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Transit Utilization and Traffic Congestion:
Is There a Connection?

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Project Director: Baruch Feigenbaum

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Executive Summary

Key Findings

- Statistical analysis of the 74 largest urbanized areas in the U.S. over a 26-year period suggests that increasing transit utilization does not lead to a reduction in traffic congestion; nor does decreasing transit utilization lead to an increase in traffic congestion.

- Policies designed to promote transit utilization can in certain instances increase traffic congestion—as appears to have been the case in Portland, Oregon.

- Vehicle-miles traveled per freeway lane-mile is strongly correlated with traffic congestion: the more people drive relative to available freeway capacity, the worse congestion gets.

- Data from New York and Los Angeles indicate that the most effective way to increase transit utilization is by reducing fares, as well as by improving basic, pre-existing service.

Introduction

Many commentators, analysts and policymakers claim that increasing transit utilization reduces urban traffic congestion. However, very few transportation studies have attempted to prove this assertion.

This policy study addresses the issue by statistically analyzing the 74 largest urbanized areas (UZAs) in the U.S. over a 26-year period, from 1982 to 2007. It also contains case studies of seven urbanized areas that one would expect to best demonstrate the statistical relationship between transit utilization and traffic congestion, if such a relationship exists. Those urbanized areas are:

- New York City, Los Angeles and Chicago, which are the three largest urbanized areas in the country;
- Dallas, Houston and Washington, D.C., which are very large urbanized areas that have made major improvements to their transit infrastructure relatively recently, and
- Portland, which is generally considered to have one of the most intensive transit-oriented "smart growth" programs in the U.S.

In its examination of both the 74 largest urbanized areas in the country and the seven case studies, this study aims to answer two overarching questions that are of vital importance to transportation policymakers:

- *Firstly,* does an increase in transit utilization lead to a reduction in traffic congestion, and *vice versa*?
- *Secondly*, does an increase in vehicle-miles traveled (VMT) lead to an increase in traffic congestion, and *vice versa*?

This study uses the Texas Transportation Institute's Travel Time Index (TTI) throughout to measure traffic congestion. Two different measures are used for transit utilization: annual transit unlinked trips per capita and annual transit passenger-miles per capita. The overall analysis of the 74 largest urbanized areas uses two VMT figures: VMT per lane-mile on freeways and VMT per lane-mile on arterial streets. The case studies use only the freeways figure, as the arterial street analysis, while significant, was far less so than the freeway analysis.

Accordingly, this study's statistical analysis provides empirical answers to the following four questions:

1. What effect does the number of annual transit unlinked trips per capita have on traffic congestion in major urbanized areas?
2. What effect does the number of annual transit passenger-miles per capita have on traffic congestion in major urbanized areas?
3. What effect does the number of vehicle-miles traveled per freeway lane-mile have on traffic congestion in major urbanized areas?
4. What effect does the number of vehicle-miles traveled per arterial lane-mile have on traffic congestion in major urbanized areas?

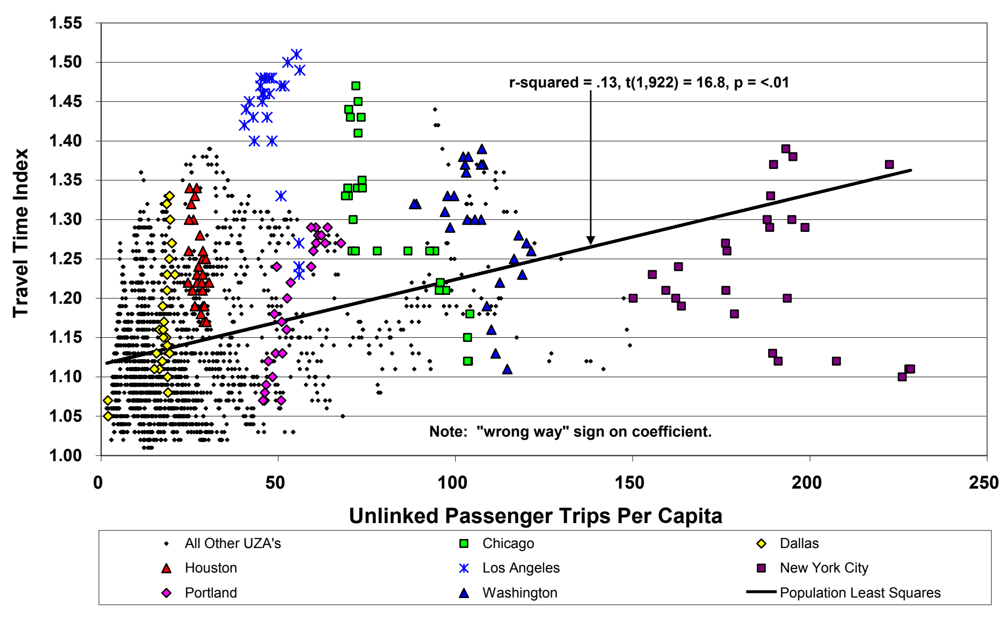
The study's finding on each of these research questions is detailed below. This is followed by summaries of all seven case studies, in which only the first three questions are discussed.

Annual Transit Unlinked Trips Per Capita and Traffic Congestion

As Figure ES-1 shows, regression analysis did not reveal any significant statistical relationship between increased annual transit unlinked trips per capita and reduced traffic congestion, or *vice versa*. In other words, the empirical evidence does not appear to support the contention that traffic congestion is reduced when people take more annual trips via transit, or increased when people take fewer trips via transit.

If there was a correlation between passenger trips per capita and congestion (represented here by the urbanized area in question's Travel Time Index score), the plots on this graph would be clustered near the trend line and we would see an 'r-squared value' closer to one (which represents a perfect correlation) than zero (which suggests no correlation). Instead our data points are widely dispersed resulting in an r-squared value of 0.13.

Figure ES1: Annual Unlinked Passenger Trips Per Capita vs TTI (74 Largest and Selected Major U.S. UZAs 1982–2007)

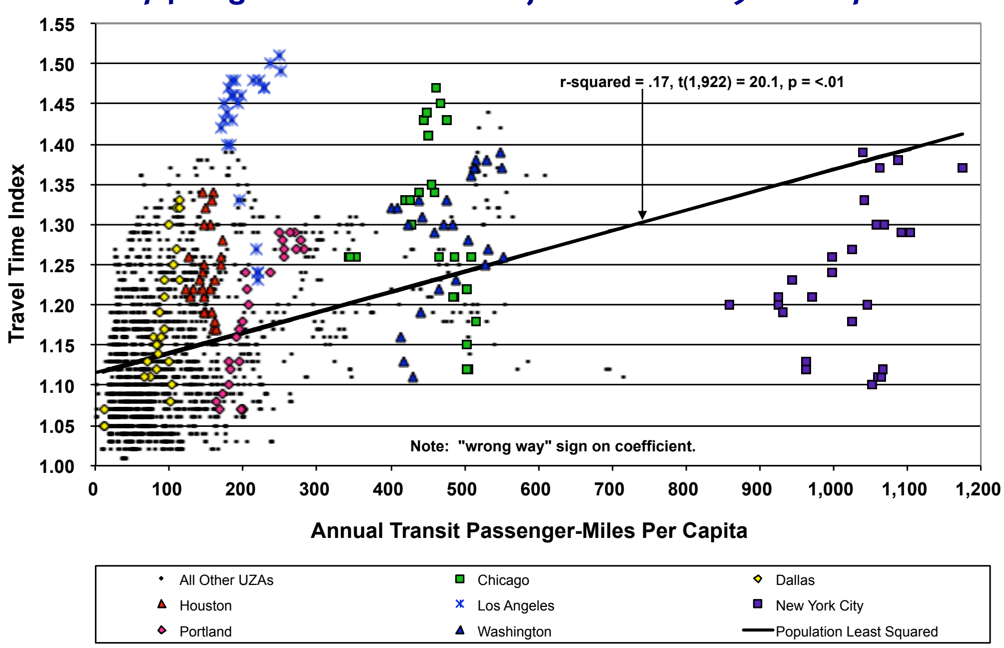


Annual Transit Passenger-Miles Per Capita and Traffic Congestion

As Figure ES-2 shows, regression analysis did not reveal any statistically significant relationship between increased annual transit passenger-miles per capita and reduced traffic congestion, or *vice versa*. In other words, the empirical evidence does not appear to support the contention that traffic congestion is reduced when people travel greater annual distances by transit.

Like the Trips Per Capita graph above, the passenger-miles per capita versus Travel Time Index graph below has a very low 'r-squared value'. If there was a correlation between passenger-miles and congestion, the plots on this graph would be clustered near the trend line and we would see an 'r-squared value' closer to one. Instead our data points are widely dispersed resulting in an r-squared value of 0.17, strongly suggesting no significant relationship.

Figure ES-2: Annual Transit Passenger-Miles per Capita vs TTI
74 Largest and Selected Major U.S. UZAs 1982–2007

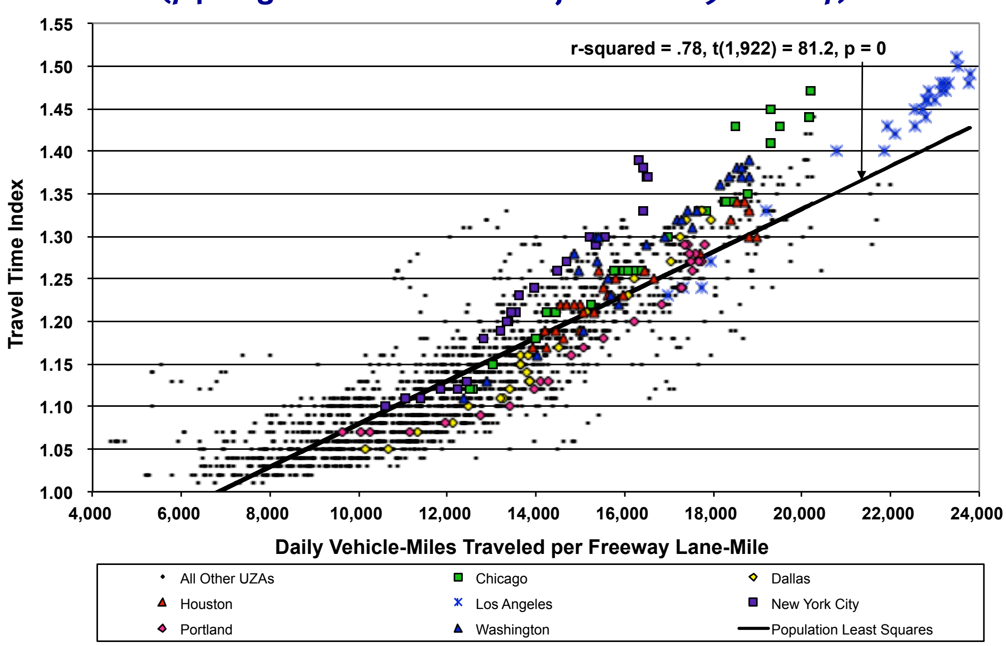


Vehicle-Miles Traveled Per Freeway Lane-Mile and Traffic Congestion

As Figure ES-3 shows, regression analysis revealed a very strong statistical relationship between increased vehicle-miles traveled per freeway lane-mile and increased traffic congestion, and *vice versa*. In other words, the empirical evidence strongly suggests that traffic congestion increases when people travel greater daily distances relative to an urbanized area's freeway capacity.

Unlike the previous two graphs, the data points on Figure ES-3 are clustered close to the trend line, which shows a very strong correlation between vehicle miles traveled per freeway mile and congestion. The 0.78 value indicates that as more vehicles use a given section of road, congestion increases.

Figure ES-3: Daily Vehicle-Miles/Freeway Lane-Mile vs. TTI (74 Largest and Selected Major UZA's 1982–2007)

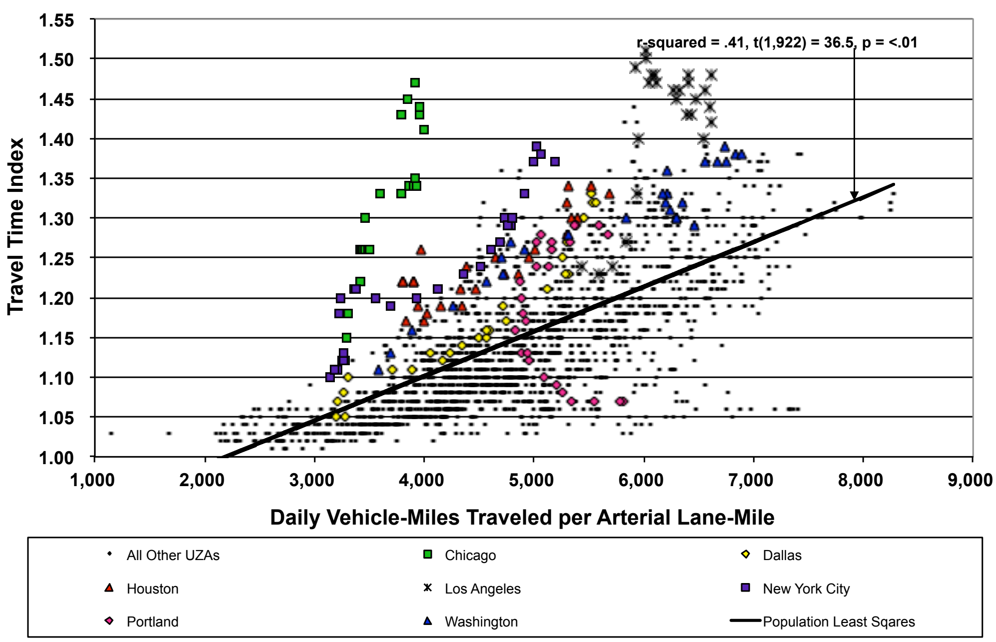


Vehicle-Miles Traveled Per Arterial Lane-Mile and Traffic Congestion

As Figure ES-4 shows, regression analysis also revealed a statistically significant relationship between increased vehicle-miles traveled per arterial lane-mile and increased traffic congestion, and *vice versa*. However, this relationship was not as strong as in the case of vehicle-miles traveled per freeway lane-mile. Nevertheless, the empirical evidence does suggest that traffic congestion increases when people travel greater daily distances relative to an urbanized area's arterial road capacity.

Figure ES-4 has an 'r-squared value of 0.41', with points on the graph mostly clustered away from the trend line. This suggests a low-medium correlation between vehicle-miles traveled per arterial lane-mile and congestion represented by Travel Time Index scores. This correlation is far weaker than the vehicle-miles per freeway-mile graph above, but still much stronger than any of the transit-congestion relationships.

Figure ES-4: Daily Vehicle-Miles/Arterial Lane-Mile vs. TTI (74 Largest and Selected Major UZA's 1982–2007)



What Conclusions Can Be Drawn from This Analysis?

The first conclusion that can be drawn from this analysis of the 74 largest urbanized areas in the U.S. is that increasing transit utilization does not seem to reduce congestion. Nor does falling transit utilization appear to lead to increased congestion. The second conclusion is that the number of vehicle-miles traveled per lane-mile on freeways and (to a somewhat lesser extent) on arterial roads appears to have a significant effect on congestion—as vehicle-miles traveled per lane-mile increases, so does congestion. The reverse also appears to be true.

By extension, the lesson for policymakers is that policies designed to increase transit utilization are unlikely to reduce traffic congestion. Achieving that aim will likely depend on either increasing the number of lane-miles on freeways and (to a lesser extent) arterial roads, and/or by pursuing policies to reduce the number of vehicle-miles traveled relative to available road capacity.

It is important, however, to note one qualification to these overall conclusions. The main reason that road travel has a stronger influence on congestion than transit travel is their relative mode shares in U.S. urbanized areas: put simply, more people travel by road than by transit. This leaves open the possibility that transit utilization will have a greater impact on congestion in urbanized areas where transit has a higher mode share (such as New York, where transit accounts for 12.2% of daily VMT equivalents) than it does in urbanized areas where transit has a lower mode share (like Los Angeles, where transit only accounts for 2.2% of daily VMT equivalents).

Overall, then, the lesson policymakers should take away from this study's analysis is not that transit must immediately be ruled out as a means of reducing congestion, but rather that any such proposals should be greeted with skepticism, tempered in some instances by the particular characteristics of the urbanized area in question.

Case Study: Chicago

The Chicago IL-IN urbanized area provides an interesting case study for several reasons. For starters, Chicago has long been one of the nation's key hubs for all modes of passenger and freight transportation, sitting at a nexus of road, rail, air and water routes running both north-south and east-west. Furthermore, Chicago has a well-developed transit system: its commuter rail operator, Metra, is the fourth-largest in the U.S.; the Chicago Transit Authority operates eight heavy rail lines and well over 100 bus lines; and Pace, known as the "Suburban Bus Division," runs the 19th largest bus network in the country.

Chicago is also interesting because one transit measure—unlinked passenger trips per capita—does appear to have a statistically significant relationship with traffic congestion in that urbanized area: as the number of trips taken by transit has fallen, traffic congestion has increased. However, this finding is not backed up by the other transit measure—passenger-miles per capita—which displays no significant relationship with traffic congestion. As such, the unlinked passenger trips per capita finding is best regarded as an outlier in the context of this entire study. Indeed, the divergence between the two measures may be explained by changes in patterns of transit utilization in Chicago between 1982 and 2007: in the period studied, there was a major shift from local, in-the-City-of-Chicago transit service to regional commuter rail service, which resulted in fewer transit riders making longer daily commutes.

Case Study: Dallas

The Dallas-Fort Worth-Arlington UZA is a major hub for all modes except water-borne transportation. As a younger, western city, Dallas does not have a long history of large-scale transit. Indeed, its major transit operator, the Dallas Area Rapid Transit Authority was only established in 1983, as the result of a voter referendum. Nevertheless, DART is the 18th largest transit agency in the U.S., with the 10th largest light rail and the 23rd largest bus operation. The Texas Railroad Express, meanwhile, which runs from downtown Dallas to downtown Fort Worth and provides access to Dallas/Fort Worth International Airport, is the 12th largest commuter rail system in the U.S.

Over the period being studied, Dallas's annual transit unlinked trips per capita fell by 2%, while annual transit passenger-miles per capita rose by 12%. This disparity reflects a policy emphasis on expanding rail service and long-haul commuter bus service, both of which tend to result in a smaller number of longer trips. Intriguingly, regression analysis suggested that in Dallas, higher transit utilization was associated with greater traffic congestion, and *vice versa*. However, this should not be interpreted as meaning that transit utilization *causes* traffic congestion in Dallas. On the contrary, the more reasonable conclusion to draw is that the relationship between transit and traffic utilization in Dallas is so weak that regressions produce meaningless results.

Case Study: Houston

Houston's Metropolitan Transit Authority of Harris County (Metro) was created by a vote of the Harris County electorate in 1977 and is funded by a 1% sales tax. Overall, it is the 16th largest transit agency in the U.S. Nevertheless, the data analyzed in this study do not suggest any meaningful relationship between transit utilization and traffic congestion in Houston—which is perhaps not surprising, given that transit's daily mode share is just 0.7%.

On the other hand, the data tell an interesting story about the relationship between vehicle-miles traveled per freeway lane-mile and traffic congestion. From 1982–1986, Houston's freeway VMT grew by 23.4% but freeway lane-miles increased by only 15.5%. As a result, VMT/freeway lane-mile increased by 6.8%, while congestion measured by the Travel Time Index increased by 37%. In 1986–1993, by contrast, the increase in freeway lane-miles (35.9%) outstripped the growth in freeway VMT (25.6%), which led to a reduction in VMT/freeway lane-mile of 5.3% and a corresponding 35% decrease in traffic congestion. Finally, from 1993–2007, freeway VMT (54.8% growth) outpaced freeway lane-miles (17.2% growth) once again. The result was that VMT/freeway lane-mile rose by 30% and congestion increased by 94%.

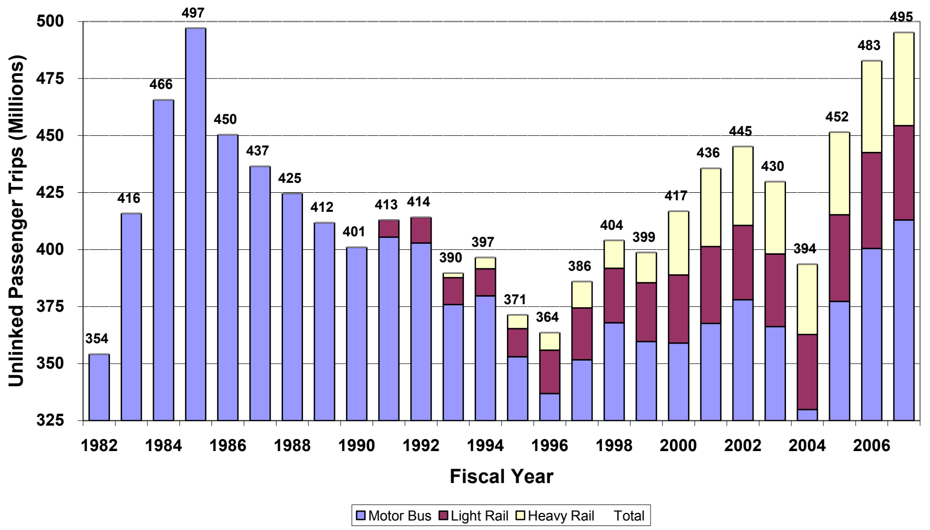
Clearly, these findings support the conclusion drawn from this study's overall analysis of the 74 largest urbanized areas in the U.S.—that as the number of vehicle-miles traveled per freeway lane-mile increases, so does congestion, and *vice versa*. It is also interesting to note that what happened in Houston between 1986 and 1993 has no equal among the other 73 urbanized areas studied over this period. The previous increase in traffic congestion was not only stopped, but *reversed*—and this during a time of significant growth in vehicle-miles traveled in what was already one of the most congested urbanized areas in America. This feat was clearly achieved by significantly expanding the capacity of the road system.

Case Study: Los Angeles

Of the seven case study cities examined here, the Los Angeles-Long Beach-Santa Ana urbanized area exhibits the strongest relationship between vehicle-miles traveled per freeway lane-mile and traffic congestion, as measured by the Travel Time Index. Throughout the study period, as VMT/freeway lane-mile rose, so did congestion. And when VMT/freeway lane-mile briefly fell between 1990 and 1994, congestion followed suit. Overall, vehicle-miles traveled per freeway lane-mile rose by 34.2% between 1982 and 2007, while congestion increased by 104.2% over the same period. As a result, Los Angeles topped the Travel Time Index rankings every year except 1984.

At the same time, there have been significant changes in transit utilization in the Los Angeles urbanized area, as Figure ES-5 shows:

Figure ES-5: Southern California Rapid Transit District/Los Angeles County Metropolitan Transportation Authority: Unlinked Passenger Trips 1982–2007



Annual transit unlinked passenger trips increased by more than 40% from 1982 to 1985, then fell 27% from 1985 to 1996, before rising by 36% through to 2007. Yet despite such pronounced changes in transit utilization over these three sub-periods, no significant relationship between transit utilization and congestion could be found in the data analyzed. The implication of this is worth spelling out: even in the most congested urbanized area in the nation, with the largest change in transit utilization of any urbanized area over the period studied, there is no discernible trend in the data that supports a connection between transit utilization and traffic congestion, as measured by the Travel Time Index.

Two other points of interest are worth noting. The first is that the changes in transit utilization outlined above seem to have been driven almost entirely by changes in transit fares—the lower the price of transit, the more people used it, and *vice versa*. The second is that despite its unenviable record as the long-time most congested city in America according to the Travel Time Index, Los Angeles does not have the longest home-to-work commute time, with its average of 27 minutes beating out New York City (33.1 minutes), Washington

(30.9 minutes), Chicago (29.7 minutes), Atlanta (29 minutes), Boston (27.3 minutes) and Miami (27.1 minutes), among others. The reason for this is the Los Angeles urbanized area's surprising density (on average, it has 49% more residents per square mile than the New York City urbanized area) coupled with its relatively insignificant central business district—taken together, these factors add up to one of the most balanced homes-jobs distributions in the U.S. and suggest that Los Angeles's "dense sprawl" might be more functional than is commonly assumed.

Case Study: New York City

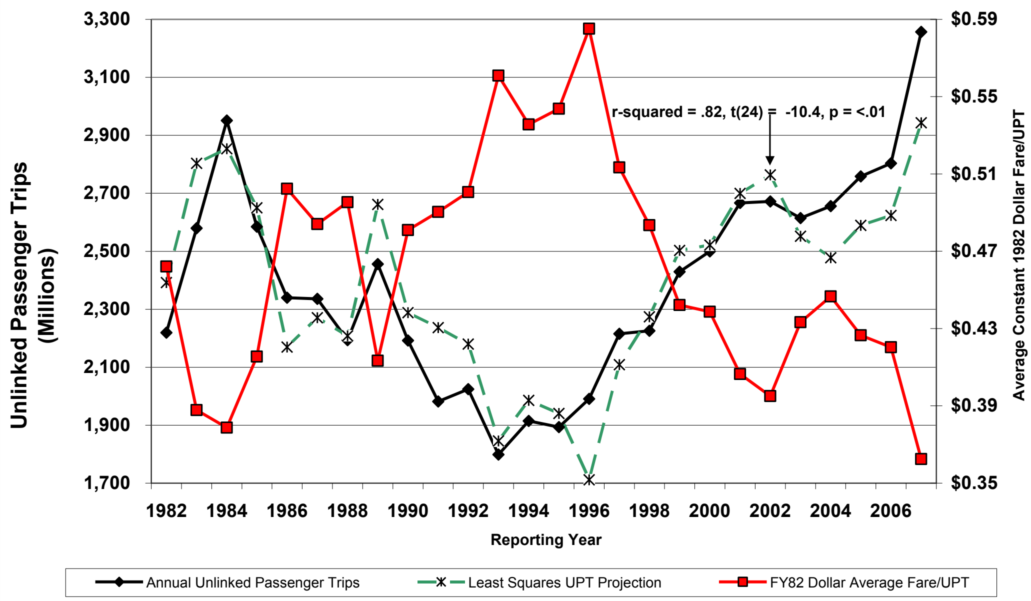
The New York City urbanized area is the largest in the nation by population, with 42% more people than second-ranked Los Angeles in 2007. From its centuries as the nation's largest city and most significant sea and, later, air terminus, New York has become a major transportation hub for all modes.

