits and project costs calculated in that study. Both highway expansion and transit improvements have Benefit/Cost Ratios less than 1.0. Highway expansion ranks somewhat higher than bus improvements, considering just congestion reduction benefits. But, as previously described, highway expansion tends to impose other costs, while transit improvements provide other benefits to users and society. As a result, when all of these impacts are considered transit is often most cost effective.

Table 2 **Congestion Reduction Economic Analysis** (WSDOT, 2006)

	Benefits	Costs	Ratio
Highway Expansion	$1,850	$3,100	0.60
Transit Improvements	$605	$1,350	0.45

This table indicates the midpoint 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.

Although, bus transit is excellent for serving dispersed destinations, on major urban corridors rail tends to be more effective at attracting riders (Henry and Litman 2006), since trains tend to offer a more comfortable ride, are propelled by electric motors rather than internal combustion engines (so train stations tend to be more pleasant than large bus stations), and more cost effective because they carry more passengers per operator. Light rail service has lower operating costs than buses when traffic volumes exceed 1,200 peak-period passengers, and is particularly appropriate for destinations with more than about 2,000 peak period passenger arrivals to avoid the noise and air pollution from large congregations of buses at a station (Pushkarev 1982; Vuchic 2005).

Critics often claim that bus service is cheaper than rail, but as performance and comfort features are added (grade separation, larger seats, better stations, alternative fuels, etc.), bus system capital costs increase and approach those of rail, and may be offset over the long run by rail's lower operating costs. Operating costs are lower and cost recovery is higher in U.S. cities with large rail transit than those with little or no rail service, due to higher load factors and greater operating efficiency (Vuchic 2005; Henry and Litman 2006). Rail stations are far more effective than bus stations at creating TOD and therefore providing the additional benefits associated with improved neighborhood accessibility and reduced per capita vehicle travel. For these reasons, where ridership volumes are high and transit oriented development is a planning objective, rail may be justified despite higher initial costs.

Road pricing can reduce urban traffic congestion and eliminate the need for grade separated busways, but most cities that have implemented urban road pricing (Singapore, London and Stockholm) have rail transit to accommodate the large numbers of transit passengers that pricing creates. By providing an attractive travel alternative, rail transit reduces the price needed to reduce traffic congestion, benefiting motorists and making rail transit a complement to congestion pricing.

High Occupant Toll (HOT) lanes are *High Occupant Vehicle* (HOV, which include carpools, vanpools and buses) lanes that also allow use by a limited number of low occupancy vehicles that pay a toll. Proponents argue that these toll can finance significant highway expansion and therefore support High Occupant Vehicle use (Poole, 2003), but in practice such revenues can generally cover only a minor portion of project costs without spoiling the lane's travel time advantage ("HOV Priority," VTPI, 2006).

To attract travelers from automobiles, HOV traffic must flow uncongested, maintaining *Level Of Service* (LOS) A or B, which means less than about 1,000 vehicles per hour on a grade-separated highway. Buses and vans typically impose about two *Passenger Car Equivalents* (PCEs) and vans about 1.2. Thus, if during peak hour there are 100 buses and 100 vans causing 320 total PCEs, there will only be space for 680 automobiles. At 25¢ per vehicle-mile this only provides about $100,000 annual revenue ($0.25/veh-mile x 680 vehicles x 2 daily peak-hours x 300 days per year), at best a third of the full cost. All too often HOV and HOT lane optimal capacity is exceeded due to political intervention or a desire to maximize revenues, degrading their quality of service and reducing shifts from driving to high occupant vehicles. It is therefore important that HOT lanes be managed to optimize HOV performance rather than to accommodate other classes of vehicles or maximize revenues.

Mobility management programs that encourage use of alternative modes can be quite effective and beneficial, but they require high quality travel options to be effective (VTPI 2006). For example, a mobility management marketing programs that encourages travelers to try public transit will fail if the transit service is slow, uncomfortable, unsafe or stigmatized. As a result, mobility management programs are complements rather than substitutes for transit investments.

Qualitative Improvements

Conventional transport modeling measures total hours of travel and congestion delay, but often overlooks important qualitative factors related to transit convenience, comfort, security and reliability, and so tends to undervalue transit service improvements.

For example, many travelers consider time spent on a comfortable train or bus (with padded seats, safe and comfortable stations) to cost less per minute than time spent as a driver in congested traffic (Litman 2007b). On the other hand, transit travelers tend to assign a high cost to waiting for a transit vehicle, to unreliable service, and to long walking distances between transit stations and destinations. As a result, transit service quality improvements can reduce travel time costs even if they do not reduce the amount of time spent traveling, because costs per minute of travel are reduced. This suggests that it could be more cost effective to shift resources currently devoted to reducing motorists' traffic congestion delays to improving public transit service quality, for example, by increasing transit frequency, providing more comfortable vehicles, providing better user information (such as real time information on transit vehicle arrival times), nicer stations, improved security and better walking conditions around stations (Litman 2007c).

Conclusions

High quality public transit reduces traffic congestion by attracting travelers who would otherwise drive and reducing the point of congestion equilibrium. As public transit service quality (speed, convenience, comfort and affordability) improves, congestion levels on parallel roadways tends to decline. Grade-separated rail transit tends to reduce congestion directly and help create more accessible communities where there are good travel options and travel distances are shorter, which reduces total congestion costs.

Many peak period travelers would prefer to drive less and rely more on alternative modes, provided they are convenient, comfortable, flexible, safe and affordable. Since transit travel times and travel time costs vary depending on attributes such as comfort, reliability and access, transit service quality improvements can be considered equivalent to traffic congestion reductions. For example, increasing transit service frequency, and locating more worksites closer to transit stations reduces travel time costs, even if there is no increase in transit vehicle operating speeds.

Below is the general ranking of strategies, considering only their ability to reduce traffic congestion reduction (not considering other impacts and objectives):

1. Congestion pricing (higher road and parking fees during peak periods).
2. Other mobility management strategies (other commute trip reduction programs).
3. High quality public transit (particularly grade separated transit).
4. Highway capacity expansion.

Land use policy impacts depend on how congestion is measured. More compact, multi-modal development tends to increase congestion intensity measured as roadway level-of-service or average traffic speeds, but reduces automobile mode share and trip distances, which reduces congestion measured as per capita annual congestion costs.

Transit investments by themselves are not usually the most cost effective way to reduce roadway congestion. However, they become more cost effective at reducing congestion if implemented with complementary road pricing, mobility management strategies and smart growth land use policies. Conversely, transit service improvements support road pricing, mobility management and smart growth, making these more effective and politically acceptable. Congestion reduction is just one of many benefits provided by transit improvements. Other benefits provided by public transit, such as road and parking cost savings, consumer cost savings, accident reductions and improved mobility for non-drivers, are of equal or greater value than congestion reductions. When all impacts are considered, transit investments are often cost effective.

Conventional transport project economic evaluation tends to undervalue transit investments by ignoring many benefits including downstream traffic reduction, user savings and benefits, improved mobility for non-drivers, and support for strategic land use objectives. This is not to say that every transit project is optimal or that transit investments alone will solve every transport problem. However, considering all benefits and costs, transit improvements are often cost effective investments.

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