New York City is also the heart of public transit in the U.S. With just 6% of the U.S. population in 2007, the New York City urbanized area had 40% of both total transit unlinked passenger trips per capita and transit passenger-miles per capita. A majority—53.7%—of residents of core cities in the New York City urbanized area use transit for home-to-work commuting. Indeed, 12.5% of *suburban* workers commute by transit—higher than the *total* percentage in every other urbanized area except Washington, D.C. and San Francisco-Oakland. Between 1993 and 2007, unlinked passenger trips on Metropolitan Transportation Agency-New York City Transit increased by 83%.

Despite this, even the New York City urbanized area fails to demonstrate any statistically significantly relationship between transit utilization and traffic congestion. Meanwhile, and as in the other urbanized areas studied, VMT per freeway lane-mile correlated strongly with traffic congestion as measured by the Travel Time Index.

Like Los Angeles, New York City's experience suggests that transit fares are a significant driver of transit utilization, as Figure ES-6 suggests:

Figure ES-6: MTA-New York City Transit: Unlinked Passenger Trips and Constant Dollar Average Fare/UPT



Case Study: Portland

Portland is one of the most interesting case study cities, in that it has made a major effort to deemphasize automotive travel in favor of transit, smart growth and non-motorized transportation. In some respects, this effort appears to have been successful: from 1982–2007, transit unlinked passenger trips per capita grew 29% in the Portland urbanized area, while transit passenger-miles per capita grew 25%. No urbanized area with a larger population saw a greater rise in transit utilization than Portland.

However, the transit regression results for Portland reveal no evidence that increased transit utilization has reduced congestion. On the contrary, there is very clear quantitative evidence that transit usage has moved *in the same direction* as traffic congestion, suggesting that in Portland increased transit utilization is associated with greater congestion, and *vice versa*.

This is a surprising finding that should not be dismissed out of hand. Nonetheless, it would be incorrect to say that increasing transit utilization in

Portland *causes* congestion to increase. What may be happening is that the same body of public sector actions that have caused transit utilization to increase has also caused traffic congestion to worsen.

Specifically, the Portland urbanized area has:

- Diverted funds that were originally intended for highways projects to transit and expanded transit at the expense of roadway capacity;
- Explicitly aimed policy at establishing high utilization/capacity ratios for roads—essentially guaranteeing congestion in peak periods;
- Ruled out any new regional trafficways and assigned priority to developing the city's transit system and encouraging transit-oriented development, and
- Devoted over half of combined road and transit funding through 2035 to transit, even though 86.3% of home-to-work commutes are on roads, versus 4.9% on transit.

This body of pro-transit, sometimes anti-road policies and actions, combined with quantitative results, indicate that the Portland-area policies designed to increase transit usage have created situations where traffic congestion has increased.

Finally—as was the case with almost every other city studied—the statistical evidence from Portland displays a strong association between VMT per freeway lane-mile and congestion as measured by the Travel Time Index.

Case Study: Washington, D.C.

The Washington DC-VA-MD urbanized area is home to the Washington Metropolitan Area Transportation Authority (WMATA), which is the major operator in the region. The Maryland Transit Administration and the Virginia Railway Express also operate commuter rail in the region. Several suburban political jurisdictions including Montgomery County, Maryland and Alexandria and Fairfax Counties in Virginia operate comprehensive bus systems.

Over the study period transit utilization was mixed: per capita trips declined 6% while passenger-miles increased 28%. This reflects the Washington, D.C. urbanized area's emphasis on the construction and operation of rail service, particularly heavy and commuter rail service to the suburban counties and beyond. WMATA, whose Metrorail is one of the most extensive and heavily used rail systems in the U.S., saw its total ridership grow by 46% over the study period.

But irrespective of Washington D.C.'s relatively well-developed transit system, transit utilization between 1982 and 2007 did not appear to have any significant impact upon traffic congestion. Road travel increased much faster than transit travel, and was strongly associated with traffic congestion.

Conclusion

Taking the 74 urbanized areas studied as a whole, there is no statistically significant evidence that links an increase in transit utilization, whether measured by annual transit unlinked trips per capita or transit passenger-miles per capita, to a decrease in traffic congestion, as measured by the Travel Time Index, or *vice versa*.

Indeed, based on this research, a weak statistical case can be made that increases in transit use correlate with *increases* in traffic congestion. This may be explained, at least in some specific urbanized areas, by a political climate that favors capital spending on transit projects over road projects, and land use decisions that tend to work against automotive mobility, sometimes deliberately.

The 74 urbanized areas, studied as a whole, and almost every urbanized area individually, revealed a strong relationship between freeway vehicle-miles traveled per freeway lane-mile and traffic congestion. Freeway usage per unit of capacity increased as congestion increased very consistently. A weaker, but still valid, relationship existed between arterial vehicle-miles traveled per lane-mile and traffic congestion.

Accordingly, policymakers who want to reduce traffic congestion should focus on increasing freeway and arterial road capacity and/or reducing vehicle-miles traveled. Transit has its place in the transportation policy mix, but should not be expected to do things it cannot do well—such as reducing traffic congestion.

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Part 1

Introduction

From justifications for transit taxes to voters to public opinion polls to primary goals of transit plans, to blogs to papers commissioned by the primary industry association and lobbying organization for American transit operators, many elected officials, transportation agency executives and agency staff, transit referendum proponents and members of the public have linked transit system use to reduction of traffic congestion.

The following statements regarding the impact of public transit on traffic congestion illustrate attitudes about transit and traffic congestion (***emphasis added***):

> *Purpose of Tax. To **improve transit service** and operations, **reduce traffic congestion**, improve air quality, efficiently operate and improve the condition of the streets and freeways utilized by public transit and reduce foreign fuel dependence.*[1]
>
> *Four in five (81 percent) Americans believe that increased investment in **public transportation** strengthens the economy, creates jobs, **reduces traffic congestion** and air pollution and saves energy, according to a new national poll conducted by Wirthlin Worldwide.*[2]
>
> *Mobility and urban livability are important issues for residents of the Minneapolis-St. Paul area. Opinion polls have found that the public perceives **traffic congestion** in the Twin Cities metro area as a problem even more serious than crime, and a large majority favor the development of **LRT, busways and commuter rail as a critical element in crafting mobility solutions.***[3]
>
> *In development since 2001, METRO Solutions is a comprehensive **transit system plan** to help solve the Greater Houston region's **traffic congestion** and air quality problems.*[4]

> ***Public transit*** *reduces the number of cars on roads and highways, which reduces* ***traffic congestion****. This can reduce commute time, reduce emissions and increase productivity.*[5]
>
> *Common sense quickly tells us that, contrary to the laments of the anti-transit troubadours,* ***transit can and often does relieve congestion.***[6]

While many claim that public transit improvements reduce traffic congestion, very few transportation studies have attempted to prove this claim. This paper performs a quantitative, statistical and graphic analysis to determine if such a link exists and, if so, attempts to quantify it. The primary methodology is an analytic study of traffic and transit of the 74 U.S. urbanized areas with populations over 500,000 in 2007 during the 1982–2007 period. The quantitative analysis is accompanied by short case studies of transit utilization and traffic congestion for the following seven urbanized areas: Chicago, Dallas, Houston, Los Angeles, New York City, Portland and Washington, DC. Our primary research hypothesis was that increases in transit use lead to a reduction in traffic congestion, and *vice versa*.

Specifically, we used simple (ordinary least-squares) regression of data pairs consisting of unlinked passenger trips and passenger-miles, per capita, for each of the 74 U.S. urbanized areas (UZA) with populations of 500,000 or more in 2007, over the period 1982–2007, as the independent variable, and the Texas Transportation Institute's Travel Time Index (TTI) as the dependent variable. We found no statistically significant relationship that transit usage reduces traffic congestion for the 74 UZAs. While there were some statistically significant relationships for the 74 individual UZAs taken separately, the overall distribution of results was close to random; indeed, there were more cases where TTI moved in the same direction as transit usage than against.

Some may argue that transit *is* working to reduce traffic congestion, but that there is too little transit operated to overcome the growth in automobile usage and, therefore, what is needed is a far larger investment in transit. We do not address the investment in transit argument but our methodology should detect the statistically significant impact, if any, on changes in transit utilization on reducing traffic congestion, even during periods when traffic congestion is increasing due to other factors.

We also tested whether or not an increase in road use per lane-mile of roadway produces an increase in traffic congestion, and *vice versa*. Specifically, we regressed the impact of changes of vehicle-miles traveled (VMT) per lane-mile on freeways and arterial streets, by year, as the independent variables, against TTI as the dependent variable. This analysis showed a strong statistical significance for freeway VMT/capita, both for the entire body of 74 UZAs and for almost all of the individual UZAs. Arterial street VMT/capita also produced statistically significant relationships, but not as strong as those for freeway VMT.

Further, we performed case studies of seven UZAs, including the three largest in the nation (greater New York City, Los Angeles and Chicago), three other very large UZAs with relatively recent major transit system improvement programs (Dallas, Houston and Washington), and Portland, which has one of the most intensive transit expansion/smart growth program of any of the UZA in this population.[7] These case studies provide interesting quantitative and anecdotal evidence showing that major changes in transit utilization do not appear to produce noticeable changes in traffic congestion, while change in VMT/lane-mile has both very strong correlations and qualitative reasons for recognizing a significant relationship.

The regression analysis results are as follows:

Table 1: Summary of Regression Results, 74 Largest U.S. Urbanized Areas (Dependent Variable: Travel Time Index*)

Independent Variable	Regression Analysis Statistical Results			
	r^2	Degrees of Freedom	*t*-score	P
Annual Transit Unlinked Passenger Trips/Capita	.13	1,922	16.8	<.01
Annual Transit Passenger-Miles/Capita	.17	1,922	20.1	<.01
Daily Vehicle-Miles Traveled/Freeway Lane-Mile	.78	1.922	81.2	0
Daily Vehicle-Miles Traveled/Arterial Lane-Mile	.41	1,922	36.5	<.01

* In all four cases, as the independent variable increased, the dependent variable—traffic congestion, as measured by TTI—also increased. This was the expected outcome for VMT per freeway and arterial lane-mile, but for transit UPT (unlinked passenger trips) and passenger-miles per capita, the expected outcome was the opposite: that traffic congestion would decrease, not increase, as transit utilization increased.

Part 2

Methodology

One of the best known measures of traffic congestion in the U.S. is the "Travel Time Index" (TTI) that has been promulgated by the Texas Transportation Institute at Texas A&M University since 1984.[8] We used the data from the 2009 *Urban Mobility Report* (*UMR*) for the period 1982–2007 for every U.S. urbanized area.[9]

The TTI is defined as follows:[10]

> *Travel Time Index (TTI) – The ratio of travel time in the peak period to travel time at free-flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.*

The *UMR* is a study of traffic congestion in American Urbanized Areas (UZAs). UZAs are geographic entities defined by real-world settlement patterns, rather than political boundaries (and may cross state lines), and are created and defined by federal surface transportation law:[11]

> ***Urbanized area**. The term "**urbanized area**" means an **area** with a population of 50,000 or more designated by the Bureau of the Census, within boundaries to be fixed by responsible State and local officials in cooperation with each other, subject to approval by the Secretary. Such boundaries shall encompass, at a minimum, the entire **urbanized area** within a State as designated by the Bureau of the Census.*

TTI interprets the boundaries of urban areas based on state guidance. TTI also updates the boundaries each year as opposed to every 10 years. As a result, TTI's boundaries may differ from UZAs particularly five to nine years removed from the decennial census.

We understand that the TTI data is not perfect, but we believe that the *UMR* authors and staff have done their best to make the database as comprehensive and accurate as possible, and that the result is valid and useful for its—and for our—purposes.

UMR has analyzed all 439 urban areas (urban areas are metro areas with populations of 5,000 or more) that had been identified by the Bureau of the Census at the time, but we limited our analysis to the 74 largest UZAs in the *UMR*:[12]

- The 14 "Very Large" UZAs with populations in excess of 2,000,000 each as of the 2007 reporting period
- The 29 "Large" UZAs with populations between 1,000,000 and 2,000,000 each
- The 31 "Medium" UZAs with populations between 500,000 and 1,000,000 each

The formal names of UZAs often include the names of several of the contained cities, such as Los Angeles-Long Beach-Santa Ana CA; we will refer to UZAs by the name of the largest contained city, which is always the first city named, e.g., "Los Angeles." If we are referring to *only* the largest city within the UZA, we will refer to the "City of Los Angeles."

We applied two general approaches in this statistical analysis. The first tested the primary research hypothesis that change in transit utilization in a UZA over time has a significant, measurable and consistent opposite effect on traffic congestion (i.e., if transit utilization increases, traffic congestion decreases, and *vice versa*.)[13] Our primary null hypothesis is that change in transit utilization over time does not produce such statistically significant results. We tested these by analyzing annual transit unlinked passenger trips per capita and annual transit passenger-miles per capita for the 26 years, 1982–2007, for each of the 74 UZAs and for the 74 UZAs as a whole, as the independent variables.

We used two sets of transit utilization indicators, one based on passenger-miles and the other on unlinked passenger trips. Our expectation was that changes in passenger-miles would be a better predictor of changes in traffic congestion than unlinked passenger trips, because passenger-miles, presumably being converted to vehicle-miles not driven on roadways, would better predict changes in traffic congestion than changes in unlinked passenger-trips. For example, a single 25-mile trip on commuter rail (one unlinked trip and 25 passenger-miles) could have a greater possible impact on traffic congestion than two two-mile trips on buses (two unlinked trips and four passenger-miles). Adding or removing transit passengers-miles were expected to have a more direct and quantifiable impact on congestion than unlinked transit trips removed, which are of uncertain average length in the available data.

The second approach tested the primary research hypothesis that an increase in road utilization has a significant, measurable and consistent direct effect on traffic congestion over time (as road utilization per unit of capacity increases, traffic congestion increases). Our null hypothesis in the second approach is that no such statistically significant relationship exists. This was tested using average vehicle-miles traveled per freeway lane-mile and per arterial lane-mile, as described above for the transit variables, as the independent variables.

The common factor in these two approaches is that we used the same measure for the quantification of traffic congestion: TTI.

1. Statistical analysis did not indicate any significant relationship between changes in transit utilization and changes in TTI—in other words, the primary research hypothesis is not supported. This lack of statistical support suggests the acceptance of the primary null hypothesis, that there is no significant statistical relationship between change in transit utilization and traffic congestion as measured by TTI. In this context, the use of "statistically significant" means that there was such a relationship found, or not found, for the entire body of 74 UZAs analyzed over time, or for the significant majority of the 74 UZAs analyzed independently. While some of the 74 did demonstrate statistically significant relationships individually, there was a lack of a consistent pattern, suggesting the distribution of results—statistically significant or not, positive or negative coefficient—approached random. If anything, the trends disprove the primary hypotheses. For the small number of the regressions that were statistically significant, with one exception, Portland, we did not find underlying facts and logic to support the acceptance of the hypothesis. Portland is a special case, as described below.

2. The alternate research hypothesis—that increase in road utilization per freeway lane-mile and per arterial lane-mile over time has a significant,

measurable and direct effect on traffic congestion—is supported. For the 74 UZAs as a whole, and for almost all of the 74 UZAs individually, the alternate research hypothesis explains such a major share of the change in traffic congestion that the primary research hypothesis is significantly called into question. (Obviously, the acceptance of the alternate research hypothesis negates the alternate null hypothesis.)

For our case studies, we examine the following major U.S. UZAs (number in parenthesis is 2007 UZA national population rankings of the 74):

1. Chicago (3)
2. Dallas (7)
3. Houston (12)
4. Los Angeles (2)
5. New York City (1)
6. Portland (24)
7. Washington, DC (9)

The New York-Newark NY-NJ-CT UZA (the formal name of the Greater New York UZA) is the largest in the U.S. by population and has, by far, the largest transit usage. In the final year of the analysis period, 2007, New York's transit unlinked passenger trips and transit passenger-miles were 43% of the totals for all 74 UZAs studied and the transit usage per capita was over four times the weighted average for the 74 UZAs for both factors.[14]

The second-largest UZA, Los Angeles-Long Beach-Santa Ana CA, has the highest freeway utilization of U.S. UZAs; its 2007 vehicle-miles traveled per freeway lane-mile were 29% higher than number two-ranked Chicago.[15] The first and second largest UZAs by population, with the highest transit use for one and the highest freeway utilization for the other, provide an interesting contrast of extremes. Chicago, the third largest UZA by population, is relatively high in both transit and highway utilization.

Besides the three largest UZAs, we examine two more of the "top 10" UZAs by population, Dallas and Washington. Both of these cities show rather extensive growth in rail transit investments in recent decades, with Washington being one of only two U.S. UZAs (the other being New York City) where rail transit ridership, measured by unlinked passenger trips, is larger than bus ridership.[16]

Houston has one of the most rapidly growing large UZAs, but differs from almost all other larger UZAs in that it has continued to aggressively expand its freeway system including a major busway/high-occupancy vehicle network.[17] Only recently has it begun constructing rail transit; the first small (7.5 mile) light rail line entered service in 2004, and it was the only one in service during this analysis period.[18]

We include Portland because it has the strongest emphasis on transit improvement and land use policies to support transit of any UZA.

Below, following an explanation of the statistical approach and results, we present four graphs with the national (for all 74 U.S. UZAs in the population) scatter plots of the four main independent variables we analyzed, presented along with the least squares line for regression for the national data and the data points for the seven case study cities. With 26 data points—1982–2007, inclusive—for each of the 74 UZAs, gives a total of 1,924 data points for each graph, including the seven sets of 26 uniquely identified points for the case study cities.

In each case, the vertical (Y-) axis is the TTI score, which is the dependent variable for each regression, and the horizontal (X-) axis is the independent variable, illustrating each of the following data sets.

1. Annual Transit Unlinked Passenger Trips per Capita vs. TTI
2. Annual Transit Passenger-Miles per Capital vs. TTI
3. Daily Vehicle-Miles/Freeway Lane-Mile vs. TTI
4. Daily Vehicle-Miles/Arterial Lane-Mile vs. TTI

Part 3

Results for Transit and Roadway Independent Variables

In summary, as the graphs and the more detailed quantitative analysis show, there is no meaningful statistical relationship for the two transit indicators, transit annual unlinked passenger trips per capita and transit annual passenger-miles per capita. For the 74 UZAs taken together, and for the vast majority of the 74 UZAs analyzed individually, there is no meaningful relationship between changes in transit utilization and changes in traffic congestion as measured by TTI score.

For the details of the statistical methodology, see Appendix B.

The graphs in the main body of the report present the results for each regression in standard statistical format. Following are the results for the first graph below, the national (all 74 UZAs for the 26 years of data for each) regression for unlinked passenger trips as the independent variable:

r-squared = .13, $t(1{,}922) = 16.8$, p =<.01

"r-squared," or r^2, is the coefficient of determination for each regression. The r^2 value ranges from zero to +1. An r^2 value of zero means that there is no relationship between the independent (transit or road utilization in this paper) and dependent (TTI) variables; a value of 1.00 means that 100% of the change in the dependent valuable is explained by the change in the independent variable. In simple (one independent variable) linear regression, which is our primary statistical tool for this study, the r^2 value is the percentage of change in the independent variable that is explained by the change in the dependent variable. For example, the r^2 value of .13 in the above equation means that the change in the independent variable explains 13% of the change in the dependent variable—which is so low that it is generally not considered sufficient to show a relationship (for our current purposes, we will assume that an r^2 value lower than

.30 is insufficient to justify further analysis of a relationship).

"*t*" refers to Student's *t*-score, which is a measurement of the goodness of fit. For our current purposes, it is an intermediate metric. The "(1,922)" is the "degrees of freedom," which is related to the sample size (calculated as follows: 74 UZAs @ 26 years of data each = 1,924, which is the sample size; the calculation of degrees of freedom minus two producing the 1,922.[19] All else equal, the larger the sample, the less risk of randomness in the results and, therefore, the higher the confidence in the results. The *t*-score itself is 16.8. The higher the *t*-score, the better the fit.

Finally, the *t*-score and the degrees of freedom are used to calculate the final value, the "p", which is the probability, or confidence interval. Here, the value is <.01, or less than 1%, which means that there is less than a 1% chance that the true value of the statistical result is outside the results reported. The lower the "'p" value, the higher the confidence in the reported mathematical relationship.

A statistical result is a mathematical relationship, which may or may not be consistent with how things work in the real world, and even a strong statistical relationship may be random. It may also have another logical explanation, such as both the independent and dependent variables being dependent on a third variable that is the true independent variable (which, in fact, we believe is the case for the transit statistics for Portland, as we discuss in that section below). In using statistical tools, the first step is to create a hypothesis that includes the expected relationship, preferably one that can be justified, at least preliminarily, by logical analysis, including of a qualitative nature; no statistical result can be fully accepted without a "common sense" review to determine if the mathematical result can be justified as logical.

On a national basis, reviewing the data for all 74 UZAs as a whole, neither transit variable did well on the "eyeball" test as the first two graphs on page 12 show. (In the eyeball test a reviewer examines a graph, and determines whether or not it "looks" like there is a relationship.) Both indicators had low correlation coefficients (r^2 = .127 and .174 for transit unlinked passenger trips per capital and transit passenger-miles per capita, respectively). Due to the relatively high number of data pairs (1,924), the Student's *t*-scores were high and the results were statistically significant—but highly illogical, at least when evaluated in the light of our primary research hypothesis. The coefficients, in both cases, are positive when the hypotheses indicated they should be negative: the expectation was that congestion would decrease as transit usage increases, rather than what the plot and least squares calculation shows, that congestion ***increases*** as transit usage increases.

Figure 1: Annual Unlinked Passenger Trips Per Capita vs. TTI (74 Largest and Selected Major UZAs 1982–2007)

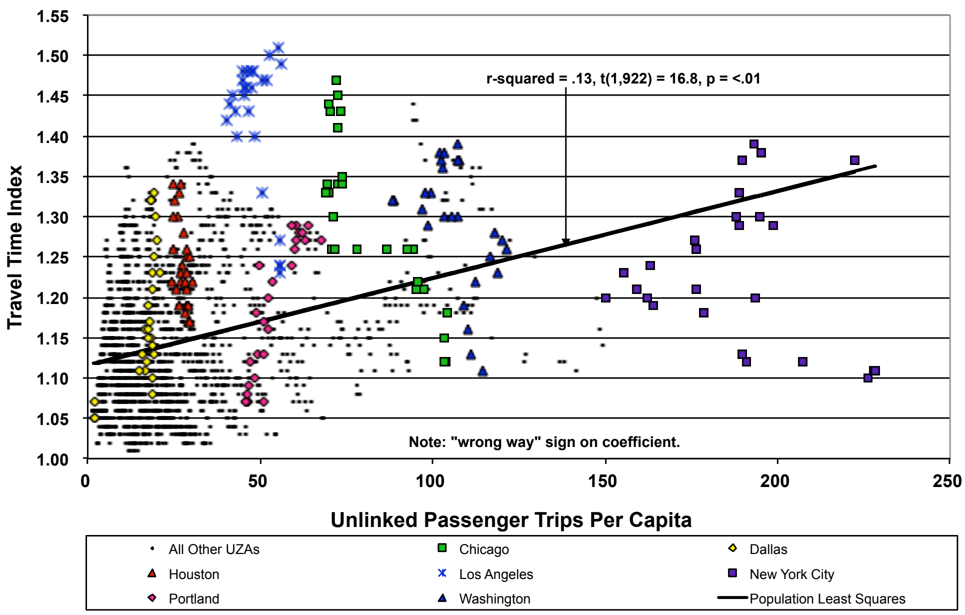


Figure 2: Annual Transit Passenger-Miles Per Capita vs TTI (74 Largest and Selected Major U.S. UZAs 1982–2007)

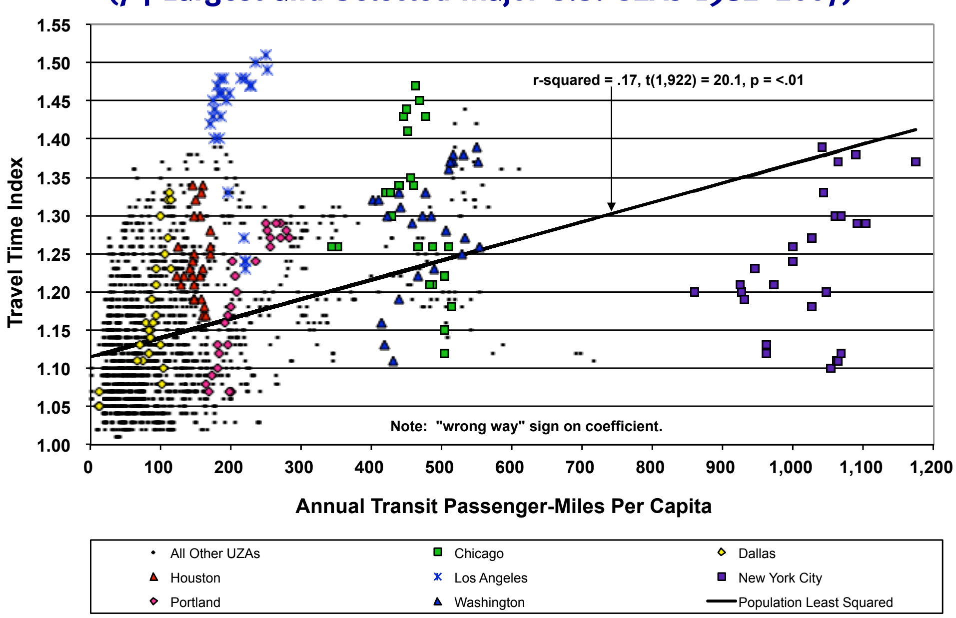


Figure 3: Daily Vehicle-Miles/Freeway Lane-Mile vs. TTI (74 Largest and Selected Major UZAs 1982–2007)

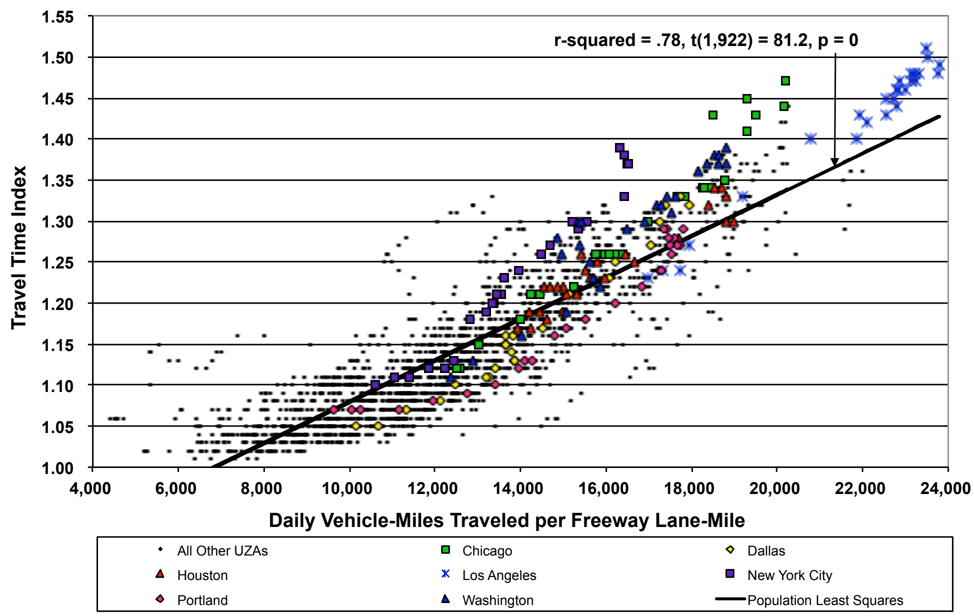
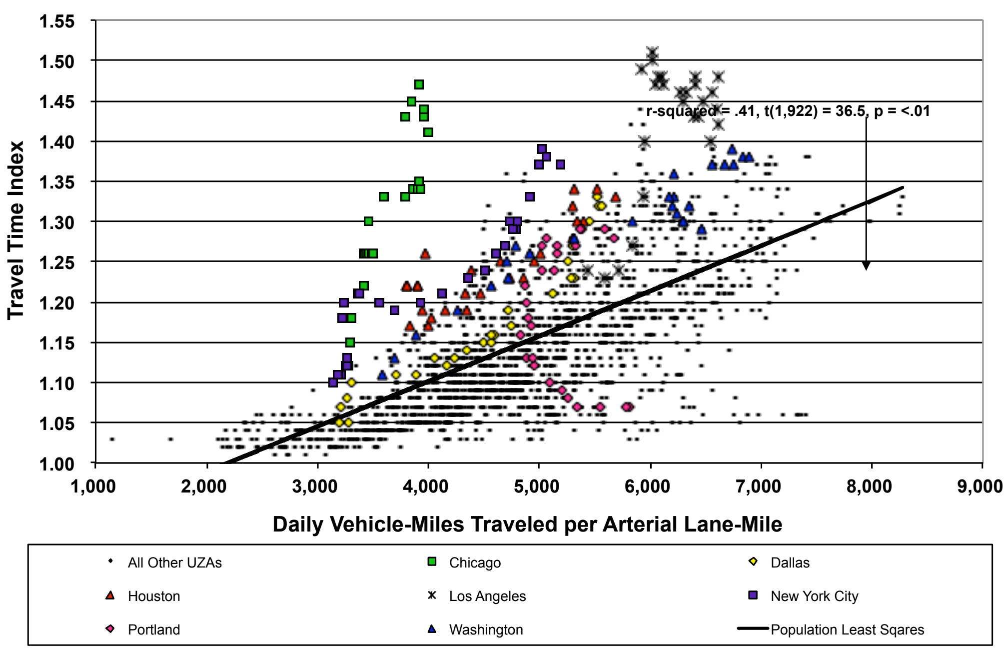


Figure 4: Daily Vehicle-Miles/Arterial Lane-Mile vs. TTI (74 Largest and Selected Major UZAs 1982–2007)



Part 4

Road and Transit Components of Travel

The relative travel share of these two modes is the biggest reason why road travel has a stronger influence on traffic congestion than transit travel. We will examine the relative shares by looking first at the New York City UZA, which has the heaviest transit utilization in the U.S.

New York, with 11.85% of the population of the 74 UZAs, had 43.40% of the UZAs total transit passenger-miles in 2007, so the New York transit utilization per capita is 571% of the weighted averages of the other 73.[20] NYC's 2007 annual transit passenger-miles per capita of 1,175 was more than double the 550 of number two Washington, DC.[21]

New York's transit systems had 21,416.6 million annual transit passenger-miles in 2007.[22] To convert this to a "working weekday" figure, we divided it by an annual-to-weekday conversion factor of 307.7, obtained from National Transit Database data for annual and working weekday average ridership. This produced approximately 70 million daily transit passenger-miles.[23] If we divide this by the 2007 average vehicle occupancy of 1.64 for non-bus/non-truck vehicles, we get an approximate road VMT equivalent of 43 million.[24]

New York reported 306 million daily VMT; if we add the 43 million transit road VMT equivalents, we get a total of approximately 349 million.[25] So, in New York, the transit capital of the U.S., approximately 12% of surface mobility VMT equivalents are taken on transit on a working weekday.

(This methodology is certainly not represented as perfectly accurate as a representation of the impact of transit on traffic congestion. There are several factors that have impacts, both ways, on this ratio calculation, including:

- Transit utilization tends to be far more peak-period-oriented than road travel and it is the delays caused by peak road utilization that TTI is measuring.
- Average road vehicle occupancy during peak period commutes tends to be significantly lower than the national annual average figure calculated above. For the 2007 reporting year, the average annual occupancy of four-tire vehicles was 1.64 while peak-hour occupancy factors for freeways were generally far lower, such as the 1.14 factor for mixed-flow lanes reported by the California Legislative Analyst.[26]
- The majority of transit usage is on roadways, where buses and other road-based transit vehicles compete for road capacity with other "rubber tire" vehicles.
- Transit usage tends to be highly centralized to and around the core central business district (CBD), with far lower levels of usage in the suburbs, particularly the more distant suburbs; therefore the impact of transit, to the extent it is notable, is likely to be more significant in, near and approaching the CBDs.

Overall, considering peak-period impacts, transit carries a somewhat larger percentage of the peak-period transportation than this simplified methodology indicates.)

There is only a small difference between a congested freeway operating at peak capacity and a freeway operating with major delays. Adding a few percentage points more vehicles to a crowded freeway at rush hour will frequently create a transition from even flow traffic to stop-and-go traffic. Therefore, New York's 12% daily transit modal split is a reasonable justification for a hypothesis that transit usage may impact traffic congestion.

How supportable is this justification? We have applied the same methodology to seven selected UZAs (Chicago, Dallas, Houston, Los Angeles, New York City, Portland and Washington), and six more that we chose to be representative of the entire population of 74 UZAs:

- We show the results for the two UZAs that were just above and below the annual weighted average transit passenger-miles per capita of 321 for all 74 UZAs, Salt Lake City (323) and Philadelphia (301).

- We also added the results for the two UZAs that were just above and below the annual simple average of transit passenger-miles per capita of 143, Cleveland (154) and Saint Louis (134).
- We added the results for the two UZAs with the least annual transit passenger-miles per capita, Tulsa (18) and Oklahoma City (17).

Table 2: Daily VMT-Equivalents by Mode and Road Type (Percentage of Daily Totals)

City	Freeway	Arterial	Other Road*	Total Road	Transit
Chicago	30.4	27.7	37.4	95.5	4.5
Cleveland	45.6	30.2	22.7	98.6	1.4
Dallas	46.4	38.7	14.0	99.1	0.9
Houston	45.7	40.3	13.4	99.3	0.7
Los Angeles	49.1	44.3	4.4	97.8	2.2
New York City	34.2	29.4	24.1	87.8	12.1
Oklahoma City	33.5	41.8	24.6	99.9	0.1
Philadelphia	32.9	43.1	21.1	97.1	2.9
Portland	37.8	38.3	21.5	97.6	2.4
Saint Louis	43.4	26.6	29.2	99.2	0.8
Salt Lake City	34.6	35.8	26.7	97.1	2.9
Tulsa	35.7	51.6	12.5	99.8	0.2
Washington D.C.	38.0	40.5	16.8	95.2	4.8
Total 74 UZAs	39.4	37.5	20.3	97.2	2.8

* Other Road refers to every road that is not classified “freeway” or “arterial.”

Outside of New York City, none of these UZAs reaches 5.0% daily transit VMT-equivalent; Washington is the highest at 4.8%.

For Dallas (.9%), Houston (.7%), Oklahoma City (.1%), Saint Louis (.8%) and Tulsa (.2%), daily transit VMT-equivalents do not reach 1% of the total. At these levels, (even assuming that changes in transit utilization in New York City do lead to changes in traffic congestion), is transit utilization high enough to have *any* noticeable impact on traffic congestion?

Part 5

Case Studies

The following applies to all case study graphs.

The graphs in each case study visually display the relationships—or lack thereof—of the key analyzed road and transportation utilization metrics.

All graphs have dual Y-axes that are synchronized to display the fit of the independent and dependent variables with the TTI scores, which are the dependent variable, always on the left Y-axis and the independent variable, such as unlinked passenger trips/capita or vehicle miles/freeway lane-mile, always on the right Y-axis. This use of dual Y-axes is a graphic way of displaying what simple regression presents by formula, showing how the values of the two variables move together—or not.

The independent road variables are hypothesized to have direct relationships with the TTI dependent variable; for example, as VMT/freeway lane-mile increases TTI is expected to also increase and *vice versa*. This makes displaying two lines moving in close relationship over time easy to present.

Conversely, the independent transit variables are hypothesized to move in the *opposite* direction of TTI, e.g., as transit usage increases, TTI is expected to decrease and *vice versa*. This makes it more difficult to display the change in the dependent variable as the independent variable changes. For graphing the transit variables, the TTI values calculated from the formula produced by the regression analysis, rather than the raw transit usage data, better illustrate the "goodness of fit." The green lines on the two Chicago transit graphs on the next page show how this works.

For half of the 14 transit independent variables (passenger-miles for Houston, New York City and Washington; both measures for Dallas and Portland), the transit regression equation coefficients were of the opposite sign than expected, e.g., as transit utilization per capita increases, TTI *increases*.

Because the coefficient is positive, there is no need for a third line to present the projected TTI values. As a result no green line is presented.

We described in the national data section above how we reviewed the impacts of four independent variables on TTI. These variables are the two transit variables, unlinked passenger trips (UPT) and passenger-miles (PM) per capita, and the two road variables: vehicle-miles per freeway lane-mile and arterial lane-mile. Each case study has three graphs showing the two transit variables—because this paper is about transit's impact on congestion—and vehicle-miles per freeway lane-mile, because it is a very good “fit” in each case. However, we decided not to include graphs for vehicle-miles per arterial lane-mile because, while it had some value in predicting TTI (far more than either transit variable), the freeway statistic connection was far stronger. Also, as discussed in Appendix B, we found that many of the UZAs showed significant “auto-correlation” (later year data were correlated to early year data) for the UZA arterial VMT statistical analyses, making it significantly less useful than the freeway VMT statistic. Therefore, we omitted the graphic representation of arterial VMT in the case studies.

A. Chicago Urbanized Area

Statistics

Table 3: Chicago Calculations

	1982	2007	2007 Rank	1982–2007 Growth
Population	7.08M	8.44M	3	19.2
Population/Square Mile	3,726	2,398	30	-35.6
TTI	1.12	1.43	2	258.3
FW VMT/FW Lane-Mile	12,571	18,507	12	47.2
Arterial VMT/Lane-Mile	3,267	3,789	70	16.0
Transit UPT/Capita	104	73	5	-29.2
Transit PM/Capita	504	477	6	-5.4
Total Road-Miles/Million Population		2,872	63	
Freeway Centerline-Miles/Million		60	70	
Freeway Lane-Miles/Million		332	71	
Average Freeway Lanes/Mile		5.49	30	
Daily Modal VMT Freeway Equivalent		30.4%		
Arterial		27.7%		
Other Road		37.4%		
Transit		4.5%		

*Population is in millions. All other figures are exact values

Table 4: Chicago, ACS Home-to-Work Commute (2006–2008)

Minutes				
	Core City	Other	Whole	Rank
• Road	31.7	27.7	28.7	
• Transit	44.4	58.9	49.5	
• Overall	32.8	28.4	29.7	71
Modal Splits				
• Road	62.8%	87.0%	79.5%	
• Transit	25.9%	6.3%	12.3%	
• Other	11.3%	6.8%	8.2%	
• Core City Population	32.5%			
• Core City Workers	30.9%			

** Population, population density, TTI, VMT/mile statistics are from the *UMR* or authors' calculations and rankings from *UMR* data. Road-miles are from *FHWA*. Home-to-work commute data are from Census Bureau, American Community Survey 2006–2008 (hereinafter "*ACS*"), Tables B01003 (Total Population, B08136 (Aggregate Travel Time to Work of Workers [16 or older] by Means of Transportation to Work)), and B08301 (Means of Transportation to Work [16 and older]), accessed September 3, 2009.

Graphs

Figure 5: Chicago UZA 1982–2007 TTI & VMT/Freeway Lane-Mile

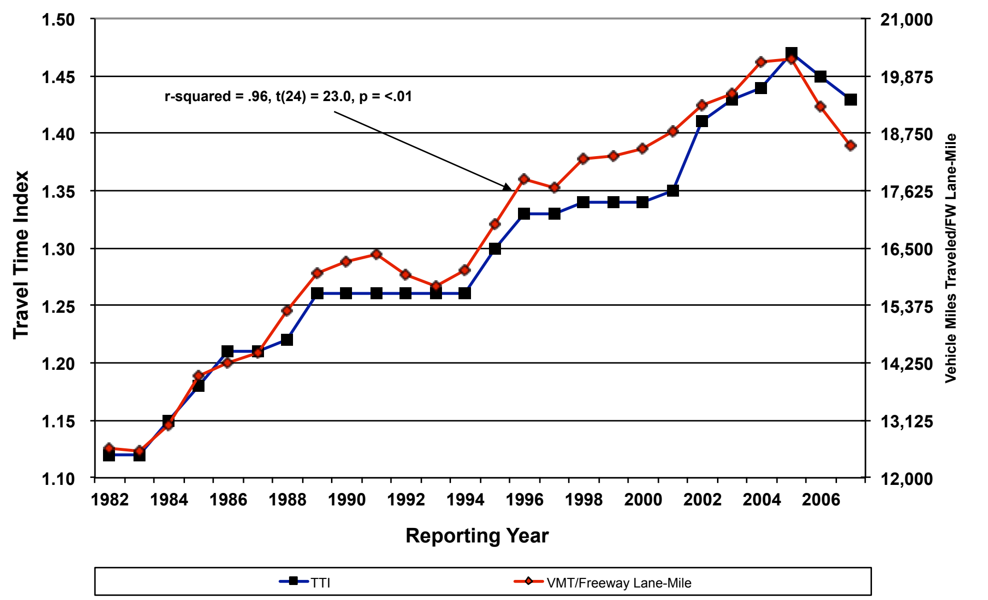


Figure 6: Chicago UZA 1982–2007 TTI and Transit Passenger-Miles/Capita

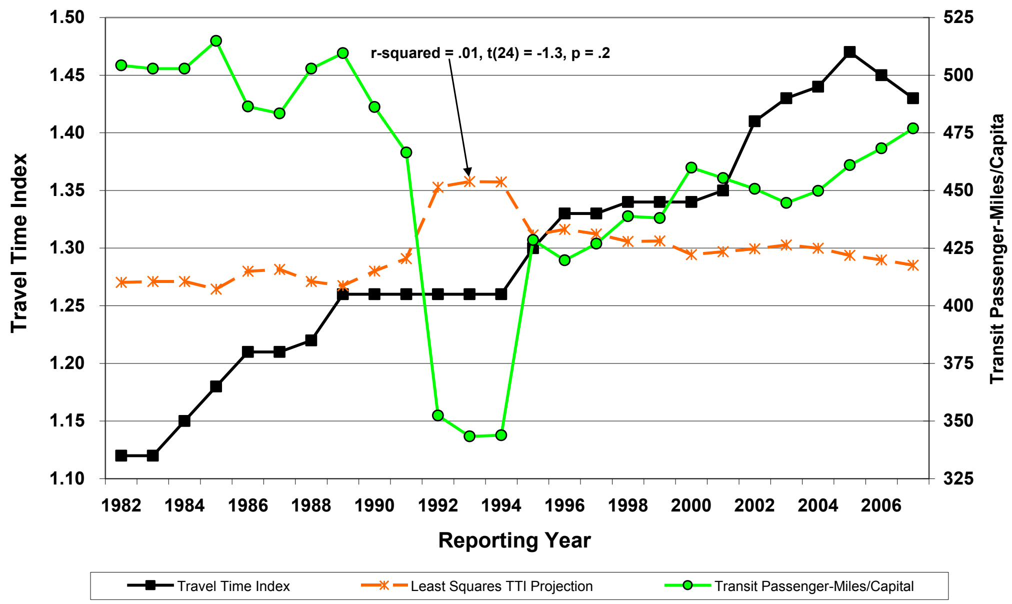
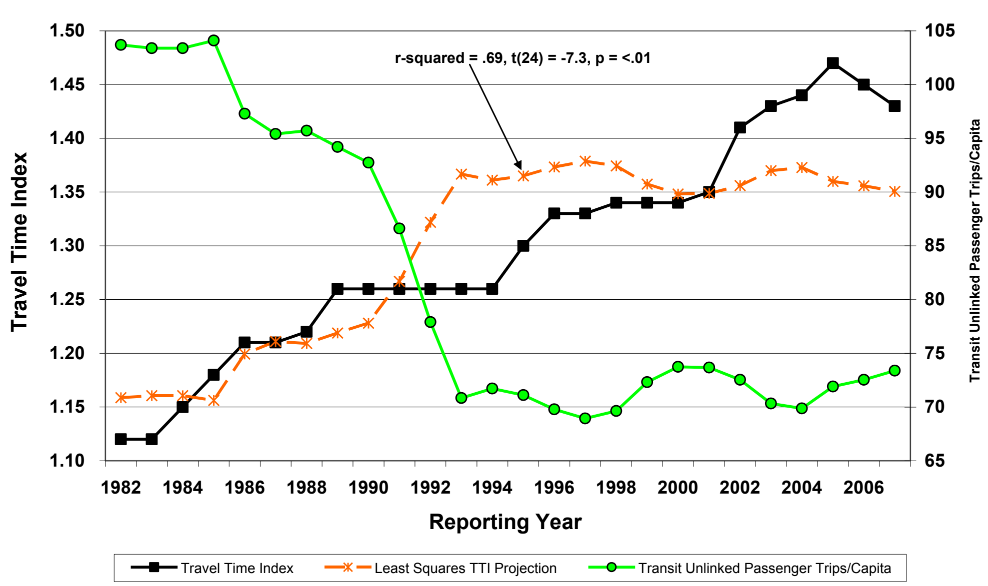


Figure 7: Chicago UZA 1982–2007
TTI and Transit Unlinked Passenger Trips/Capital



Discussion

The Chicago IL-IN urbanized area includes all of the city of Chicago and suburban Cook County; portions of DuPage, Grundy, Kane, Kendall, Lake, McHenry and Will Counties, Illinois; and portions of Porter and Lake Counties, Indiana. [27]

Chicago has long been one the nation's key transportation hubs for all modes of passenger and freight transportation, road, rail, water and air. Its location at the southwest corner of Lake Michigan means that almost any surface shipping from the East Coast to the upper Midwest or the Northwest must go through Chicago to get around the Great Lakes. Chicago is along the route for many other destinations west of the Mississippi. The various transportation modes of all types reflect this geographic reality; as a result Chicago serves as a funnel and trans-shipment point.

Many of the nation's most important Interstate highways, both east-west and north-south, travel through or originate in Chicago, and many of these are key local "rubber tire" transportation/commute routes as well. These include I-55 to Saint Louis and Memphis, I-57 to Cairo, IL; I-65 to Indianapolis and Mobile, I-80 from New York City to San Francisco; I-90 from Boston to Seattle, and I-94 from Detroit to Milwaukee and Minneapolis-Saint Paul.

With the exception of a few small transit operators in outlying areas, primarily in Indiana, the overwhelming majority of transit in Chicago is operated by the Chicago Transit Authority (CTA), Metra and Pace. CTA, which operates heavy rail and bus service within the city of Chicago and parts of suburban Cook County, is the second largest U.S. transit agency overall and the third largest operator, by passenger-trips, of both bus and heavy rail service.[28] As of 2010, it operated eight heavy rail lines and well over 100 bus lines.[29]

With Chicago a key national rail hub, commuter rail, now operated by Metra, is a major component in the local transit system. Metra operates 11 lines to all points of the compass not covered by water from the downtown Chicago Loop—which traces its name to the elevated heavy rail line that encircles much of the central business district.[30] Metra is the fourth largest commuter rail operator in the U.S. by both unlinked passenger trips and passenger-miles.[31]

Pace (aka, "Suburban Bus Division," referring to its original statutory legal status as the Suburban Bus Division of the Regional Transportation Authority, the Chicago-area transit planning, funding and oversight agency), as of 2010, operates bus service in suburban Chicago counties and demand-responsive and vanpool service throughout the region. It is the 30th largest transit system overall, the 19th largest bus system, the 17th largest demand-responsive and the third-largest vanpool operator in the nation.[32]

Over the period being studied, transit usage in Chicago has been declining, unlinked passenger trips/capita are down 29% and passenger-miles/capita are down 5%. There has a been a major shift from local, inner-city-of-Chicago transit service, operated by CTA, to regional, primarily Metra commuter rail service, with fewer transit riders making longer daily transit commutes.[33] This shift has been more-or-less continual over the period studied, but is particularly notable during the early 1990s, when the economic downturn hurt both overall transit funding—and therefore service provided—as well as demand for transit. The reduction in CTA ridership preceded the increase in longer Metra trips. It is this shift that leads to the major difference in the regression results for these two indicators. This trend spreads the range of relationships, making one (passenger-miles) appear not significant and the other (unlinked passenger trips) significant, rather than making both not significant. While the fairly strong regression results for unlinked passenger trips is interesting, without a confirmation from transit passenger-miles, it is difficult to place much importance on it. In the context of the study, this is an extreme outlier.

Of the 16 graphs (two for each of the seven case studies and the 74 UZAs as a whole) of transit variables, the Chicago passenger trips graph is the only one that displays the anticipated relationship, which is a change in transit use associated with an opposite change in traffic congestion. Of the other 15 analyses, nine show traffic congestion changing in the same direction as transit use changes, and four of the other six have r^2 values of .01 or .00—which is a hair's breath from the statistical equivalent of a random number generator. The remaining two values, .21 and .23, are so low that they would not be significant in any similar context. While this Chicago relationship can be explained logically, in the context of the full body of the transit-TTI relationship analyzed for the entire population, this is the statistical equivalent of a blind squirrel finding an acorn.

B. Dallas Urbanized Area

Statistics

Table 5: Dallas Calculations

	1982	2007	2007 Rank	1982–2007 Growth
Population	2.45M	4.45M	7	81.4%
Population/Square Mile	1,756	1,933	25	10.1%
TTI	1.05	1.32	12	540.0%
FW VMT/FW Lane-Mile	10,155	17,390	16	71.3%
Arterial VMT/Lane-Mile	3,278	5,566	28	69.8%
Transit UPT/Capita	19*	18	36	-2.0%
Transit PM/Capita	101*	113	27	12.1%
Total Road-Miles/Million Population		4,032	41	
Freeway Centerline-Miles/Million		119	41	
Freeway Lane-Miles/Million		719	27	
Average Freeway Lanes/Mile		6.05	14	
Freeway Daily Modal VMT Equivalent Percentage		46.4%		
Arterial Daily Modal VMT Equivalent Percentage		38.7%		
Other Road Daily Modal VMT Equivalent Percentage		14.0%		
Transit Daily Modal VMT Equivalent Percentage		0.9%		

Transit UPT/Capita and Transit PM/Capita 1982 data is for 1985, as the first three years of transit data are suspect.

Table 6: Dallas, ACS Home-to-Work Commute (2006–2008)

Minutes				
	Core City	Other	Whole	Rank
Road	24.6	25.9	25.3	
Transit	49.0	47.6	48.5	
Overall	24.4	25.1	24.7	57
Modal Splits				
Road	90.8%	92.1%	91.5%	
Transit	2.8%	1.3%	2.0%	
Other	6.4%	6.6%	6.5%	
Core City Population	48.6%			
Core City Workers	47.3%			

There is a significant problem with the first three years of Dallas UZA transit utilization data provided by the Texas A&M Transportation Institute. The "raw" data are identical for each year, total UZA passenger-miles are only 29.6 million, and unlinked passenger trips are 5.0 million, which are extremely low for a UZA of this size. In the fourth year, these time series jump to reasonable levels of 278.4 million and 51.9 million, respectively, which appear consistent with the subsequent data reported.

We attempted regressions without the first three years of data, but decided to present the data for the full 1982–2007 period, as this was the data analyzed in the Texas A&M Transportation Institute's own calculations and analysis. The regression results did not improve with the omission, and none of the four results were very enlightening; for both the transit passenger-mile and unlinked passenger trip per capita data series, the regressions yielded positive coefficients, indicating that, as transit utilization increased, congestion increased, which is counter to the primary research hypothesis. (This was also the case for the regressions without the first three years of data.)

Graphs

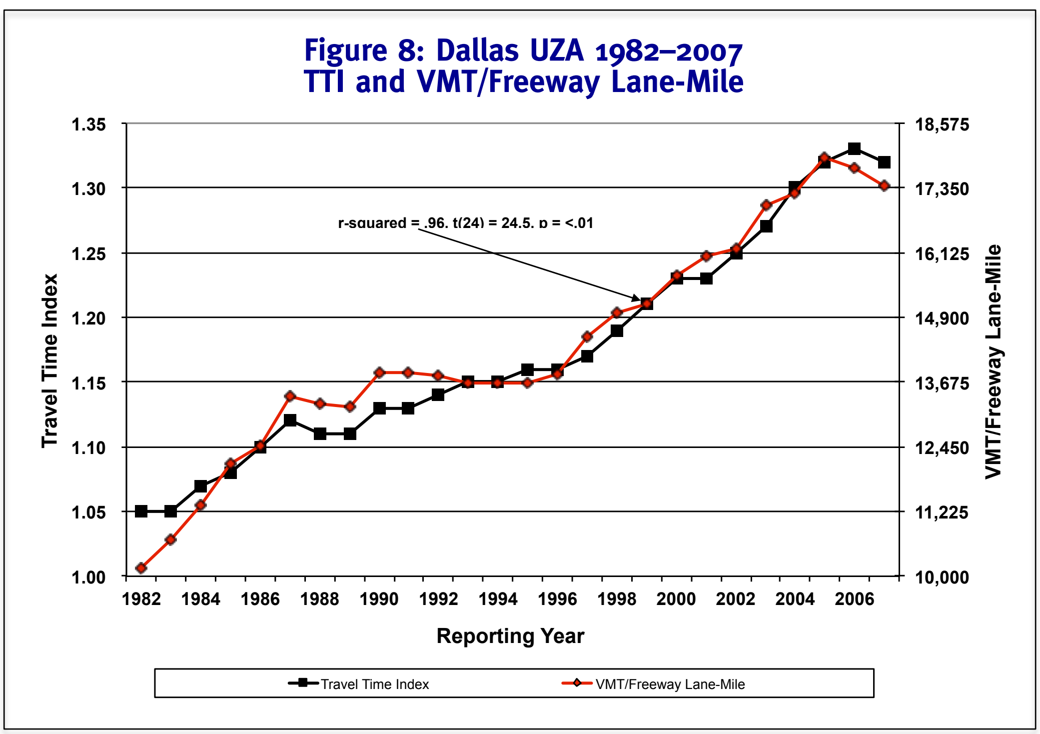


Figure 9: Dallas UZA 1982–2007
TTI and Transit Passenger-Miles/Capita

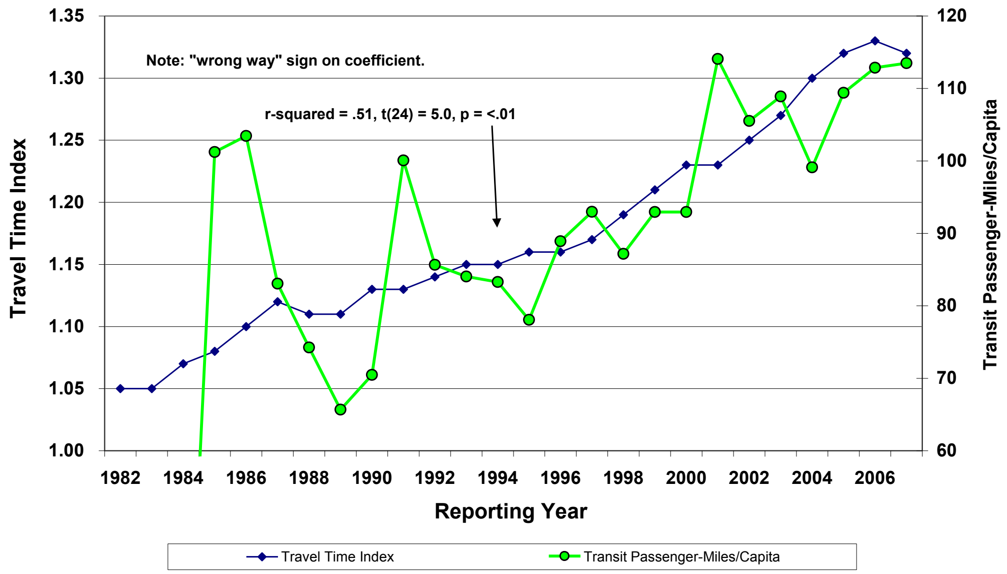
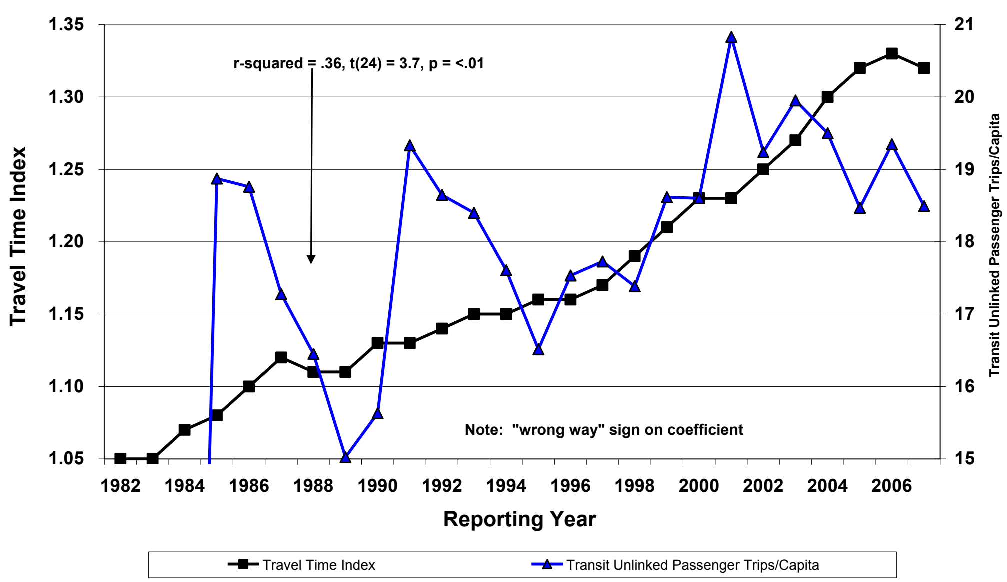


Figure 10: Dallas UZA 1982–2007
TTI and Transit Unlinked Passenger Trips/Capita



The transit utilization graphs should *not* be interpreted as showing that, in the Dallas UZA, increases in transit use cause increases in congestion. Rather, we interpret these results as indicating that the relationship between transit and congestion in the Dallas UZA is so weak that the regressions produce obviously meaningless results—or, perhaps, that both the increase in transit utilization and the increase in congestion are both effects of a single cause, or causes, such as a regional decision to devote available transportation funding to transit, rather than to roads.

Discussion

The Dallas-Fort Worth-Arlington UZA—aka the "Metroplex"—occupies all or portions of Collin, Dallas, Denton, Ellis, Johnson, Parker, Rockwell and Tarrant Counties, Texas.[34] It is a major U.S. transportation hub for all transportation modes except for water-borne transportation.

The most important Interstate highways are the north-south I-35, from Laredo to Minneapolis/Saint Paul, the nation's most important for road transportation to and from Mexico; east-west I-20, from Los Angeles (via I-10) to Atlanta and South Carolina; I-30, from Dallas to Little Rock and (via I-40) to Nashville and North Carolina; and I-45 linking Dallas to Houston. These Interstates are augmented by several local freeways.

The vast majority of transit service for Dallas is operated by the Dallas Area Rapid Transit Authority (DART) and the Fort Worth Transportation Authority (The T) and their joint venture, Texas Railroad Express. These entities provide bus, light-rail and commuter rail service.

Dallas, as a younger, Western city, does not have the long and continuous history of large-scale transit that older, eastern cities such as Chicago and New York City have. DART was established by a voter referendum in 1983. This referendum initiated a 1% sales tax for the purchase, operation and expansion of the former city of Dallas Transit System and the planning, design and construction of a rail system to serve the city of Dallas and the surrounding jurisdictions (now 12) on the Dallas side of the Metroplex.[35] As of 2009, the date of the TTI data used for this paper, DART had two light rail lines and a portion of a third in operation, with expansion of the third under construction, a downtown streetcar line, and it operates over 100 bus lines.[36] Further light rail lines and commuter rail are in various stages of planning and design.

DART is the 18th largest U.S. transit agency overall, the 23rd largest bus operator, the 10th largest light rail operator and the 28th largest paratransit operator.[37] DART has also funded the construction of a number of high-occupancy vehicle (HOV)/busway lanes. The T is a bus and demand-responsive operator, serving the city of Fort Worth with service to other near-by cities, and carries approximately 10% of the annual ridership of DART.[38] DART and The T jointly fund and operate Texas Railroad Express (TRE), a commuter rail system from downtown Dallas to downtown Fort Worth with access to DFW Airport.[39] TRE is the 12th largest commuter rail system (out of 21) in the nation.[40]

Over the period being studied, (excluding the first three years with questionable data), transit usage in Dallas has been mixed, with unlinked passenger trips/capita down 2% and passenger-miles/capita up 12%. This is a reflection of the emphasis on the construction and operation of rail service, light rail and commuter rail, as well as expansion of long-haul commuter express bus service, particularly to provide service to Dallas suburbs that are taxpaying jurisdictions within DART, both of which tend to have longer trip lengths.

C. Houston Urbanized Area

Statistics

Table 7: Houston Calculations

	1982	2007	2007 Rank	1982–2007 Growth
Population	2.40M	3.82M	14	59.0%
Population/Square Mile	1,569	1,987	35	26.6%
TTI	1.19	1.33	11	73.7%
Freeway VMT/Freeway Lane-Mile	14,440	18,824	10	30.4%
Arterial VMT/Arterial Lane-Mile	4,345	5,681	25	30.7%
Transit UPT/Capita	29	26	20	-7.9%
Transit PM/Capita	148	158	25	6.5%
Total Road-Miles/Million Population		2,872	17	
Freeway Centerline-Miles/Million		60	38	
Freeway Lane-Miles/Million		332	14	
Average Freeway Lanes/Mile		6.74	8	
Freeway Daily Modal VMT Equivalent		45.7%		
Arterial Daily Modal VMT Equivalent		40.3%		
Other Road Daily Modal VMT Equivalent		13.4%		
Transit Daily Modal VMT Equivalent		0.7%		

Table 8: Houston, ACS Home to Work Commute				
Minutes				
	Core City	Other	Whole	Rank
Road	25.4	28.8	27.3	
Transit	49.1	51.0	49.5	
Overall	25.5	28.1	26.9	64
Modal Splits				
Road	87.5%	92.6%	90.2%	
Transit	5.1%	1.6%	3.2%	
Other	7.4%	5.8%	6.5%	
Core City Population	47.3%			
Core City Workers	46.7%			

Graphs

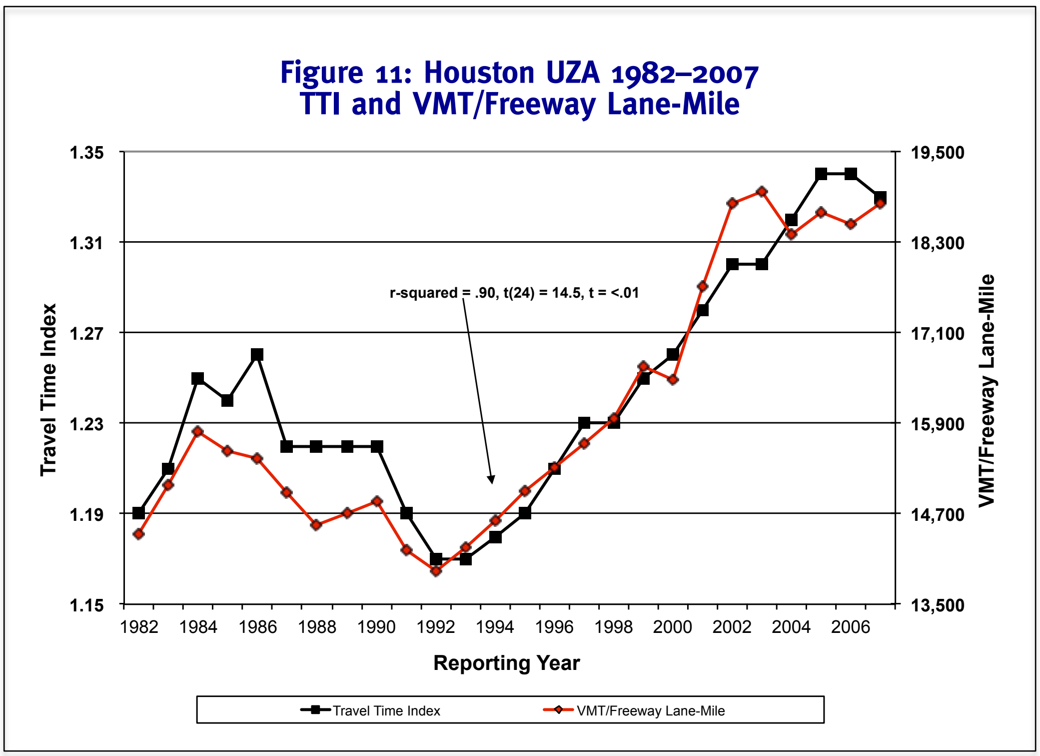


Figure 12: Houston UZA 1982–2007
TTI and Transit Passenger-Miles/Capita

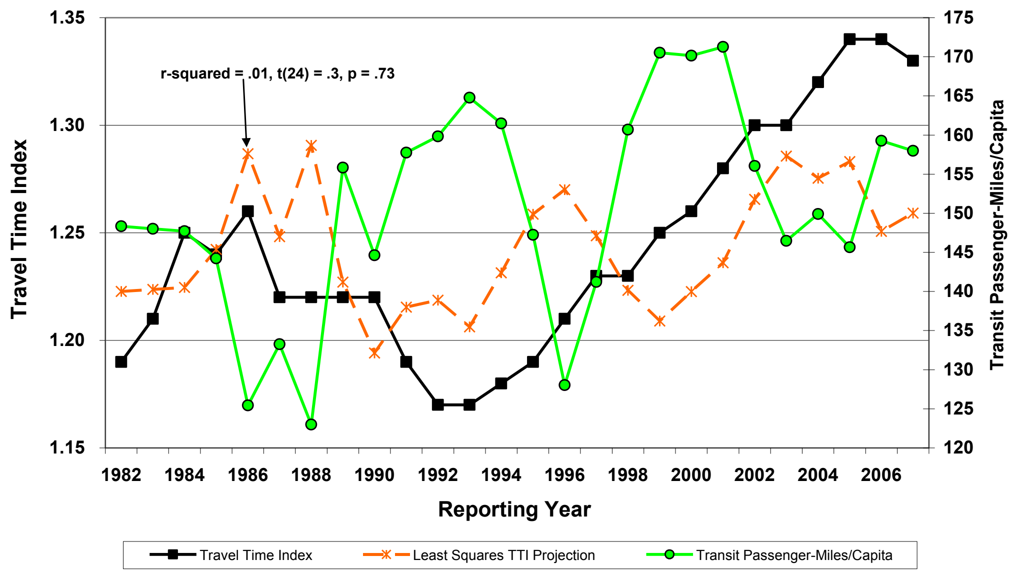
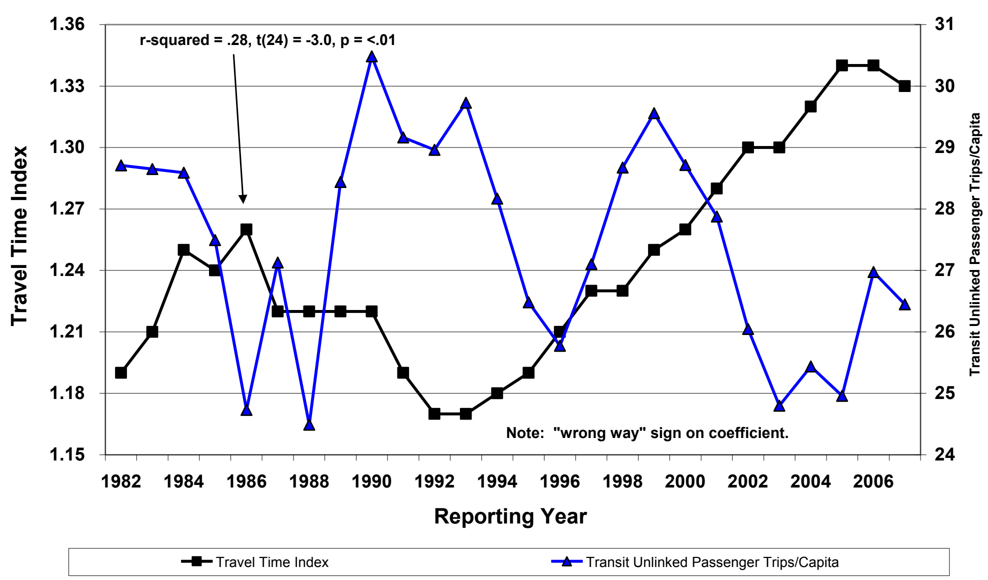


Figure 13: Houston UZA 1982–2007
TTI and Transit Unlinked Passenger Trips/Capita



Discussion

The Houston, Texas UZA includes the city of Houston and all or portions of Brazoria, Chambers, Fort Bend, Galveston, Harris and Montgomery Counties, Texas.[41] Houston, while a major transportation hub in its own right, is somewhat less of a hub than Dallas for surface modes. Unlike inland Dallas, Houston is a major seaport.

The most important Interstate Highways are the east-west I-10, the southern-most of the major east-west Interstates, stretching from Jacksonville, Florida to Los Angeles, and I-45 linking Houston to Dallas. (I-69, the "NAFTA Superhighway," which would run from Corpus Christi, Texas to Port Huron, Michigan, has had a few segments completed, including a 35-mile segment from the beltway North to Liberty County.) These Interstates are augmented by several local freeways.

Like other major Sunbelt cities, Houston had not, until very recently, developed modern rail transit after it abandoned its former streetcar system. The Metropolitan Transit Authority of Harris County (Metro) was created by a vote of the Harris County electorate in 1977. Under the Texas statute that created the organization, it is funded by a 1% local sales tax.[42]

Metro operates almost all of the transit service in Houston. It currently operates over 100 bus lines, including extensive commuter express bus service on high-occupancy lane/busways that Metro constructed. Metro began service on its first light rail line (the 7.5-mile, 16-station Red Line, which operated from the north side of downtown Houston through the Medical Center to the Astro Complex south of downtown) on Superbowl Sunday in 2004. Metro is currently planning six other light-rail lines or extensions, five of which it is attempting to construct simultaneously. Metro is also planning three commuter rail lines and extensive bus rapid transit lines.[43]

Metro is the 16th largest U.S. transit agency overall, the 11th largest bus operator, the 13th largest light rail operator, the ninth largest paratransit operator and the second largest vanpool operator.[44]

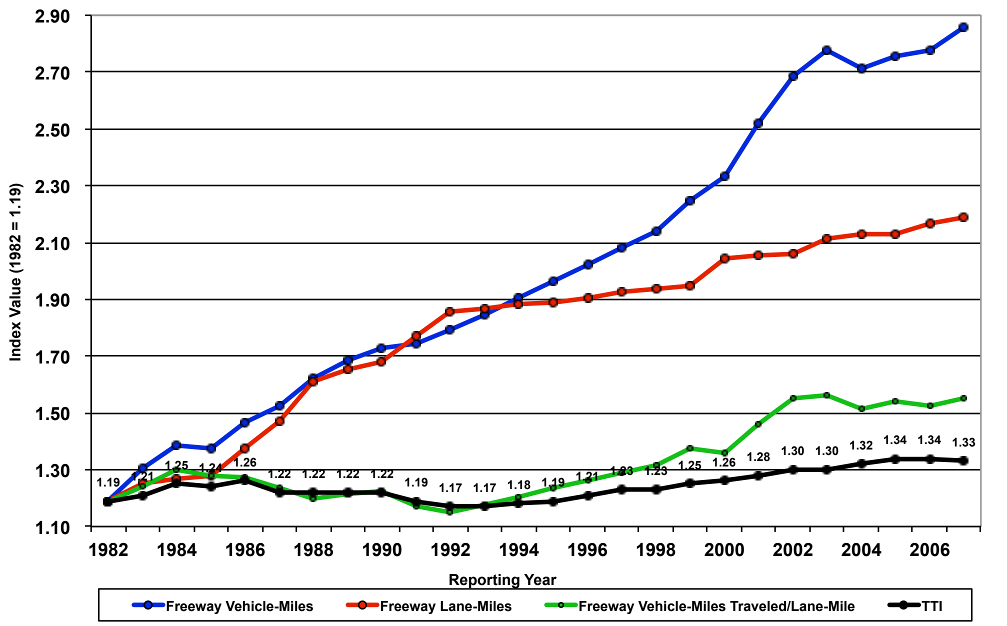
From the statistics in the table below it is easy to justify the key role of VMT/freeway lane-mile in the growth of congestion and the lack of significance of transit; the former has over 65 times the daily mode share and has grown quickly, while the latter is minor and has changed very little.

Houston's TTI time series has an interesting, almost unique, pattern, which appears to directly relate to the trends in freeway VMT and lane-miles, as shown below.[45]

Table 9: Houston TTI and Freeway Time Series 1982–2007

Year	TTI	TTI Rank	Freeway VMT	Freeway Lane-Miles	VMT/Freeway Lane-Mile
1982	1.19	3	20,000	1,385	14,440
1983	1.21	2	21,930	1,455	15,072
1984	1.25	1	23,280	1,475	15,783
1985	1.24	3	23,135	1,490	15,527
1986	1.26	3	24,680	1,600	15,425
1987	1.22	6	25,635	1,710	14,991
1988	1.22	6	27,280	1,875	14,549
1989	1.22	9	28,310	1,925	14,706
1990	1.22	11	29,055	1,955	14,862
1991	1.19	13	29,280	2,060	14,214
1992	1.17	20	30,095	2,160	13,933
1993	1.17	22	31,000	2,175	14,253
1993	1.18	20	32,000	2,190	14,612
1995	1.19	21	33,000	2,200	15,000
1996	1.21	19	34,000	2,220	15,315
1997	1.23	15	35,000	2,240	15,625
1998	1.23	17	36,000	2,255	15,965
1999	1.25	16	37,730	2,265	16,658
2000	1.26	15	39,195	2,380	16,468
2001	1.28	13	42,320	2,390	17,707
2002	1.30	10	45,165	2,400	18,819
2003	1.30	13	46,665	2,460	18,970
2004	1.32	9	45,630	2,480	18,399
2005	1.34	11	46,350	2,480	18,690
2006	1.34	10	46,700	2,520	18,532
2007	1.33	11	48,000	2,550	18,524

Figure 14: Houston UZA Freeway Vehicle-Miles, Freeway Lane-Miles, Freeway VM/LM and TTI



The pattern of TTI can be broken into three phases (which are summarized graphically above):

- **Phase I** – 1982–1986, when freeway VMT grew by 23.4%, outpacing the growth of freeway lane-miles of 15.5%, leading to growth of VMT/freeway lane-mile of 6.8%, and TTI increased from 1.19 to 1.26 (37% increase in congestion). Houston's TTI in 1984 was 1.25, making Houston's TTI for that year the worst of any UZA, the *only* year that Los Angeles was not number one.
- **Phase II** – 1986–1993, when freeway VMT grew by 25.6%, but freeway lane-miles grew 35.9%, leading to a reduction in VMT/freeway lane-mile of 5.3%. During this time TTI decreased from 1.26 to 1.17 (35% decrease in congestion). At the end of this period, Houston's TTI ranking was 22nd.
- **Phase III** – 1993–2007, when freeway VMT grew by 54.8%, outpacing the growth in freeway lane-miles of 17.2%, with VMT/freeway-mile growing by 30.0%. During this time TTI increased from 1.17 to 1.33 (94% increase in congestion). At the end of the period, overall,

> Houston's TTI was the 11th worst in the nation. Considering that Houston started as third worst in 1982, and was the absolute worst in 1984, moving eight to 10 places down the listing should be regarded as a significant positive accomplishment.

What occurred in Houston from 1986 to 1993—a reduction of nine points in the TTI score—has no real equal in the other 73 UZAs over this period.[46] Not only was the increase in traffic congestion in one of the most congested UZAs in the nation stopped, *but reversed*, during a time of continued significant growth in VMT. This was evidently accomplished by expansion of the capacity of the road system.[47]

Houston addressed congestion far differently from Los Angeles, which many consider the epicenter of the American urban freeway system.[48]

- Over the period 1982–2007 Houston population grew 59%, while Los Angeles grew 29%.
- While Houston is located in a flat coastal plane, providing excellent opportunities for growth in almost all directions (except into the Gulf of Mexico), the mountains that surround and divide greater Los Angeles, as well as the Pacific Ocean, severely limit opportunities for greenfield development. The same mountains also pose significant problems for roadway development and expansion in the developed areas.
- Houston freeway daily vehicle-miles (DVM) grew by 140%, while Los Angeles grew by 94%.
- DVM/capita grew almost identically, 51% for Houston vs. 50% for Los Angeles–and Houston's was 11% higher in 2007.
- Houston freeway lane-miles grew by 84%; in contrast, Los Angeles freeway lane-miles grew by 44%.
- Houston's freeway structure can be characterized as a "hub-and-spoke," with a series of freeways radiating outward in all directions from downtown and a series of ring roads with successively longer diameters; Los Angeles's is more of a grid structure.
- Only one planned Houston freeway, the Harrisburg Freeway (which would have been a "spoke" at approximately the four o'clock position

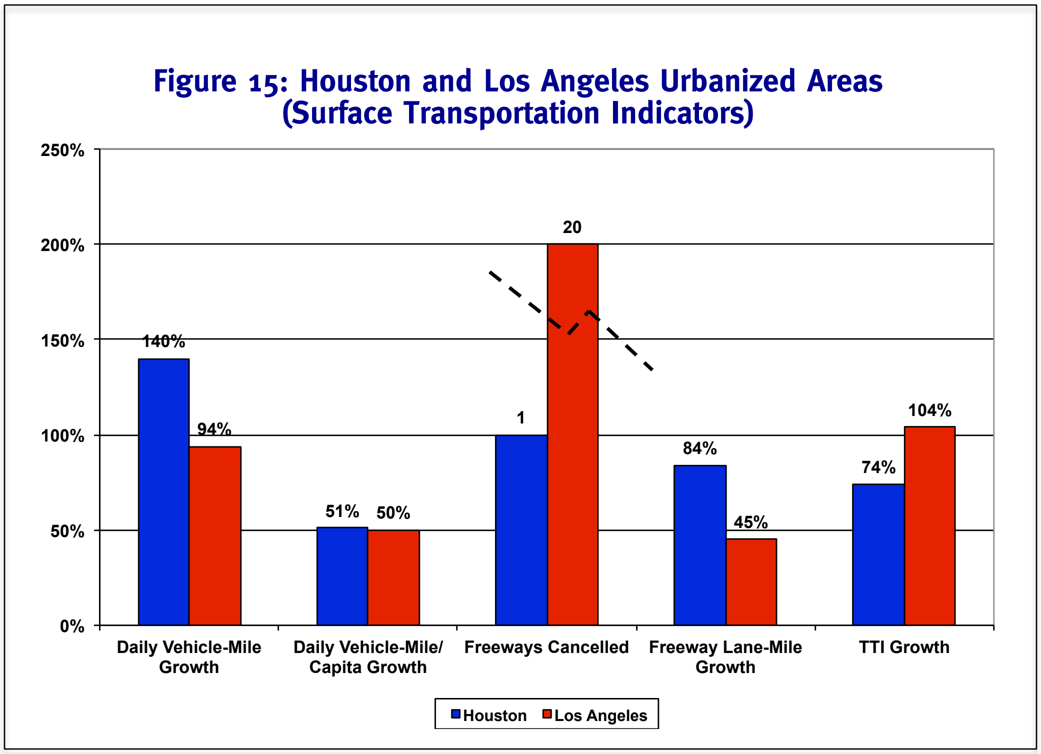
from the Houston CBD) has ever been cancelled.[49] Approximately 20 planned Los Angeles freeways have been cancelled.[50]

- Both Los Angeles and Houston have been leaders in freeway design. Los Angeles claims the world's first four-level directional interchange (aka "stack" interchange, aka "four-stack") at the intersection of the Hollywood (US 101) and Harbor/Pasadena (CA 110) Freeways near the northeast corner of the Los Angeles CBD, completed in 1949.[51] Houston has topped this with several five-level interchanges.[52] The fifth level is for U-turn lanes for the one-way frontage roads that, almost uniquely to Houston, parallel many local freeways.

The obvious conclusion is that Los Angeles had, with a few major exceptions, completed building its new freeways by the 1970s. Most Los Angeles highway construction projects are now freeway-widening projects, including HOV lanes, plus some toll roads and high-occupancy toll projects, primarily in Orange County.[53]

Houston, on the other hand, is actively pursuing freeway extension projects, as well as widening projects. The work toward completion of the third loop, The Grand Parkway, SH 99, is the most significant extension.[54] The Katy Freeway (I-10 west of the CBD) widening, adding four continuous through-lanes, plus two special use (HOV/busway/toll) lanes in each direction, plus significant frontage road expansion and enhancements, make this one of the highest capacity roadway systems in the world.[55]

From this comparative analysis of Houston and Los Angeles, their respective freeway and transit expansion plans, and the results achieved, the only logical conclusion that can be reached is that Houston has been far more successful in holding down increases in congestion than Los Angeles because it has done far more to expand its freeway system. It is interesting that the reaction of the transportation leadership of Houston to this roadway expansion-based success has been to initiate a major rail transit construction program.



D. Los Angeles Urbanized Area

Statistics

Table 10: Los Angeles Calculations

	1982	2007	2007 Rank	1982-2007 Growth
Population	9.90M	12.80M	2	29.3%
Population/Square Mile	5,410	5,664	1	4.7%
TTI	1.24	1.49	1	104.2%
Freeway VMT/Freeway Lane-Mile	17,742	23,806	1	34.2%
Arterial VMT/Arterial Lane-Mile	5,445	5,929	18	8.9%
Transit UPT/Capita	56	56	10	0.3%
Transit PM/Capita	221	252	11	13.9%
Total Road-Miles/Million Population		2,015	71	
Freeway Centerline-Miles/Million		55	71	
Freeway Lane-Miles/Million		455	60	
Average Freeway Lanes/Mile		8.33	1	
Freeway Daily VMT Modal Equivalent		49.1%		
Arterial Daily VMT Modal Equivalent		44.3%		
Other Road Daily VMT Modal Equivalent		4.4%		
Transit Daily VMT Modal Equivalent		2.2%		

Table 11: Los Angeles American Community Survey, Home to Work Commute

Minutes				
	Core City	Other	Whole	Rank
Road	27.5%	27.2	27.3	
Transit	46.3%	48.4	47.0	
Overall	27.7%	26.6	27.0	65
Modal Splits				
Road	79.6%	88.4%	85.1%	
Transit	10.5%	3.7%	6.2%	
Other	9.9%	7.9%	8.7%	
Core City Population	37.5%			
Core City Workers	37.6%			

Graphs

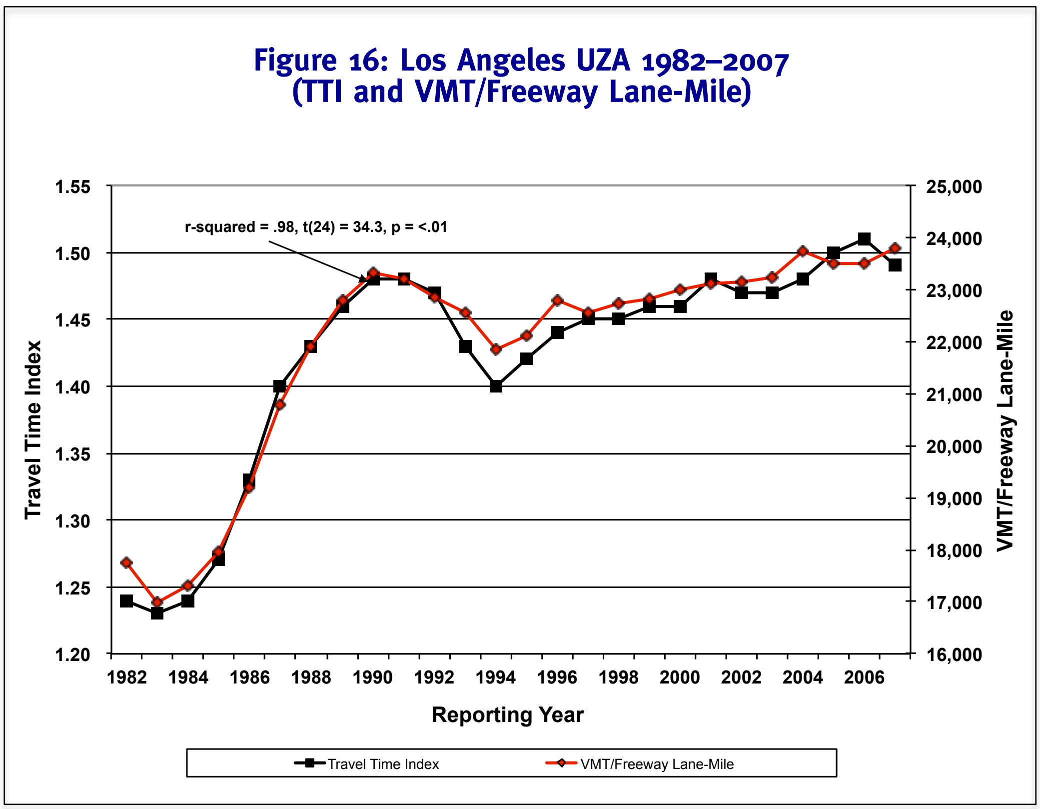


Figure 17: Los Angeles UZA 1982–2007
(TTI and Passenger-Miles/Capita)

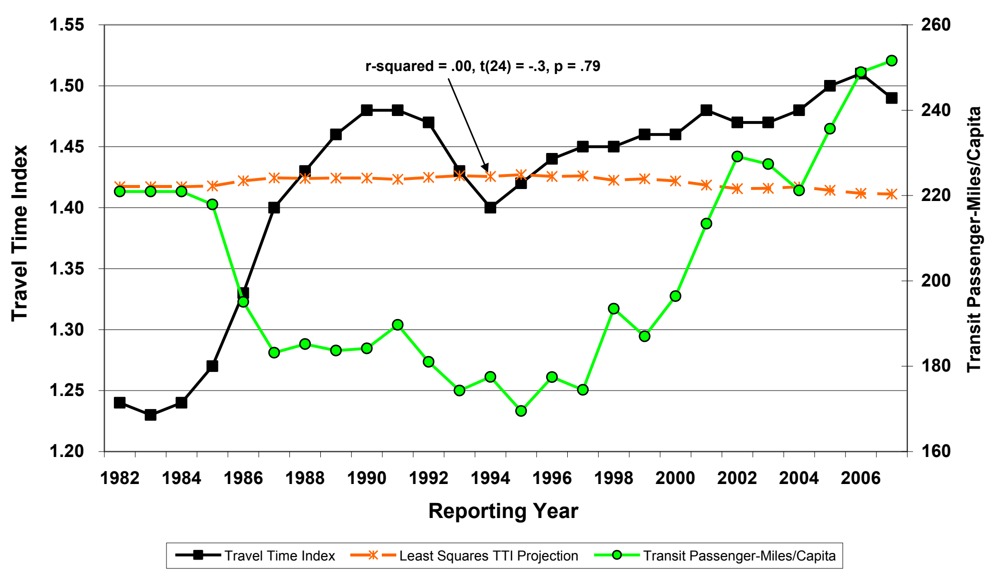
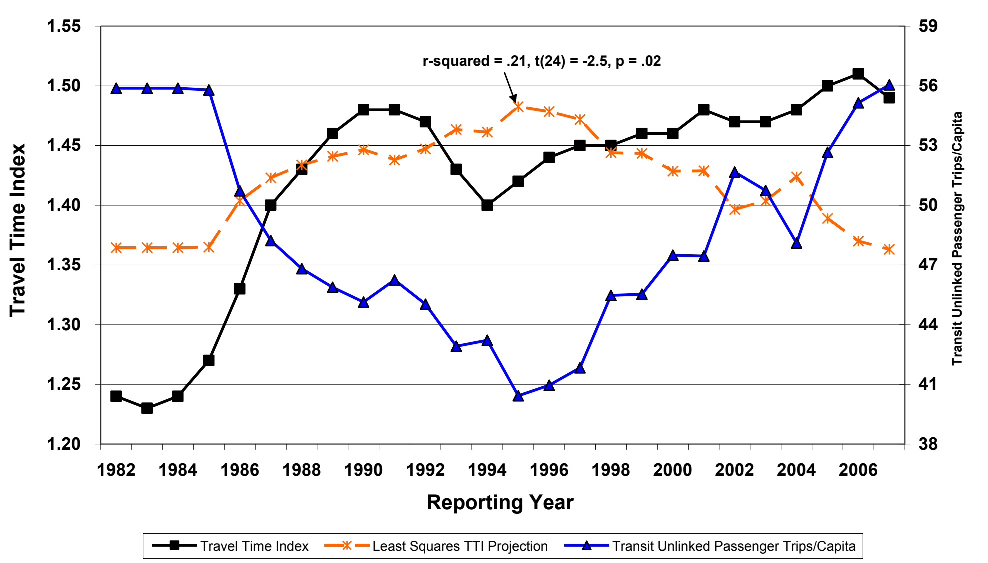


Figure 18: Los Angeles UZA 1982–2007
(TTI and Transit Unlinked Passenger Trips/Capita)



Discussion

The Los Angeles-Long Beach-Santa Ana CA UZA includes the three named cities and portions of Los Angeles, Orange, Riverside, San Bernardino and Ventura Counties, California.[56]

Los Angeles is the second-largest UZA in the nation by population. Located on the Pacific coast near the southwest corner of the contiguous 48 states, it is more of an origin and a destination than a crossroads for surface transportation modes, although it is a major air and ocean shipping trans-shipment point. The Ports of Long Beach and Los Angeles combined are by far the nation's largest container port. They serve as the United States' freight gateway to/from the Pacific and generate large freeway and rail freight traffic volumes.

The most important Interstate Highways are I-5, from the Mexican Border at San Diego to the California Central Valley and north to Portland, Seattle and Vancouver, British Columbia; I-10 eastward to Phoenix, Dallas/Fort Worth (via I-20), Houston, New Orleans and Jacksonville, Florida; I-15, from San Diego to Las Vegas, Salt Lake City and north to Alberta, Canada; and I-40, which branches from I-15 northeast of Los Angeles to Albuquerque, Oklahoma City, Memphis and North Carolina. There are also numerous state and local freeways.

There are well over two-dozen individual agencies providing transit service in Los Angeles. Of these, the largest is the Los Angeles County Metropolitan Transportation Authority (Metro), which was formed in 1993 through the merger of the former Southern California Rapid Transit District, the largest transit operator, and the former Los Angeles County Transportation Commission, the county transportation planning, funding and oversight agency.[57] Of the 717.4 million transit unlinked passenger trips (UPT) and 3,220.2 million transit passenger-miles (PM) in the UZA for 2007, Metro carried approximately 69% of the UPT and 63% of the PM.[58] In that year, Metro was the third largest transit system in the nation overall, the second largest bus operator, the ninth largest heavy rail operator, the third largest light rail operator and the 33rd largest vanpool operator.[59]

To a large extent, Los Angeles grew along Henry Huntington's Red Car lines, which, at its peak, had over 1,150 miles of track in four counties, but, by 1961, the last Red Car was retired from the last remaining route.[60] In 1990, the

Blue Line (light rail) began service over what is, in many places, the same alignment as the last Red Car line.

However, the longest operating guideway transit line in Los Angeles is not a rail line, but the highly successful El Monte Busway/HOV lane on the I-10 San Bernardino Freeway, running approximately 11 miles from El Monte almost due west to the city of Los Angeles central business district, which opened for bus use in 1973 and three-person carpools in 1976.[61] During peak hours, the Busway/HOV lane carries more passenger-miles than the four general-purpose lanes *combined*.[62] (Metro and Caltrans, with the assistance of Federal funding, are converting these HOV lanes to HOV/HOT lanes.) The Harbor Freeway Busway/HOV lane opened in 1996 and has also recently been converted to HOV/HOT.

The Blue Line was joined in 1993 by the Red Line (heavy rail subway) from Union Station through downtown Los Angeles, completed to North Hollywood in the San Fernando Valley in 2000. A short stub, the Purple Line, extends due west along Wilshire Blvd., the first leg of what is now being proposed as the "subway to the sea" at Santa Monica. The Green Line (100% exclusive guideway light rail) began east-west service between Norwalk and Redondo Beach in 1995, and the Pasadena Gold Line entered service (light rail to downtown) in 2003. The Orange Line (San Fernando Valley bus rapid transit [BRT] on semi-exclusive busway) opened in 2005, and the Gold Line Eastside extension entered service to East Los Angeles in 2009.[63] The first leg of the Expo Line, which is intended to eventually reach Santa Monica, opened to Culver City in 2012.[64] Metro also has several other major rail and BRT transit projects in various stages of planning, design and construction.[65]

The Southern California Regional Rail Authority (Metrolink) is the commuter rail operator for the five counties (Los Angeles, Orange, Riverside, San Bernardino and Ventura) that are members of the joint powers agreement.[66] Metrolink also operates service to northern San Diego County. It operates seven lines, six of which terminate at Los Angeles Union Station, and the seventh connects San Bernardino and Riverside Counties to Orange County and northern San Diego County.[67] Metrolink is the seventh largest commuter rail operator in the nation.[68] Its UPT are approximately 2.5%, and its PM approximately 20%, of Metro's.[69]

The Orange County Transportation Authority (OCTA) is the primary transit operator for intra-county service in California's second most populous county. It is the 26th largest transit operator in the nation overall, the 17th largest bus operator, and the 12th largest paratransit operator.[70] Its UPT and PM are both approximately 14% of Metro's.[71]

Over the period being studied, transit unlinked passenger trips/capita were flat and passenger-miles/capita up 14%. The former reflects a shift of transit emphasis from operating bus routes to funding rail system expansion; the latter is driven primarily by the addition of Metrolink's long-haul transit services (average trip length over 34 miles) midway through the study period.[72] For 2007, Los Angeles was 10th in unlinked transit trips/capita and 11th in transit passenger-miles/capita. Transit utilization in Los Angeles is below that of the other largest UZAs in the U.S., particularly the older eastern cities such as New York, but usage is large by any other comparison.

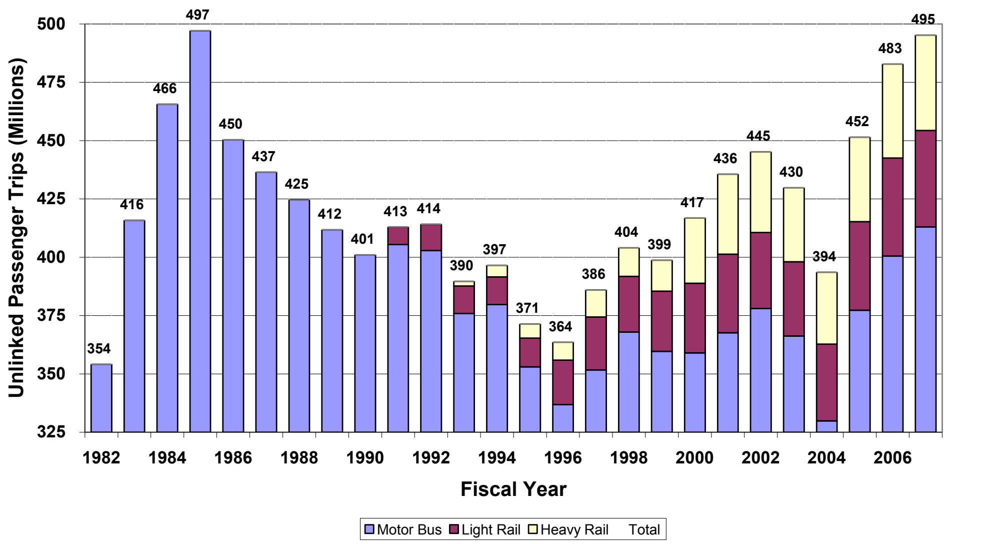
Los Angeles is the second largest UZA in terms of total population; in terms of population density, it is, by far, the densest, with 49% more residents per square mile than New York City despite the popular misconception that Los Angeles has relatively low density.[73] However, the Los Angeles UZA has a "different" type of density than most other major U.S. urbanized areas, with the core city density being much lower than other super dense metro areas such as New York City or Chicago. Eric Eidlin stated, "Los Angeles has 'dense sprawl.' Or, to be less charitable, it has dysfunctional density."[74] However, as we will see, whether or not the system is dysfunctional is in the eye of the beholder.

Interestingly, despite having had the highest TTI score of any UZA every year but one since the first UMR came out, Los Angeles does *not* have the longest home-to-work commute time, coming in 65th at 27.0 minutes and beating out Lancaster/Palmdale (35.4), New York City (33.1), Washington (30.9), Chicago (29.7), Riverside-San Bernardino (29.4), Atlanta (29.0), Poughkeepsie-Newberg (28.3), Boston (27.3) and Miami (27.1).[75] One of the reasons is that Los Angeles, with one of the smallest downtowns per capita of any UZA, actually has one of the best jobs-homes balances in the U.S., ranking fourth best in 1990 among the 40 largest UZAs.[76] This means that many Los Angeles residents have somewhat shorter home-to-work commutes than those who reside elsewhere, and that the usually very congested commutes to the core CBD are minimized, compared to other major UZAs. This distribution of jobs, which appears to produce a somewhat superior matching of job to residence locations than in the other very large UZAs mentioned above, appears to be a "functional" type of sprawl which moves peak period travel away from the most overcrowded freeway system in the U.S.

One of the key reasons for this is a very strong network of arterial grid streets. While major segments of the region have irregular streets, particularly in the mountainous areas, many major areas—including most of the region around downtown Los Angeles and south and west, most of the San Fernando Valley, and large portions of Orange County—have a grid system of major arterials one mile apart with a semi-arterial splitting the distance. This system of arterials, coupled with the relatively minor role of the central business district compared to other major urbanized areas (which means distributed jobs and other trips), allows the Los Angeles system of freeways and surface streets to manage traffic surprising well, particularly when compared to cities like Atlanta and Boston, which notoriously lack such high-capacity grid system surface streets. The city of Los Angeles also has one of the most professional, and most effective, traffic engineering departments in the nation.[77]

Transit usage in Los Angeles over this period offers a unique opportunity to track the impact of transit on congestion, as the 26-year period cleanly divides into three shorter periods, each with a very significant change in transit usage. We will track the ridership of SCRTD/Metro, which, for the peak year of 1985, constituted 85% of total UZA ridership, declining relatively steadily to 69% in 2007.[78]

Figure 19: Southern California Rapid Transit District/Los Angeles County Metropolitan Transportation Authority Unlinked Passenger Trips 1982–2007



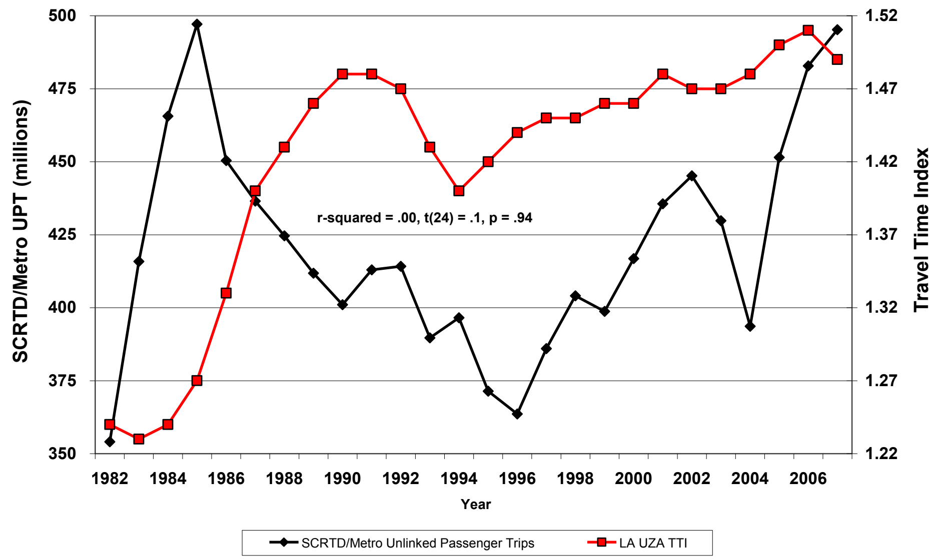
- 1982–1985 – Following the passage of Proposition A, the first (of three) half-cent sales taxes primarily for transit in Los Angeles County, and in accordance with the terms of the Proposition, LACTC reduced SCRTD adult cash fares from \$.85 to \$.50, and reduced other fares proportionately, for the three-year period from 1983 to 1985.[79] Ridership (UPT) increased slightly over 40%, with peak-period ridership up over 36%, despite transit vehicle revenue-miles only increasing 1.5%.[80] (A transit vehicle revenue-mile is a transit vehicle traveling one mile in revenue service.) This is the most successful short-term transit utilization improvement in the U.S. since World War II. Unfortunately, because the TTI database records the years 1982–1984 with the same UPT for the entire UZA (553.2 million, increasing to 585.8 million in 1985), we are unable to determine the impact that this major increase in transit utilization would have had on TTI scores with proper data.
- 1985–1996 – During this period, the LACTC, again in accordance with the terms of Proposition A, ceased using part of the Proposition A funds for the SCRTD fare reduction program and shifted emphasis to planning, design and construction of rail transit (during the three years of the 50-cent fare, slightly under 20% of the total Proposition A sales tax

revenues had gone for this purpose).[81] Two light rail lines and part of the heavy rail system went into service during this period. As the adult cash fares increased from 50¢ in 1985 to 85¢ in 1986 to $1.10 in 1988 and $1.35 in 1994, SCRTD UPT declined approximately 27%.[82]

- 1996–2007 – As a direct result of the 1994 fare increase passed by the MTA Board—which targeted eliminating monthly passes, which were extensively utilized by transit-dependent riders and, therefore, would have amounted to approximately a doubling of average fares—a federal Title VI (discrimination in the utilization of federal funding) legal action was filed against Metro (see box below).[83] This produced a Consent Decree (CD) that remained in force during the remaining portion of the study period.[84] The CD required Metro to reintroduce the $42 monthly transit pass, institute a new $11 weekly pass, increase bus service to reduce extreme bus overcrowding and add additional bus lines.[85] After 11 years of losing an average of 12 million UPT a year, the CD requirements not only immediately stopped the loss, but turned it around, producing an average annual increase of 12 million UPT—a 36% increase over this period. While Metro rail ridership increased significantly during the 1996–2007, period, 58% of the added riders were bus riders and approximately 60% of the new rail riders were former bus riders.[86] Using the FTA "new starts" methodology for annualizing costs, the average taxpayer subsidy per new passenger, expressed in FY07 dollars, was $1.40 for the bus riders added by the CD, vs. $25.82 for the added rail transit (Blue, Gold, Green, Orange and Red Line).[87] This equates to a taxpayer subsidy per new passenger ratio of 1:18.4, whereas adding transit trips via bus required a taxpayer subsidy of 5.4% of the cost of adding transit trips via guideway transit (rail and dedicated busway surface bus rapid transit).

Despite these major large changes in transit utilization over these three periods—rapidly up, then down, and then up again—there is no significant relationship between transit usage and TTI, as can be seen in the results reported in the following graph. The correlation is not just low; at $r^2 = .00$, there is no relationship at all.

**Figure 20: Los Angeles UZA
SCRTD/Metro Unlinked Passenger Trips and Travel Time Index**



Even in the most congested UZA in the nation, even with the largest change in transit utilization of any UZA in this time period and two more of the largest changes for the third largest transit agency in the nation which serves the core of the UZA where traffic congestion is the worst, there is no discernible trend in the data that supports a connection between transit utilization and TTI.

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Labor/Community Strategy Center et al. v Los Angeles County Metropolitan Transportation Authority et al.

United States District Court—Central District of California, Case No. CV 94–5936 TJH (MCx)

Proceeding before Special Master Donald T. Bliss—Memorandum Decision II and Final Order on Remedial Service Plan to Meet 1.25 and 1.20 Load Factor Target Requirements

January 12, 2004

Excerpt

The following is an excerpt from the Special Master Donald T. Bliss decision in the long-running legal battle between the parties in regard to MTA's compliance with the terms of the Consent Decree (CD) *re Labor/Community Strategy Center v. MTA*, a Federal Title VI (discrimination in the utilization of Federal Funds) lawsuit originally filed in 1994, and "settled," via the CD, in 1996.

The specific question before the Special Master was the amount of bus service that MTA would have to add to come into compliance with the load factor reduction elements of the CD. This included how many hours of service, the number of buses to be purchased, and a variety of other matters. In ruling on the specifics, both in the larger sense and in the details, Special Master Bliss—while giving neither side all that it was seeking—was generally far closer to the plaintiff's positions on most matters, including the main issues, the number of hours of service to be added and the number of buses that would have to be purchased.

All paragraphs are Special Master Bliss' words; he is *not* quoting any other party:

"MTA's new management apparently is not pleased with the way the Consent Decree entered into by its predecessors has been implemented. In his declaration, David Yale states that "the Consent Decree has had no benefits that could not have been achieved without the Decree, and it has diverted significant financial resources in process to questionable bus service expansions," Yale

Decl. 19, which are "a poor investment of scarce public funding." Id. 17. Moreover, according to Mr. Yale, "the Consent Decree has, and will continue to have, detrimental impacts on the Regional Transportation System in Los Angeles County for many years to come." Id. 4. Without the Decree, Mr. Yale states that the MTA "would have had additional financial resources" for highway construction. Id. Mr. Yale candidly acknowledges that "the MTA has carefully developed a <u>short range plan</u> that balances these needs as best it can under the constraints of the Consent Decree...." Id. (emphasis added). However, Mr. Yale continues, "any further unanticipated financial changes that are needed for the Decree <u>will have to be undone as soon as the Decree expires in early FY 2007….</u>" Id. (emphasis added).

"Given these views on the alleged shortcomings of the Consent Decree presented by an MTA planning official in the record of this proceeding, it is all the more imperative that the MTA commit to a specific bus capacity expansion program that will provide lasting improvements in the quality of bus service for the transit-dependent—in accordance with the letter and spirit of the Consent Decree—beyond the expiration of this Decree. It should be noted that Mr. Yale's views present an interesting contrast to what the MTA staff apparently wrote, at least with respect to the procurement of new buses, in a briefing for the MTA Board on the Consent Decree. The staff outlined the benefits of compliance with the Decree, including the transformation of the MTA bus fleet from "the oldest to the newest fleet of major bus companies," and stated that "MTA's new buses are worth every penny." See Declaration of Thomas A. Rubin Re Consent Decree Costs at Attachment II (Oct. 14, 2003) ("Rubin Decl. Re Consent Decree Costs") (briefing update on Consent Decree prepared by MTA staff dated September 19, 2002).

"Furthermore, the BRU and its expert, Thomas Rubin, who have been sharply critical of the MTA's implementation of the Decree, also have presented a more positive view of the benefits achieved by the Decree in improving bus service for transit-dependent riders, which is, after all, the singular purpose of the Decree. In his Declaration Re Reallocation of MTA Funds, Mr. Rubin analyzes in detail the effects of the Consent Decree, finding that in the six-year post-Consent Decree period, the MTA has gained a total of 81.6 million annual riders. Rubin Decl. Re Reallocation of Funds 23. According to Mr. Rubin, MTA ridership increased from 364 million in 1996 to 445 million in 2002, resulting in an increase in total fare revenues of $100.5 million over the six-year period. Rubin Decl. Re Consent Decree Costs at 3. This in stark contrast to a loss of 133.6 million annual passengers over the eleven year period preceding the Consent Decree. Rubin Decl. Re Reallocation of Funds 23. Mr. Rubin also shows that, even taking into account what he views as "extremely overstated" Consent Decree expenditures per new rider, the cost per new rider—83% of whom are bus riders—is still far below other transit modes. Id. 25, 26, 28. Mr. Rubin describes other benefits of the Consent Decree: "The [Consent Decree] has made great progress in reducing overcrowding, and pass-by's, on MTA bus routes …MTA service has also become more reliable and the condition of MTA's bus fleet improved substantially as the average age has decreased. The fares to ride MTA bus and rail have been kept low for MTA's huge numbers of extremely low-income riders. The service added for CD compliance has meant shorter headways, and the reduced overcrowding has decreas[ed] running times, speeding travel for these bus riders. The Rapid Bus Program, which MTA has claimed as a [Consent Decree] cost …is another significant benefit for bus riders. Many new bus lines have begun service. The speed-up of bus replacement has meant cleaner air for all Los Angeles County residents…. All in all, hundreds of thousands of MTA bus and rail riders each day, and many more non-transit users, are receiving benefits in lower cost transit; a faster, higher quality, and more reliable transit experience; access to new destinations; and improved environmental quality and traffic flow—all due to the workings of the [Consent Decree]." Id. 27.

"Hopefully, these benefits are not the temporary results of a "short range plan" due to expire at the end of the Consent Decree but rather are permanent improvements in the quality of bus service that will be sustained well beyond the Decree's expiration."

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E. New York City Urbanized Area

Statistics

Table 12: New York City Calculations

	1982	2007	2007 Rank	1982–2007 Growth
Population	15.50M	18.23M	1	17.6%
Population/Square Mile	4,874	3,789	5	-22.3%
TTI	1.10	1.37	T5	270.0%
Freeway VMT/Freeway Lane-Mile	10,610	16,527	23	55.8%
Arterial VMT/Arterial Lane-Mile	3,128	5,186	34	65.2%
Transit UPT/Capita	226	222	1	-1.6%
Transit PM/Capita	1,053	1,175	1	11.6%
Total Road-Miles/Million Population		2,396	67	
Freeway Centerline-Miles/Million		67	65	
Freeway Lane-Miles/Million		396	67	
Average Freeway Lanes/Mile		5.95	17	
Freeway Daily VMT Modal Equivalent		34.2%		
Arterial Daily VMT Modal Equivalent		29.4%		
Other Road Daily VMT Modal Equivalent		24.1%		
Transit Daily VMT Modal Equivalent		12.2%		

Table 13: New York City, American Community Survey Home to Work Commute

Minutes				
	Core City	Other	Whole	Rank
Road	31.7	26.7	27.9	
Transit	48.5	59.8	51.0	
Overall	37.6	29.4	33.1	73
Modal Splits				
Road	30.1%	79.1%	57.1%	
Transit	53.7%	12.5%	31.0%	
Other	16.2%	8.4%	11.9%	
Core City Population	46.8%			
Core City Workers	44.9%			

Figure 21: New York City UZA TTI and VMT/Freeway Lane-Mile

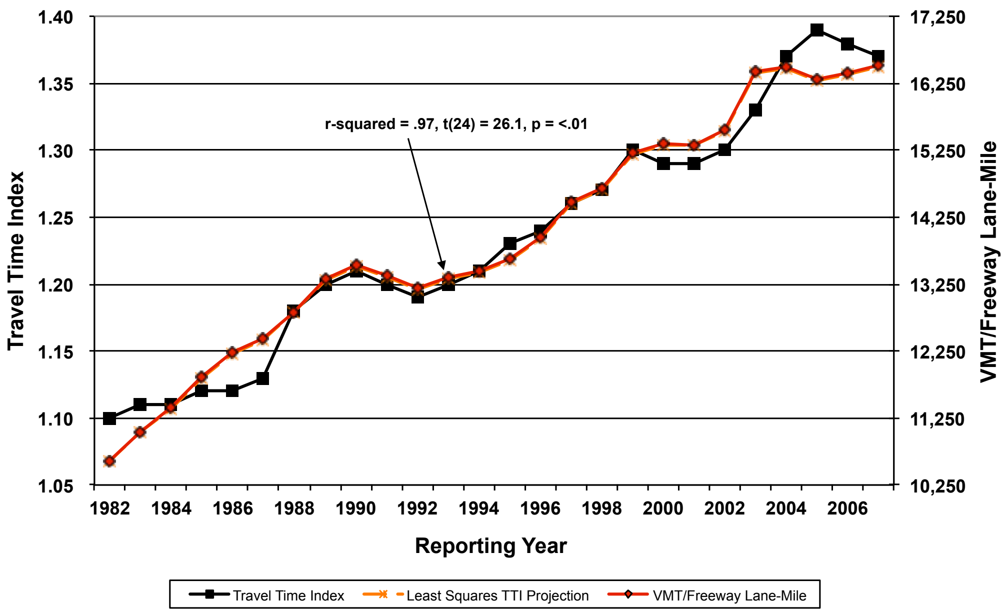


Figure 22: New York City UZA TTI and Transit Passenger-Miles/Capita

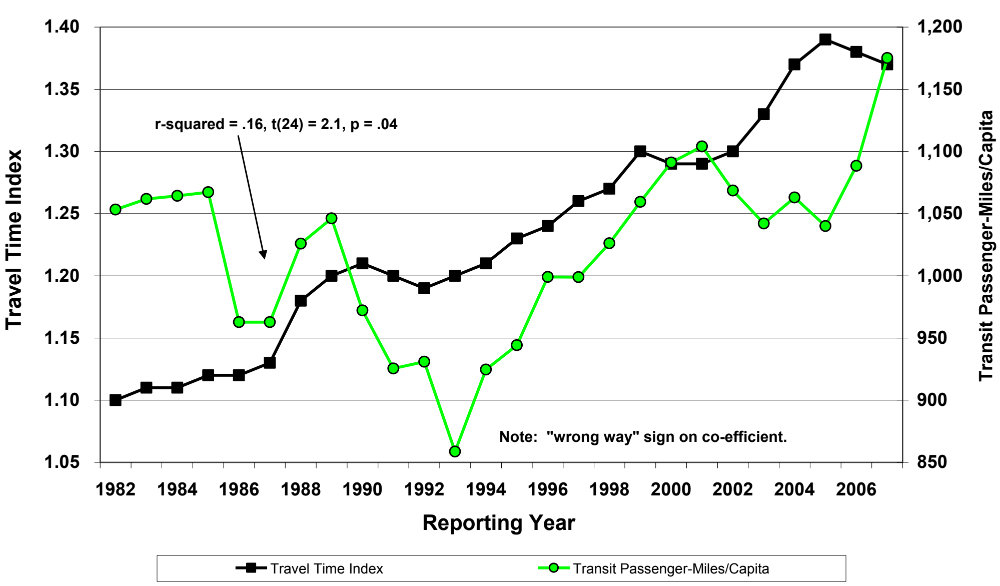
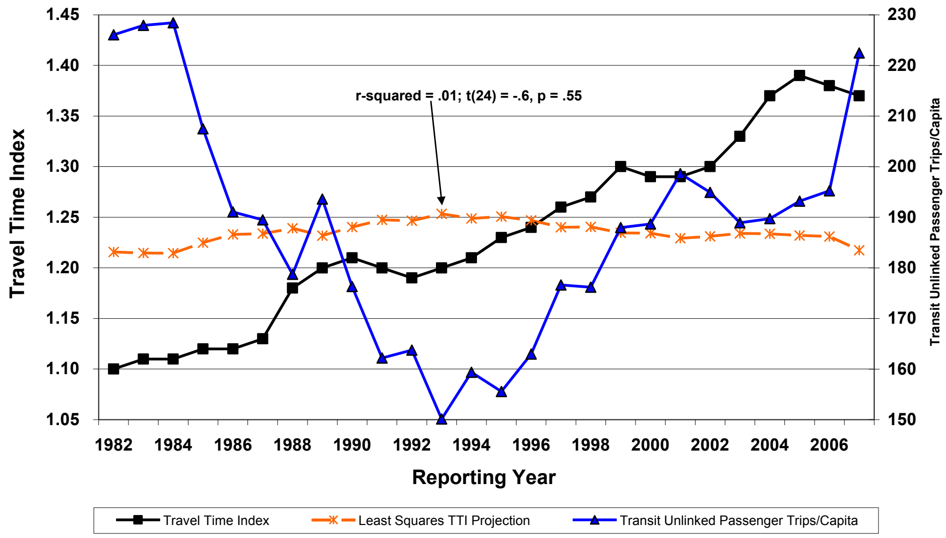


Figure 23: New York City UZA TTI and Unlinked Transit Trips/Capita



Discussion

The New York-Newark NY-NJ-CN UZA includes the two named cities and the component counties of New York City (Bronx, Kings [Brooklyn], New York [Manhattan], Queens, Richmond [Staten Island]) and portions of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk and Westchester Counties, New York State; Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmount, Morris, Ocean, Passaic, Sommerset, Sussex, Union and Warren Counties, New Jersey; and portions of Fairfield County, Connecticut.[88]

New York is the largest UZA in the nation by population by a wide margin, with 42% greater population than number two Los Angeles in 2007.[89] From its centuries as the nation's largest city and largest sea and air terminus, New York has become a major transportation hub for all modes.

The most important Interstate Highways are I-80, from New York to San Francisco via Cleveland, Chicago and Denver; I-78/I-81/I-76/I-70/I-15/I-10 to Harrisburg, Pittsburgh, Columbus, Indianapolis, Saint Louis, Kansas City, Denver and Los Angeles; I-87 to Albany and Montreal; and I-95, from Maine through Boston to Philadelphia, Washington and on to Miami. There are also numerous state and local freeways. Due to the Hudson River and other waterways and the many densely populated islands and isthmuses, New York has an extraordinarily high number of bridges and tunnels, mostly tolled.

There are well over three-dozen individual agencies providing transit service in the New York UZA. Of these, most of the largest are part of the Metropolitan Transportation Authority (MTA) family of transportation agencies:

- MTA-New York City Transit (NYCT) is the largest transit agency in the nation, carrying over six times the UPT of number two CTA, and is the largest rapid rail operator (with 69% of total U.S. heavy rail UPT), the largest bus operator and the largest paratransit operator.[90] MTA-NYCT alone carries 31% of all U.S. transit passengers.[91]
- MTA Bus Company (formerly New York City Department of Transportation) is the 12th largest transit agency by UPT and seventh largest bus operator.[92]
- MTA Long Island Railroad is the 15th largest transit agency by UPT (third by PM) and largest commuter rail operator in the nation.[93]
- MTA Metro North Commuter Railroad is the 21st largest transit agency by UPT (fourth by PM) and third largest commuter rail operator in the nation.[94]
- MTA Long Island Bus (aka Metropolitan Suburban Bus Authority) is the 41st largest transit agency and 34th largest bus transit operator.[95] (As of 2011, this is now Nassau Inter-County Express (NICE), operated by Veolia Transportation, a private contractor, for Nassau County; MTA is no longer involved).[96]
- Staten Island Rapid Transit Operating Authority is the smallest (of 15) rapid rail operators in the U.S.[97]

The MTA family also includes MTA Bridges and Tunnels (formerly the Triborough Bridge and Tunnel Authority), which operates nine toll bridges and tunnels in the area and which provides significant subsidies to MTA transit projects.

Besides the MTA family of transit operators, the New Jersey Transit Corporation (NJ Transit) is the seventh largest transit operator, fifth largest bus operator, 19th largest paratransit operator, second largest commuter rail operator and the eighth largest light rail operator in the nation.[98]

Port Authority Trans-Hudson Corporation (PATH), part of the Port Authority of New York and New Jersey, is the seventh largest heavy rail operator, operating service into lower and mid-town Manhattan from New Jersey, including many commuter rail passengers who transfer to PATH for the last legs of their journeys.[99]

During the studied period, transit unlinked passenger trips/capita were down slightly and passenger-miles/capita up 12%. For 2007, New York was first in both transit unlinked trips/capita and transit passenger-miles/capita, both by very wide margins.

NYC is the heart of public transit in the U.S. With 6.0% of the 2007 U.S. population, NYC had 40% of both total U.S. transit unlinked passenger trips and passenger-miles in that year.[100]

Transit is extremely important to passenger travel in New York, with 53.7% of the residents of the core cities using it for home-to-work commuting. Indeed, the 12.5% of the *suburban* workers who commute via transit is more than the *total* transit UZA commute percentages for every other UZA except Washington, DC. (16.4%) and San Francisco-Oakland (16.3%); New York's suburban share matches Chicago total share (12.5%).[101]

However, even in New York, there is no statistically valid relationship between changes in transit usage and TTI; the continually increasing overloading of VMT on road capacity is the key metric. New York transit ridership actually increased radically during this period, as best evidenced by MTA-NYCT time series data displayed in Figure 24.

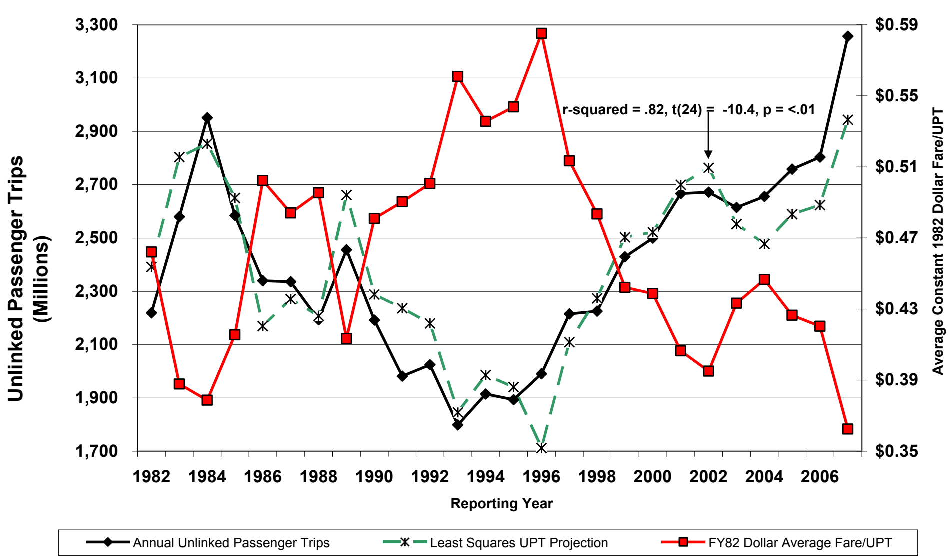
At the beginning of the study period, NYCT, as well as the other MTA transit agencies, were beginning to emerge from an intense recapitalization effort that reversed decades of underinvestment and neglect.[102] Significant improvements were being made in both the quality and reliability of transit service, as well as other aspects important to riders such as security, cleanliness and graffiti reduction.

However, another major factor was the adoption by the MTA operators of more technically modern fare collection equipment, which enabled various types of multi-ride fare media including transfers and monthly passes to be used for the first time by NYCT. All MTA agencies could use the same fare media.[103] This caused the average fare per boarding for heavy transit users to decrease over time in constant dollar terms, even as the published single-ride fares were experiencing nominal increases. The use of multi-ride fare media encouraged users to take additional rides; with these new passes there was no out-of-pocket cost for taking a bus for the half-mile from the subway station to the job site. The new equipment and fare media were implemented over a period of years, beginning with the first limited test in 1993 through substantial completion in 1997–1999.[104] MTA ceased selling the world-famous subway tokens in 2003.[105]

The following figure shows the close relationship between average fare per boarding and unlinked passenger trips over the study period.[106]

Despite the good "eyeball" fit, and the high $r^2 = .82$, this is another example of the old adage that "correlation is not causation"—or, more properly, that while the change in fare media and price almost certainly was *a* causation, and arguably a significant one, there were a large number of things going on at this time that were also major influences. One somewhat simplistic interpretation is that the transit system infrastructure improvements were the underlying necessary conditions for the fare decreases to be effective in generating more unlinked transit trips.

Figure 24: MTA-New York City Transit Unlinked Passenger Trips and Constant Dollar Average Fare/UPT



Due to the effective decrease in transit fares/boarding and other factors from the low point in 1993 through 2007, NYCT UPT increased 83%, or 1.231 billion boardings. This accounted for 61% of the total national increase in transit UPT over this period.[107]

F. Portland Urbanized Area

Statistics

Table 14: Portland Calculations

	1982	2007	2007 Rank	1982–2007 Growth
Population	1.13M	1.80M	23	59.3%
Population/Square Mile	3,229	3,333	10	3.2%
TTI	1.07	1.29	T20	314.3%
Freeway VMT/Freeway Lane-Mile	9,649	17,357	15	79.9%
Arterial VMT/Arterial Lane-Mile	5,810	5,374	30	-7.5%
Transit UPT/Capita	46	59	8	28.6%
Transit PM/Capita	199	249	12	25.1%
Total Road-Miles/Million Population		3,860	45	
Freeway Centerline-Miles/Million		84	56	
Freeway Lane-Miles/Million		435	63	
Average Freeway Lanes/Mile		5.16	49	
Freeway Daily VMT Modal Equivalent		37.8%		
Arterial Daily VMT Modal Equivalent		28.3%		
Other Road Daily VMT Modal Equivalent		21.5%		
Transit Daily VMT Modal Equivalent		2.4%		

Table 15: Portland, American Community Survey Home to Work Commute

Minutes				
	Core City	Other	Whole	Rank
Road	21.6	22.7	22.4	
Transit	38.2	46.3	41.9	
Overall	22.2	22.8	22.6	39
Modal Splits				
Road	72.1%	86.3%	81.8%	
Transit	12.5%	4.9%	7.3%	
Other	15.4%	8.8%	10.9%	
Core City Population	31.1%			
Core City Workers	31.8%			

Graphs

Figure 25: Portland UZA 1982–2007
TTI and VMT/Freeway Lane-Mile

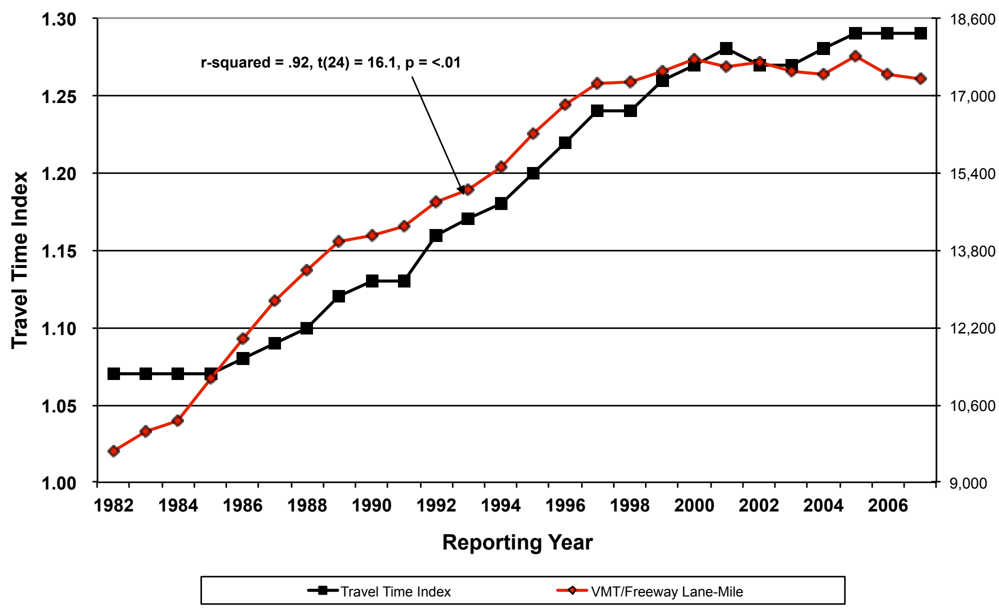
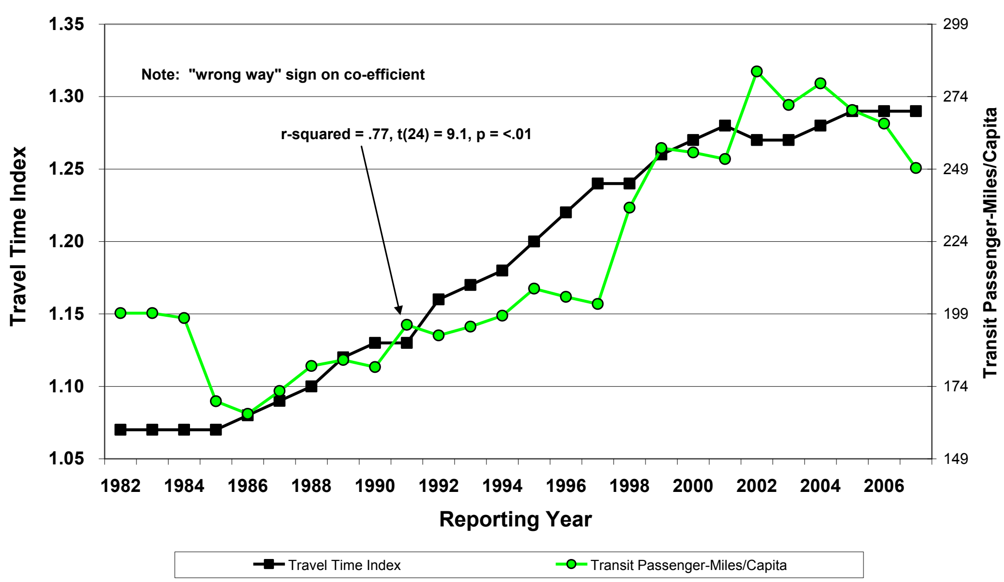
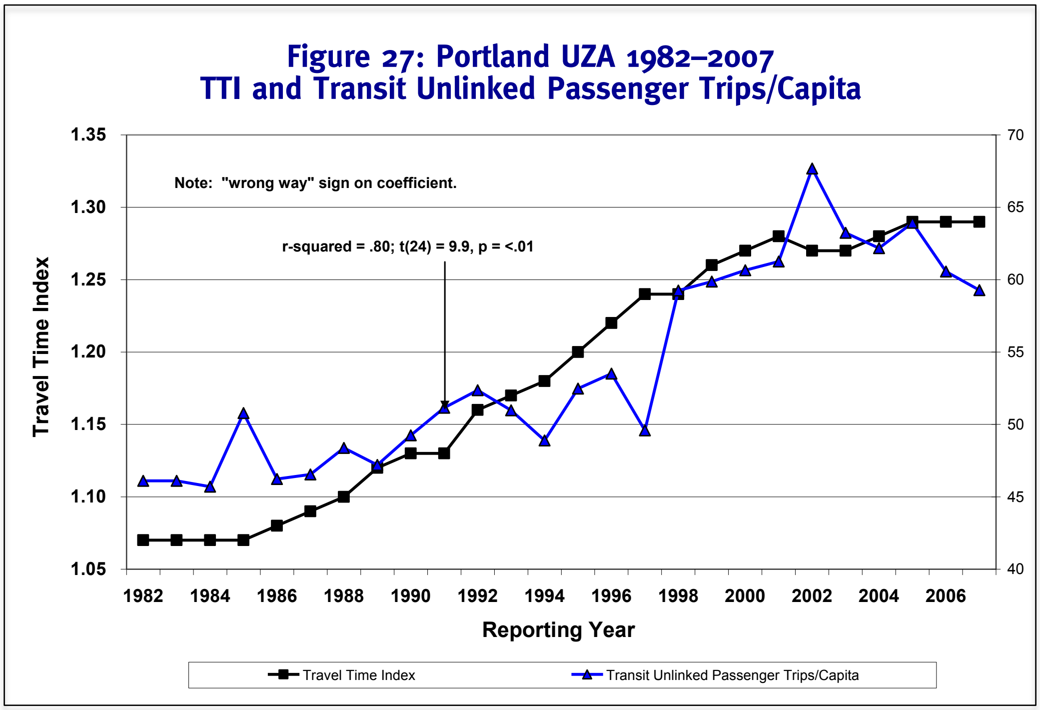


Figure 26: Portland UZA 1982–2007
TTI and Transit Passenger-Miles/Capita





Discussion

The Portland OR-WA UZA includes the city of Portland and all or portions of Clackamas, Marion, Multnomah, Washington and Yamhill Counties in Oregon, as well as Clark County, Washington.[108]

Portland, located where the Willamette River flows into the Columbia River approximately 100 miles inland from the coast, began as a major seaport. As it became the population and economic center of Oregon, Portland added significant road and rail connections.

The most important Interstate Highways are the north-south I-5, from San Diego on the Mexican border to Los Angeles and the California Central Valley up to Seattle and Vancouver, British Columbia, and I-84 to Salt Lake City, connecting to I-80 east to Denver, Chicago and New York City.

The Tri-County Metropolitan Transportation District of Oregon (TriMet; the three counties referenced in the name are Clackamas, Multnomah and Washington) is the transit operator on the Oregon side of the Columbia.[109] It is the 17th largest U.S. transit operator overall, the 20th largest bus operator, the 20th largest paratransit operator and the fourth largest light rail operator.[110]

Besides approximately 80 bus lines, TriMet currently operates four Metropolitan Area Express (MAX) light rail lines, with more extensions planned.[111] TriMet also operates the city of Portland's streetcar system, which operates in and near the Portland CBD.[112] In 2009, TriMet began operating commuter rail service on the Westside Express Service (WES).[113]

On the Washington side of the Columbia, the Clark County Public Transportation Benefit Area Authority (C-TRANS) provides bus and demand-responsive service to Vancouver and the surrounding area and provides commuter bus service to Portland. For 2007, it provided approximately 6% of the unlinked passenger trips of Tri-Met.[114]

Over the period being studied, UZA transit UPT/capita grew 29% and transit PM/capital grew 25%, placing Portland just outside the top 10 UZAs of the total 74 for transit utilization growth, but more than any UZA with larger population.

Portland is interesting in that it has made a major effort to deemphasize automotive travel in favor of transit, smart growth and non-motorized transportation. The transit regression results for Portland reveal no evidence that transit utilization has reduced traffic congestion. In fact, there is very clear quantitative evidence that transit usage has moved in the same direction as traffic congestion.

For Portland, we are *not* automatically dismissing these transit results as meaningless, rogue results showing nothing but that the relationship is so weak as to suggest that there is no valid causation. However, we are also *not* saying that increasing transit utilization in Portland causes congestion to increase—which does appear to satisfy the casual eyeball test. What we will do is to explore the possibility that the same body of public sector actions that have caused transit utilization to increase has also caused traffic congestion to worsen—at least, in the case of Portland.

Let us examine some of the unique aspects of Portland:

1. The first of TriMet's light rail lines, the Banfield line, was funded in part by $180 million in Federal Interstate Transfer funds derived from the decision to abandon the Mount Hood Freeway after a significant—and successful—local "freeway revolt" against that freeway, principally by those who objected to the proposed freeway's impact on the

neighborhoods it would traverse and those who were part of a movement to create a less auto-intensive urban structure.[115]

2. The construction of the Banfield light rail line required the elimination of a high-occupancy vehicle lane on the I-84 (Banfield Freeway), which the light rail line runs alongside. This HOV lane was short (approximately two miles in the eastbound direction and one mile in the westbound direction), but appeared to be successful during the period it operated, from 1978 through 1982, when average daily total freeway traffic increased only 1.85% (over pre-opening 1977 traffic). The HOV lane addition added a traffic lane in each direction, but its primary impact was encouraging former drive-alones to carpool to reduce travel time and save money. In 1986, the first year after the light rail line opened, average vehicle traffic increased 14.16% over 1982, the last year the HOV lane operated. Traffic volume increased an additional 10.65% in 1987, and continued the upward trend thereafter.[116] Therefore, the alignment selected for the placement of the first light rail line eliminated a highway resource that was having a positive impact on traffic congestion in a key commute corridor.
3. Oregon has a state-wide land use planning program, with Senate Bill 100 in 1973 as a key landmark in the program.[117] As a result of Senate Bill 100, Oregon has 19 Planning Goals to support its land use program, ranging from Citizen Involvement to Land Use Planning to Transportation to Ocean Resources.[118] Goal 14, "Urbanization," which spells out the Urban Growth Boundaries program states:[119]

   Urban growth boundaries shall be established and maintained by cities, counties and regional governments to provide land for urban development needs and to identify and separate urban and urbanizable land from rural land.
4. Metro, the metropolitan planning organization (MPO) for the Portland UZA, has the only directly elected regional governing board in the U.S.[120] (Typically, MPO governing boards are composed of elected officials from local cities and counties.) Metro is also unusual for an MPO for its several direct operating responsibilities: the Oregon Zoo,

the Oregon Convention Center, the Portland Center for the Performing Arts and the Portland Metropolitan Exposition Center.[121] Metro also manages over 12,000 acres of parks and natural areas including over 100 miles of river and stream banks, and oversees the region's garbage and recycling programs (with one of the nation's highest recycling rates: 58%).[122] Metro also has a limited direct taxing authority, which is also unusual for a MPO.[123]

However, much of Metro's influence, over and above the norm for MPOs in the conventional planning process, stems from the combination of its directly elected governing board and its role as the local implementing agency for the Oregon urban growth boundary requirements, which gives it absolute control over expansion of the limits of where development can occur.[124]

Metro has adopted its *Regional Transportation Functional Plan* (Ordinance No. 10-1241B, § 5), which includes its "Interim Regional Mobility Policy standards for peak hour and mid-day demand-to-capacity ratios."[125] For the "Mid-Day One-Hour Peak," the standards are all .99, except for "Corridors, Industrial Areas, Intermodal Facilities, Employment Areas, Inner Neighborhoods, and Other Neighborhoods" and "Other Principal Arterial Routes," which are at .90. The two principal freeways, I-5 and I-84, are at .99. For the "PM 2-Hour Peak," the first hour standards are from .99 (for the two categories set at .90 for the Mid-Day Peak) to 1.1 for the rest. For the second hour all are .99.

Road utilization is described, in transportation engineering terms, by "Level of Service," or "LOS:" six levels from "A" to "F," with "A" showing the least utilization and "F" the most—and there is an "E" in this grading scale.[126]

LOS F, on a freeway, is where traffic is no longer consistently flowing, even at reduced speed, and stop-and-go conditions begin. 1.00 is the absolute top end of the LOS E, the point where, if anything at all negative occurs, including one additional vehicle per lane per hour, LOS F—and stop-and-go traffic—will begin.[127]

When developing long-range transportation plans, most agencies target a LOS C or D to create acceptable operating service. Portland, by targeting level of service D or lower, where a facility operates at 80% of capacity, was the first metro area to deliberately plan for congestion. Recently, Portland lowered its service standards and now plans for LOS F or a facility operating at 90% to 110% of capacity.

Most MPOs, and other transportation planning entities, adopt plans for non-congested roadway service and then fail to meet their planned results during peak periods. Metro, by planning for LOS F, or the absolute high end of the LOS E range, has been extremely successful in achieving its planned levels of traffic congestion. While many large UZAs all over the U.S. and world have major traffic congestion, Metro is the rare—perhaps even unique—transportation planning agency that has actually set stop-and-go traffic congestion as its objective.

5. I-5 is the primary West Coast north-south road between Seattle and Vancouver, B.C. in the north and California in the south and the major truck route for the three Pacific Coast states and cargo bound for Canada and Mexico. For most long-haul truck movements and all short-range movements in the region, there are no real alternatives to crossing the Columbia River but the I-5 and I-205 bridges between Portland and the Washington State side. There are also no alternatives to these two bridges for passenger car and transit travel between the Oregon and Washington sides of the Portland UZA.

   For many years, these bridges have represented a considerable bottleneck to "rubber tire" movements, impacting not only local travel within the Portland UZA, but also longer distance truck and travel movements. The Columbia River Crossing (CRC) project was proposed to replace the existing overloaded I-5 Bridge. This I-5 corridor that includes the bridge was recently ranked as Oregon's number one transportation chokepoint and impacts traffic in the following manner:[128]

   [The] Chokepoint causes the worst congestion in the metro region, one of the biggest bottlenecks on the I-5 trade corridor, congestion lasts 4-6 hours per day and is projected to increase to 15 hours by 2030.

Reduces freight access to Port of Portland, 644,200 hours of freight delay per year, 300 accidents experienced annually.

The urban form plans and implementation on the Portland side of the river have resulted in significantly higher housing costs and reduced housing options there, causing many people with jobs in Oregon to live in Washington (Washington State having no income tax, and Oregon having no sales tax, have also contributed to many location decisions being made based on economics). This has led some members of the community to speculate that Portland leadership is not interested in making the commute, particularly the drive commute, any easier for Washington residents who work in Oregon.

The bridge's capacity, form and finances were studied for years. The final version was a compromise between Oregon and Washington and included a pair of two-deck, five-lane (three through lanes and two "add/drop" lanes for entrance and exit) bridges, up from the current six total lanes, with two light rail tracks on the lower deck of one bridge and a walk/bike lane on the lower deck of the other.[129] This compromise gave the Washington side what it was most interested in by adding road capacity, while providing the Oregon side with a coveted light rail line on the bridge.

The high cost of the bridge, which was more than the sponsors could fund from available sources, was due in part to the inclusion of the light rail line. As a result project sponsors proposed a toll bridge that required funding from both states and the federal government.[130] The defeat of a local transit sales tax issue on the Clark County, Washington side of the bridge and the discovery that the proposed bridge had lower clearance for water vessels than the current lift bridge reduced political support for the bridge.[131] When the Republican-controlled lower house of the Washington legislature failed to approve its share of the required funding for the CRC, the project was considered dead and the project team disbanded.[132]

However, there is still a need for additional road capacity on I-5 and a desire for light rail along the same corridor. Project proponents, working with the state of Oregon—which did pass its share of the funding for the CRC project—are proposing the construction of the basic bridges and other features of the original project, with light rail on the bridge. Federal, state of Oregon, and local Oregon funding could cover the reduced $2.75 billion cost.[133] (This new proposal would not include most of the roadway and intersection improvements on the Washington side. No final decision has been made on this new proposal.)

6. The city of Portland has an adopted "Comprehensive Plan Transportation Goal And Policies," which contains the following elements:[134]

    Policy 6.3 No New Regional Trafficways: *The Regional Trafficway system within the city of Portland is complete. Any future increases in regional traffic should be accommodated by improvements to the existing trafficways and not by building new corridors for circumferential freeways within the City. Specifically, the proposed Western Bypass should not be extended north of U.S. 26 into the City, through Forest Park, and across the Willamette and Columbia Rivers.*

    Policy 6.6 Urban Form: *Support a regional form composed of mixed-use centers served by a multimodal transportation system. New development should be served by interconnected public streets, which provide safe and convenient pedestrian, bicycle, and vehicle access. Street and pedestrian connections should be provided to transit routes and within and between new and existing residential, commercial, and employment areas and other activity centers.*

    Policy 6.7 Public Transit: *Develop transit as the preferred form of person trips to and from the Central City, all regional and town centers, and light rail stations. Enhance access to transit along main streets and transit corridors. Transit shall not be viewed simply as a method of reducing peak-hour, work-trip congestion on the automobile network, but shall serve all trip types. Reduce transit travel times on the primary transit network, in the Central City, and in regional and town centers, to achieve reasonable travel times and levels of reliability, including taking measures to allow the priority movement of transit on certain transit* *streets. Support a public transit system that addresses the special needs of the transportation disadvantaged.*

Policy 6.8 Regional Rail Corridors: *Assign priority to the funding and development of the regional mass transit system to reduce both the need for new regional traffic facilities and reliance on the automobile. Decisions on light rail transitway alignments and their connections to other regional facilities will be based on individual corridor studies. Regional Transitway designations in the northern and southern corridors represent alternative alignments for future light rail transitways. The Transportation Element will be amended to show the chosen alignment as determined by the Draft Environmental Impact Statement process and as adopted by City Council. Funding decisions for light rail transit corridors should be based upon the population served, the opportunities for redevelopment, and the traffic congestion problems in the corridors.*

Policy 6.9 Transit-Oriented Development: *Reinforce the link between transit and land use by increasing residential densities on residentially-zoned lands and encouraging transit-oriented development along Major City Transit Streets and Regional Transitways, as well as in activity centers, at existing and planned light rail transit stations, and at transit centers in conformance with the Comprehensive Plan and Zoning Code.*

Portland has also adopted a policy that gives priority to transit vehicles: "It is the goal of the Transit Preferential Streets Program to improve transit travel times and service by giving priority to transit vehicles where conflicts with autos occur." This policy was originally implemented on five arterial streets with transit lines and has since been expanded.[135]

7. Despite 86.3% of home-to-work commutes being on roads, vs. 4.9% for transit, a ratio of 17.6:1, and an even higher ratio for non-work-commute trips, and none of the freight traffic moving on transit, Metro is allocating 48.6% of combined road and transit funding through 2035 for roads, and 51.4% for transit.[136]

The previous seven decisions show that surface transportation decisions in the Portland UZA have been significantly shifted toward transit and toward transit funding. This includes policies and actions such as shifting funding for an approved Interstate highway to a light rail line, removing a very productive HOV lane for a light rail line, preventing action on a vital Interstate river crossing until a light rail line is included in the project, and providing preference to transit vehicles over automobiles on arterial streets. This body of pro-transit, sometimes anti-road policies and actions, combined with the quantitative results over the time period, provide support for the contention that the Portland-area policies designed to increase transit usage have created situations where traffic congestion has increased.

Again, it is *not* the increase in transit utilization that has caused the increase in congestion, it is the body of decisions to favor transit over roads that have caused the increase in congestion.

G. Washington, D.C. Urbanized Area

Statistics

Table 16: Washington, D.C. Calculations

	1982	2007	2007 Rank	1982–2007 Growth
Population	2.70M	4.33M	3	60.4%
Population/Square Mile	3,396	3,305	30	-2.7%
TTI	1.11	1.39	4	254.5%
Freeway VMT/Freeway Lane-Mile	12,358	18,817	11	52.3%
Arterial VMT/Arterial Lane-Mile	3,582	6,733	7	87.9%
Transit UPT/Capita	115	107	3	-6.3%
Transit PM/Capita	431	550	2	27.7%
Total Road-Miles/Million Population		2,709	64	
Freeway Centerline-Miles/Million		76	62	
Freeway Lane-Miles/Million		479	57	
Average Freeway Lanes/Mile		6.29	13	
Freeway Daily VMT Modal Equivalent		38.0%		
Arterial Daily VMT Modal Equivalent		40.5%		
Other Road Daily VMT Modal Equivalent		16.8%		
Transit Daily VMT Modal Equivalent		4.8%		

Table 17: Washington, D.C. American Community Survey Home to Work Commute

Minutes				
	Core City	Other	Whole	Rank
Road	26.6	30.5	30.2	
Transit	37.5	48.9	45.5	
Other	28.0	31.4	30.9	72
Modal Splits				
Road	43.1%	79.3%	74.6%	
Transit	37.8%	13.2%	16.4%	
Other	19.1%	7.5%	9.0%	
Core City Population	14.0%			
Core City Workers	13.0%			

Graphs

Figure 28: Washington, D.C. UZA 1982–2007
TTI and VMT/Freeway Lane-Mile

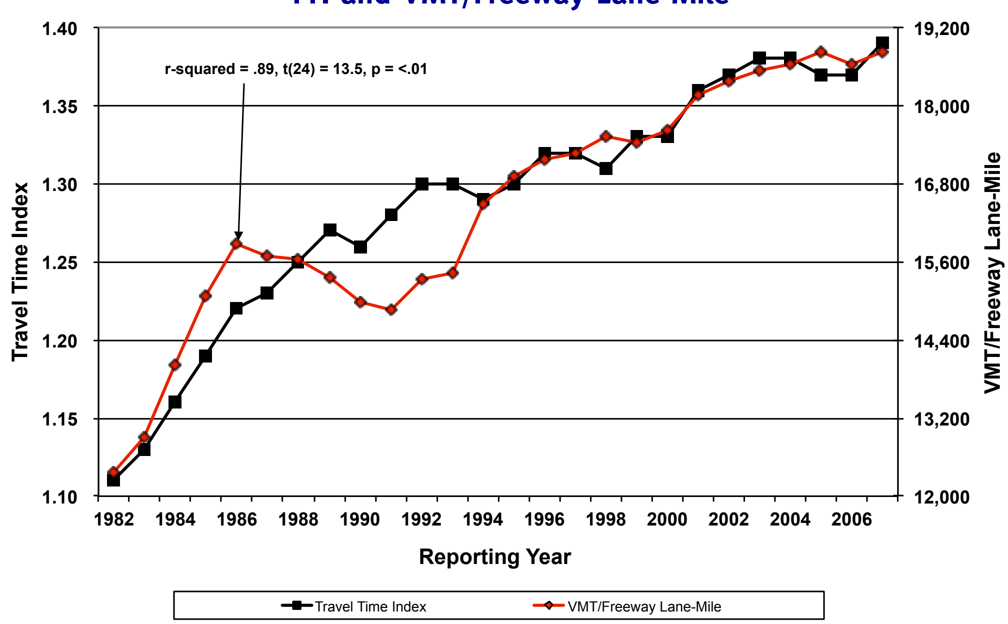


Figure 29: Washington, D.C. UZA 1982–2007 TTI and Transit Unlinked Passenger Trips/Capita

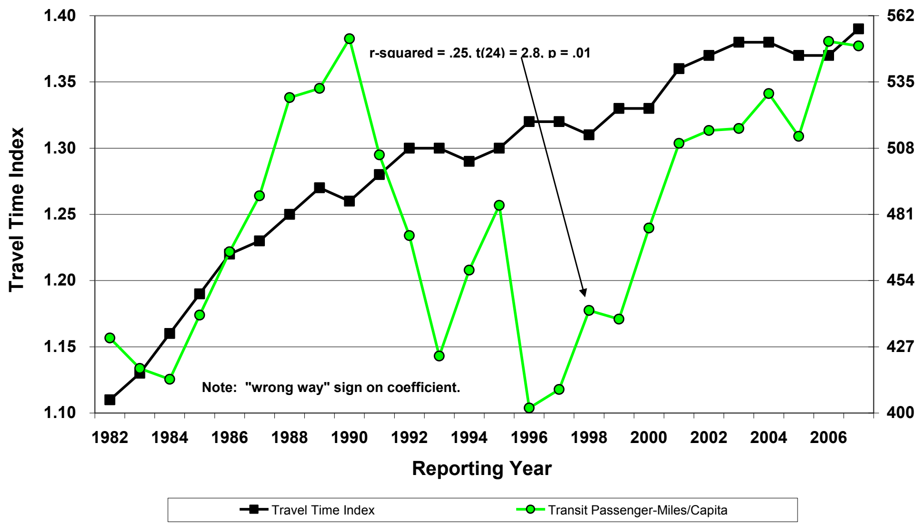
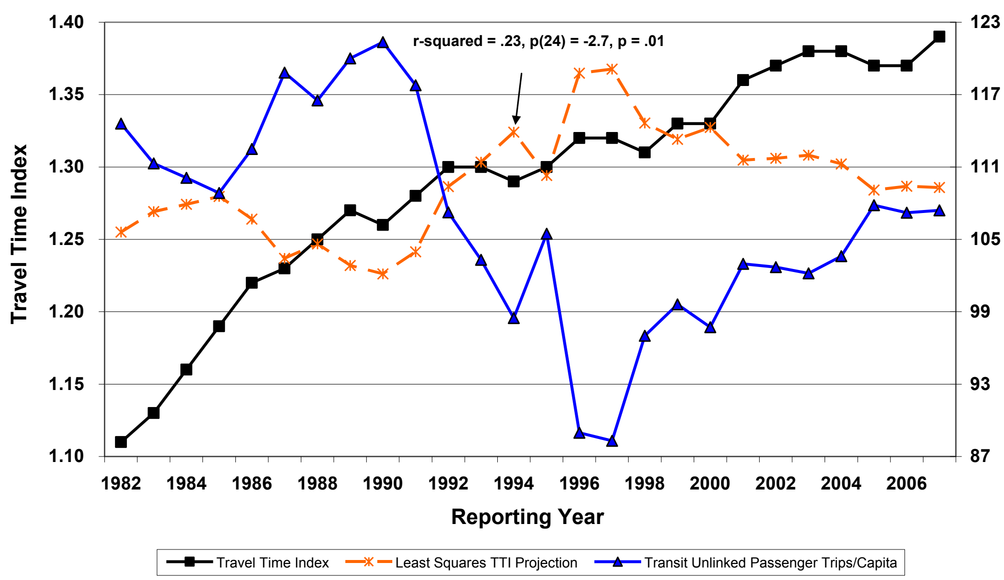


Figure 30: Washington, D.C. UZA 1982–2007 TTI and Unlinked Passenger Trips/Capita



Discussion

The Washington, DC-VA-MD UZA includes the District of Columbia and all or parts of Alexandria, Arlington, Fairfax, Loudoun, Manassas, Manassas Park, Prince William, and Stafford Counties in Virginia and Montgomery and Prince George's Counties in Maryland.[137]

As the nation's capital, Washington has never been a major national goods production center. Lacking a major seaport, it has also not been a major transshipment point for goods, although it is in the main N-S surface transportation corridors for the U.S. East Coast. It is a major destination, hub and pass-through location for movements of people.

The most important Interstate Highways are the north-south I-95, from Maine, Boston, New York City and Philadelphia to Miami, the main road for the U.S. East Coast, and I-70/I-270/US 15 west to Pittsburgh, Columbus, Indianapolis, Saint Louis, Denver and Los Angeles.

The core city of Washington has less freeway service than almost every other North American city, there being only one freeway that actually travels continuously through the District of Columbia. The Anacostia Freeway (I-295/DC 295) goes north from I-95/I-495 in Maryland near the Woodrow Wilson Bridge through southeast DC until it links up with Baltimore-Washington Parkway (MD295), which proceeds north to Baltimore.

All other freeways begin or end in the District. I-66 from Virginia terminates when it reaches the District mainland just upstream of the Lincoln Memorial. I-395 crosses into the District from Virginia to southwest DC, then turns north where it crosses under the Mall just west of Capital Hill and terminates about a mile north of the Mall. I-695, which is unsigned, connects I-395 near Capital Street with I-295 in Anacostia via the 11th Street Bridge. New York Avenue (US 50), which transitions from a surface arterial near the National Arboretum in Northeast Washington into a freeway, proceeds east to Annapolis and over to the Eastern Shore of Maryland. These leave the largest of the four sectors of the District, Northwest, with just over a mile of stub-end freeways.

There are many stories about why the District does not have more freeways, including an account by President Eisenhower's staff that the president was dismayed when he realized that his subordinates had disobeyed his instruction that the Interstate Highway system was intended to connect major urbanized areas to rural America, *not* to connect different parts within an urban area.[138] While there are other stories as to why District of Columbia freeways were not constructed there is no question that the District transferred $2.2 billion of

Interstate Highway funding to WMATA Metrorail construction, beginning in 1976.[139]

The Washington Metropolitan Area Transportation Authority (WMATA) is the major transit operator in the region. It is the fourth largest U.S. transit operator overall, the sixth largest bus operator, the eighth largest paratransit operator and the second largest heavy rail operator.[140] WMATA is one of only two major multi-modal U.S. transit operators (the other being MTA-NYCT) where heavy rail ridership exceeds bus ridership.

The Maryland Transit Administration, which operates commuter rail services (Maryland Area Regional Commuter) in the Baltimore-Washington Corridor and from Frederick, Maryland and Martinsburg, West Virginia, is the ninth largest commuter rail operator.[141] Virginia Railway Express, which operates two lines into Washington from Manassas and Fredericksburg, is the 12th largest.[142]

Several outlying political jurisdictions also operate bus and paratransit service including Montgomery County, Maryland Ride On; Alexandria, Virginia *DASH*; and Fairfield, Virginia *Connector*.[143] The major reasons for these suburban transit systems are local control and cost savings over the cost of WMATA bus operations, largely through the use of contract service providers.

WMATA Metrorail is one of the most extensive, and most heavily used, rail systems in the U.S., with five lines totaling 106 miles serving 86 stations, in operation.[144]

Over the period being studied, transit utilization in Washington has been mixed, with unlinked passenger trips/capita down by 6% and passenger-miles/capita up by 28%. This is a reflection of the emphasis on the construction and operation of rail service, particularly long-haul heavy and commuter rail service to the suburban counties and beyond.

WMATA Metrorail—"America's Subway"—received significantly more federal funding for construction than any other major transit system during the study period, up to 90% of capital costs in the early years, at a time when the maximum federal participation for other such projects was 80%.[145] WMATA's lowest federal funding percentage on a specific rail construction project was 62.5%.[146] This occurred when the actual federal participation for other major transit construction projects was 50% or less.[147] While WMATA total ridership grew 46% over this period, the Washington UZA population grew 60%.

Once again, the changes in transit utilization over this period fail to reach a level of significance to the overall surface transportation usage to have any significant impact on traffic congestion. Total transit utilization certainly grew during the study period, as did transit passenger-miles/capita, but road traffic grew far faster—and transit travel was a small percentage of total travel.

Part 6

Conclusion

For the 74 UZAs taken as a whole, we have found no evidence that links an increase in transit utilization, measured by either annual transit unlinked passenger trips per capita or transit passenger-miles per capita, to a decrease in traffic congestion, or *vice versa*. Indeed, a weak statistical case can be made that increases in transit utilization are associated with *increases* in traffic congestion, which we believe can be explained for some specific UZAs, by a decision-making process that favors spending on transit capital projects over road projects and land use decisions that tend to work against automotive mobility, sometimes deliberately.

For the group of 74 and for each UZA individually, there was a strong relationship between freeway vehicle-miles traveled per freeway lane-mile and traffic congestion; freeway usage per unit of capacity increased as congestion increased in a very consistent manner. There was also a weaker, but still valid, relationship between arterial vehicle-miles traveled per lane-mile and traffic congestion.

For our seven case study UZAs, the results were as follows:

- **Chicago –** In Chicago, as for all of the case study UZAs, there was a very strong relationship between freeway VMT/lane-mile and traffic congestion (we will omit mentioning this for the remaining UZA discussions). Chicago showed the only strong statistical relationship between transit use and traffic congestion; the decrease in UPT/capita inversely paralleled the increase in TTI. However, this relationship was not confirmed by a similar valid relationship between PM and TTI (r^2 = .01). For transit, Chicago shifted its priorities and funding during the last portion of the study from the Chicago Transit Authority's relatively short bus and rail trips in the urban core to Metra, the regional commuter rail operator, with its very long trips from the suburban areas of the UZA to the core city. Given that only one of the 16 transit indicators among the whole group and seven case studies had a strong statistical relationship with traffic congestion, this is likely a random mathematical relationship, rather than a cause-and-effect one.

- **Dallas** – Transit usage in Dallas showed a moderate (r^2s of .57 and .37 for PR and UPT, respectively) *positive* relationship between transit usage per capita and traffic congestion; this does not mean that transit is a cause of traffic congestion in the Metroplex. More likely, the massive spending on new rail transit projects, produced a small increase in transit usage *per capita*, but with the transit home-to-work modal split at 1.3% in 2007 (down from 2.8% in 1982), this was insufficient to have any impact on traffic congestion.
- **Houston** – Although transit spending in Houston increased significantly at the beginning of the study period, we once again failed to find any significant relationship between transit usage and traffic congestion. Houston, however, did produce one of the more interesting findings in the study—that traffic congestion actually improved significantly over a period of several years, and that this was due in large part to the increase in freeway lane-miles. The reaction to this accomplishment, unique among the 74 UZAs, was for the Houston transportation decision-makers to prioritize a massive light rail construction program.
- **Los Angeles** – The pattern of transit usage in Los Angeles—exhibiting two of the three largest usage increases in the nation, separated by a major decline—could provide an exceptional opportunity to study the impact of transit on congestion. While problems with the TTI transit data negated the opportunity to analyze the first increase period, we found no significant relationship between transit use and traffic congestion in an area best know for its freeways, but actually 10th in *per capita* transit usage of the 74 UZAs studied. Also interesting was the strong relationship between fare level and transit usage, raising the issue of its utility as a cost-effective means of increasing transit usage.

- **New York City** – With 40% of the combined transit usage of the 74 UZAs in New York, we were hopeful that we would find a strong relationship between transit usage and traffic congestion, particularly since transit passenger-miles per capita fell 18% over the first 11 years of the study period, then increased 37% over the remainder, providing interesting periods of contrasts. However, once again, there was no meaningful statistical relationship between transit usage and traffic congestion, even in the transit capital of the U.S., where over half of the City's residents commute to their jobs via transit. As in L.A., an important take-away is the impact of fare level on transit ridership, where MTA-NYCT in particular used an effective reduction in fare levels through the introduction of multi-ride fare media to significantly increase ridership, building on the recapitalization of the former sadly deteriorated transit capital plant.
- **Portland** – Portland has an interesting policy of transit priority and transit-oriented development with the specific objective of *increasing* traffic congestion as it increases transit use. Our analysis shows that it has been successful in both. But, even with rather strong and consistent statistical relationships between transit utilization and traffic congestion *moving together* (r^2 of .77 for PM/capital and .80 for UPT/capital, respectively), we do not believe that transit usage is a cause of traffic congestion; rather, we believe that it is the totality of land use and transportation policies of the UZA, which focus on transit expansion, frequently at the expense of roads, that is the cause of both the increase in transit usage and the increase in traffic congestion.
- **Washington** – Our nation's capital is the home of "America's Subway," the massive MetroRail construction project over the past four-plus decades. However, once again, we see no meaningful relationship between the change in transit usage and the change in traffic congestion.

While fare policy is not the focus of this paper, it is interesting to note that the largest multi-year national increase in transit usage over this period was at MTA-NYCT. This was caused, to a major extent, by a program of fare reductions coupled with improvements to basic, pre-existing transit service—as were the second and third largest national increases in transit ridership, both at Los Angeles Metro.

The first LA Metro ridership increase occurred when there was no rail service in the UZA. The second LA Metro increase occurred when there was substantial increase in rail transit service, but the majority of the new rail passengers were former bus passengers switching to rail mode—and the majority of the added ridership was on Metro's buses. MTA-NYCT added no new miles of track during its period of major ridership increase.

Public sector decision-makers who believe that the purpose of public transit is to move people should note which mechanisms increase and decrease transit usage. Policies that increase transit usage are different from policies that promote urban form enhancements and lifestyle or other world improvements. To a large extent, most of the non-transportation benefits of transit—economic growth, employment, air emission reductions, etc.—are proportional to passengers carried.

When transit is tasked to do things it cannot and does not do well, such as reducing traffic congestion, it fails to accomplish that task. In addition, using scarce transit funds for construction and operation of new rail lines frequently reduces funds for existing, mainly bus, transit service, often leading to fare increases that harm the transportation-disadvantaged, who frequently do not have other viable transportation options.

Appendix A

Appendix A: Some Notes on the *2009 Urban Mobility Report* and its Methodology

The prime source of data for this study was the Texas Transportation Institute *Urban Mobility Report 2009* ("*UMR*"), which provides annual data for the period 1982–2007 for every major U.S. urbanized area (UZA).[148]

While the *UMR* and TTI are certainly not without their critics, including those who disagree with certain aspects of how transit data are used for calculation of congestion statistics, we believe that the *UMR* is not "unfair" to transit and transit users.[149] As the primary transit industry trade association and lobbying group, the American Public Transit Association is not only a major source of data used in the *2009 UMR* that was the primary subject of analysis for this report, but APTA also sponsors the report, along with the American Road & Transportation Builders Association (Transportation Development Foundation), and the University Transportation Center for Mobility (Texas A&M Transportation Institute), the home agency for the authors.[150] For many years APTA has issued a press release timed to coincide with the publication of the *UMR,* highlighting the accomplishments and benefits of transit in urban mobility, citing the details of that year's *UMR*.[151] We believe that any representation of the *UMR* as being unfit for use for evaluation of the impact of transit usage on traffic congestion due to an institutional bias against transit, or errors in data or methodology, is unsupportable.

While the basic methodology of the *UMR* has been continually revised and updated over time, it has remained substantially consistent in purpose over the years. For our purposes, we have utilized primarily the Travel Time Index (TTI), which is defined as follows:[152]

> *Travel Time Index (TTI) – The ratio of travel time in the peak period to travel time at free-flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.*

While the TTI has long been the *de facto* national standard for the study of traffic congestion time series analysis and comparisons between urbanized areas (UZAs), and is what we have chosen to utilize for our analyses in this paper, it is important that the reader understand how the metric works, particularly in regards to transit.[153] To better explain the TTI, we have prepared a table comparing it to another well-known and widely utilized metric for urban travel, the home-to-work commute survey of the U.S. Census Bureau, as reported in the American Community Survey.[154]

Table A1: Comparison of Travel Time Index and ACS Home-to-Work Survey

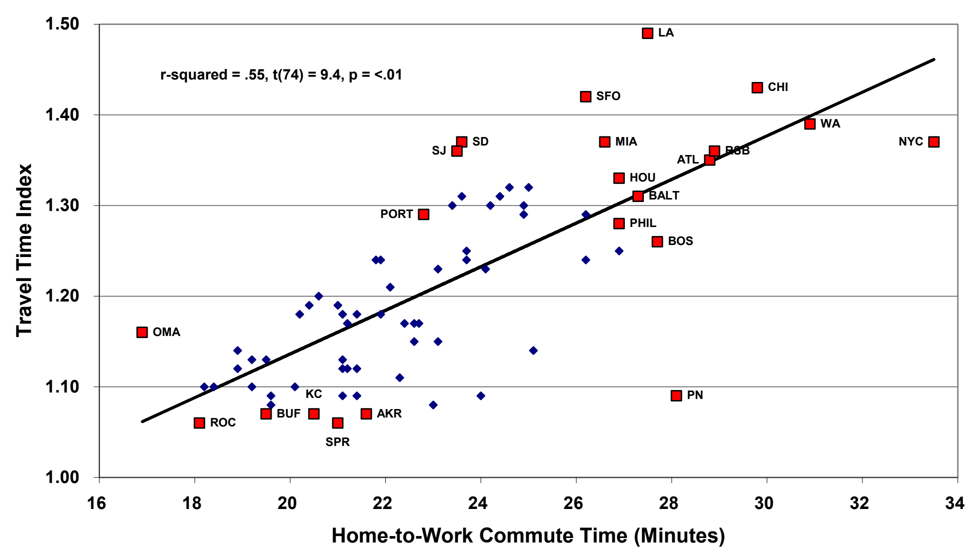
Characteristic	Travel Time Index	ACS Home-to-Work Survey[155]
Types of Travel Comprehended	All	Home-to-work commute only
Times of Day	Comparison of peak-period (6:00–10:00 a.m. and 3:00–7:00 pm.) to off-peak travel for working weekdays[156]	Not specifically considered; data include all home-to-work commute trips at all times of day
Presentation Format	The ratio of peak-period travel time to off-peak travel time for similar trips, presented as two-decimal point result (i.e., 1.25 ➔ peak-period travel time is 25% higher than non-peak travel time)	Minutes for one-way trip
Modes of travel	Road (primarily freeway and arterial street) and transit; walking, cycling and work-at-home *not* included	All, including work-at-home
Data Source	Federal Highway Administration, Highway Performance Monitoring System, National Transit Database[157]	Surveys of individual commuters
Calculation of Reported Indicator	Formula weighting various factors, variables, and constants[158]	Simple sums and averages of data reported by individuals
Impact of Varying Trip Lengths	Not directly considered; TTI is a ratio of travel times	Longer trip lengths will generally require longer travel time, all else equal
Geographic and Time Period Coverage	Urbanized Areas (UZAs), as defined by the Census Bureau, for designated years – no differences	

Specific Discussion of New York City and Los Angeles

When we plotted TTI vs. ACS for our 74 UZAs on the following figure, the resulting regression was only fair: $r^2 = .55$. Two of the biggest outliers are the two largest in the nation, which were two of our case study UZAs, New York City and Los Angeles. As this paper tests the impacts of transit usage on congestion, as measured by TTI, it is important to understand how transit utilization is used in the calculation of TTI values.

(The extreme outlier at approximately 1.10/28 below is Poughkeepsie-Newburgh, NY. It is located approximately 70 miles north of midtown Manhattan. Poughkeepsie is the last stop on the Metro-North Commuter Railroad Hudson Line from Grand Central Terminal, a trip that is scheduled for one hour forty-five to one hour fifty minutes, one-way, train-moving time only. Some residents of the Poughkeepsie-Newburgh UZA utilize this line to commute to work on a daily basis over extremely long distances for home-to-work commutes, which gives this UZA one of the longer average commute times in the U.S.)

Figure A1: Dallas UZA 1982–2007
(TTI and Transit Unlinked Passenger Trips/Capita)



In the following section, we clarify how the UMR measures transit service.

Travel Time Index

> *The method used in this analysis to estimate a revised Travel Time Index focuses on "similar expectations". Transit service is operated according to a schedule. When buses and trains stop to pick up and discharge passengers, their average speed is generally slower than vehicles on the road. Riders and potential riders evaluate the service and make choices according to either the departure and arrival times or in the case of operations that run very frequently, the travel time to the destination with the expectation that the departure time will be relatively soon after arrival in the station. In transit operations this can be thought of as similar to an uncongested roadway trip.* ***Public transportation service that operates on time according to the schedule, then, would be classified by the patrons as uncongested roadway travel.***[159] (emphasis added)

Future Changes

> *There will be other changes in the report methodology over the next few years. There is more information available every year from freeways, streets and public transportation systems that provides more descriptive travel time and volume data. Travel time information is being collected from travelers and shippers on the road network by a variety of public and private data collection sources.* ***Some advanced transit operating systems monitor passenger volume, travel time and schedule information and share those data with freeway monitoring and traffic signal systems.***[160] (emphasis added)

In other words, since incorporating schedule non-adherence data is discussed as a "Future Change," it follows that the current process assumes all transit is operated on schedule and all current transit travel is given an effective TTI score of 1.00.[161]

Let us now examine how this impacts the relative TTI rankings of different UZAs. We will compare the TTI and ACS Home-to-Work commute results for the two largest U.S. UZAs: greater New York City and greater Los Angeles.

Because the ACS data utilized are for the 2005–2007 period, inclusive, we will average the TTI values for these three years for these two UZAs to produce data for comparable time periods:

- New York-Newark, NY-NJ-CT: 1.39, 1.38, and 1.37 for 2005, 2006 and 2007, respectively; simple average 1.38
- Los Angeles-Long Beach-Santa Ana, CA: 1.50, 1.51, 1.49; simple average 1.50

The following table includes the ACS data:[162]

For the TTI scores for this three-year period, we have the NYC UZA at 1.38 and the LA UZA at 1.50. Since a score of 1.00 means no congestion, the relative TTI scores show LA with 32% longer peak period delays (.50/.38) than NYC.

Looking at the home-to-work average commute times, with NYC at 33.1 minutes and LA at 27.0, NYC has 23% longer average commute times.

Examining the details of the ACS data, we find that the auto/truck/van drive-alone (for simplicity's sake, we will refer to this as "road", even though a substantial portion of transit is via bus and, therefore, road-bound) and carpool travel times are almost identical, 27.9 minutes for NYC vs. 27.3 minutes for LA; NYC is only 2% longer.

NYC, at 51.0 minutes, has a 9% longer commute than LA, at 47.0 minutes. However, this is a relatively small value compared to the TTI difference of 32%.

NYC is slower than LA in both road and transit commute minutes, although the TTI scores show LA as having the greater delay.

What appears to be causing LA to have higher TTI scores than NYC is the relative modal splits: NYC is 57%/39% road/transit, while LA is 85%/6%. Because NYC has about six-and-one-half times LA's transit modal split and two-thirds of its roads modal split, the 1.00 TTI score of transit for both means that NYC's overall TTI score gets a far larger downward adjustment than LA's for the "1.00" TTI transit utilization.

Table A2: Average Travel Time to Work by Means of Transportation; New York-Newark, NY-MJ-CT and Los Angeles-Long Beach-Santa Ana Urbanized Areas; American Community Survey 2005-2007

Means to Work	Number of Commuters	Commute Minutes	Average Commute Time	Percentage of Commuters
	New York-Newark, NY-NJ-CT			
Car, Truck, or Van				
Drove Alone	4,097,977	111,840,030	27.3	49.59%
Carpooled	621,850	19,853,320	31.9	7.52%
Car, Truck, or Van Subtotal	4,719,827	131,693,350	27.9	57.11%
Public Transportation				
Bus or Trolley Bus	760,282	36,276,765	47.7	9.20%
All Other	2,90,253	94,234,710	52.3	21.78%
Public Transportation Subtotal	2,560,424	130,511,475	51.0	30.98%
Walked	514,345	6,891,935	13.4	6.22%
Taxicab, Motorcycle, Bicycle, Other	177,128	4,445,600	25.1	2.14%
Subtotal	7,971,724	273,542,360	34.3	96.46%
Worked at Home	292,254	0	0.0	3.54%
Grand Totals	8,263,978	273,542,360	33.1	100.00%
	Los Angeles-Long Beach-Santa Ana, CA			
Car, Truck, or Van				
Drove Alone	4,027,174	108,621,090	27.0	73.46%
Carpooled	638,190	18,920,535	29.6	11.64%
Car, Tuck, or Van Subtotal	4,665,364	127,541,625	27.3	85.10%
Public Transportation				
Bus or Trolley Bus	315,570	14,583,710	46.2	5.76%
All Other	25,841	1,475,890	57.1	.47%
Public Transportation Subtotal	341,411	16,059,600	47.0	6.23%
Walked	145,884	1,810,220	12.4	2.66%
Taxicab, Motorcycle, Bicycle, Other	111,842	2,829,81522	25.3	2.04%
Subtotal	5,264,501	148,241,260	28.2	96.02%
Worked at Home	217,981	0	0.0	3.98%
Grand Totals	5,482,482	148,241,260	27.0	100.00%

In short, NYC has a significantly *lower* TTI congestion score than LA because it has far higher use of the *slower* means of urban transportation, public transit, which is scored as resulting in *less* delay by the TTI methodology.

We are making this point to show that, if there is any "favoritism" in the TTI methodology toward transit or roads (in the *UMR* methodology utilized for the period studied by this paper), it is clearly toward transit. As the above discussion demonstrates, all else (relatively) equal, UZAs with a greater transit modal split will tend to have lower (better) TTI scores, and a UZA with increasing transit modal split, while keeping all other factors constant, will show lower TTI scores over time, compared to one that had lower or constant transit modal split.

In the following section, we comment on how the UMR evaluates transit:

- "Transit service is operated according to a schedule."

  With the exception of demand-responsive service (aka dial-a-ride, now used most commonly for ADA transit services to the transportation-disadvantaged), almost all transit service is operated under a published schedule. However, transit service being "operated according to a schedule" is not the same as actually operating *on* schedule, meaning the bus, train, etc. arrives at the specified location exactly on the scheduled time. While there is no single, standard, transit industry-wide definition for "on-time" service, a long-standing generally accepted bus rule for "on time" has been arriving at a scheduled stop between one minute early and five minutes late.[163] A study completed by the Los Angeles County Metropolitan Transportation Authority (MTA) of bus transit operators in nine major urban areas showed objectives of averaging 80.8% on-time performance (from a high of 92.0% to a low of 73.9%), with average actual performance of 78.9%, with MTA having an objective of 70.0% and actual performance of 62.7%.[164]

  As a general rule, the vast majority of rail transit service operates either on totally exclusive rights-of-way (heavy rail, monorail) or semi-exclusive, where the interactions with "rubber tire" traffic are generally limited to at-grade crossings (commuter rail, light rail). As a result, rail transit is generally subject to far fewer delays than is bus transit. However, "rubber tire" transit (demand responsive, jitney/publico, motor bus [95.6% of all "rubber tire" transit], trolley bus and van pool) was 55.5% of all national transit (unlinked) trips in 2007.[165] Further, of the 44.5% that was not road-based, 63.4% was in greater NYC, which was home to 5.6% of the U.S. residents at that time.[166] Therefore, then 94.4% of the U.S. populace that does not reside in the greater New York City area has access to only 16.3% of the nation's transit that is operated on an exclusive or semi-exclusive right-of-way and not (or less) subject to road delays.

- "When buses and trains stop to pick up and discharge passengers, their average speed is generally slower than vehicles on the road. Riders and potential riders evaluate the service and make choices according to either the departure and arrival times or in the case of operations that run very frequently, the travel time to the destination with the expectation that the departure time will be relatively soon after arrival in the station."

  We agree with these statements to a large degree, but we believe that all urban travelers, including non-transit road travelers, make their modal choice decisions using the same types of logic. Specifically, those peak-hour non-transit road travelers who commonly make the same type of peak-hour trip, such as home-to-work, home-to-school, etc., are very knowledgeable of peak-hour road conditions and travel times and make their travel plans accordingly. Therefore, we do not see major differences between road and transit travelers in this regard.

- "In transit operations this (transit trips operating on a schedule) can be thought of as similar to an uncongested roadway trip."

  This contention appears a bit strong in this context. The previous discussion included the TTI statement, "Transit service is operated according to a schedule." For road-based transit, standard practice is to set schedules according to expected traffic conditions, where applicable, which almost always means that fixed route bus service trip times during peak hours are longer than for off-peak times. Similarly, experienced peak-hour travelers know that travel during peak hours will generally take longer than the same trip during off-peak hours, and thus they have their own, internalized, anticipated trip times. A large and growing number of mechanisms will offer travel time projections to drivers on a real-time basis, both prior to commencing the trip and while the trip is underway (this a major component of INRIX®'s business model). Therefore, is a formal printed or on-line schedule for transit service, showing slower trip times during peak hours, really all that different from the slower trip experienced by peak-hour drivers? Further, is there a justification for a different treatment for transit trips—including the majority of transit trips that are on the nation's roads—compared to non-transit road trips? Perhaps the best response is referenced in the *2009 UMR* (and echoed in the *2012* UMR) above: that in the future TTI will attempt to incorporate actual schedule vs. actual travel time for transit. It will be interesting to see if, when these data are available, the calculation for the transit component of the total TTI will be peak-hour actual transit travel time as a ratio to peak-hour scheduled travel time, or peak-hour actual travel time vs. non-peak hour actual travel time. But this is not yet a component of the *UMR* calculations and we do not know when it may be.

One additional factor is the consistency of travel time. Those travelers who face negative consequences for arriving late to their destination, such as an employee on a home-to-work trip who faces disciplinary action if late for work, will tend to allow more time for their travel to provide a buffer factor for variation in travel time due to more than the usual traffic congestion, road incidents that tie up traffic, etc.

Non-road transit, such as heavy rail, is not subject to road delays and, therefore, will often offer greater consistency of travel time, which may lead to transit travelers with time-critical arrivals allowing a smaller safety factor in their travel plans. This common traveler behavior of allowing for potential travel delays, is recognized in the *2012* UMR through the addition of the "Planning Time Index," which is designed to mimic how freeway travelers in each UZA increase their expected travel time to protect against unanticipated travel delays for trips where on-time arrival is critical.[167]

The majority of transit utilization in the U.S., including the overwhelming majority of utilization outside of the greater NYC UZA, is road-based, which means that the vast majority of transit commuters are subject to road delays.

This is not to say that rail transit (and other non-rail non-road systems, such as ferryboat) is never subject to delay, as any frequent user of rail transit knows.

However rail transit tends to have fewer delay incidents and the ones that do occur tend to be of low duration. Unfortunately, when rail transit systems do encounter major delays, they can shutdown entire lines for substantial periods. Light rail and commuter rail train-vs.-vehicle and train-vs.-pedestrian incidents often not only require the involved train to completely stop, and the passengers to be interviewed in many cases, but it is often impossible to run any other trains over the portion of track involved, even if it is not a single track at the point of impact.

Appendix B

Appendix B: Statistical Methodology

Regressional Analysis Results

For most purposes, and unless otherwise indicated in the report, we have utilized the detailed data provided in the *UMR* for each UZA for each reporting year. These data include:

- Population
- Urban area size (square miles)
- Freeway vehicle-miles of travel
- Freeway lane-miles
- Arterial street vehicle-miles of travel
- Arterial lane-miles
- Public transportation annual passenger-miles
- Public transportation annual unlinked passenger trips

From these data, and after preliminary analysis of various alternatives, we chose eight variables to be used as explanatory variables (independent variables) for the primary and alternate research hypotheses, and other data were used in our descriptive tables for the major UZAs in our case studies:

1. Primary (transit utilization) research hypothesis (transit utilization approach):
   a. Annual Passenger-Miles (PM)
   b. PM/Capita
   c. Annual Unlinked Passenger Trips (UPT)
   d. Unlinked passenger trips (UPT)/Capita
   e. UPT adjusted (The dependent variable [TTI] that we are using in all

our models is in index format. So we normalized the UPT and PM to index format, using 1982 as our base year and the value of the variables at 1982 as the value of TTI at 1982.)

f. PM adjusted (as for UPT as explained above)

2. Alternate (road utilization) research hypothesis (road utilization approach):
   a. Freeway vehicle-miles of travel/freeway lane-mile (Freeway VMT/Mile)
   b. Arterial vehicle-miles of travel/arterial lane-mile (Arterial VMT/Mile)

We tested multiple regression models, finding that some individual UZAs where these indicators showed improved results over single variable regressions, but the lack of any identifiable, consistent and logically supportable pattern from such multiple regressions led us to reject these results as not useful. Therefore, the statistical method we used in analyzing the data is the "ordinary least squares" (OLS) single independent variable regression.

A crucial test we applied on all our variables before running regressions is the "stationarity test." Stationary data means that all of the statistical properties of the data (for example mean and variance) are constant over time so that there is no trend in the data.

Our analysis did show that some primary data did *not* satisfy this test; there was auto-correlation (the cross-correlation of the data in a series with itself, or, in simple terms, each year's data tend to be not all that much different from the prior year's), as both VMT/freeway-mile and VMT/arterial-mile showed significant upward trends and there were weaker trends for the transit data). The "first difference" treatment was applied (calculating the difference between each data element and the next one in the time series and applying the regression analysis to these differences), using an Augmented Dickey-Fuller (ADF) test, producing stationary data and statistically valid results.

Below, we show the distribution of outcomes of the ADF tests for each of our four independent variables ("expected" means that the regression equation coefficient had the "proper" sign, showing that, as transit usage increased, traffic congestion decreased and *vice versa*; "unexpected" means that as transit usage increased, congestion increased and *vice versa*.

Results for Transit Independent Variables

Table B1: Regression Analysis of 74 UZAs—Distribution of Results (Independent Variance: Annual Unlinked Passenger Trips per Capita. Dependent Variable: Travel Time Index)

	Coefficient Sign	
	Expected	Unexpected
Statistically Significant @ 5%	2 Las Vegas, San Francisco-Oakland	1 Boston
Statistically Significant @ 10%, but not 5%	4 Allentown, Miami, Philadelphia, Raleigh	
Not Statistically Significant	33	34
Totals	39	35

Table B2: Regression Analysis of 74 UZAs—Distribution of Results (Independent Variance: Annual Passenger-Miles per Capita. Dependent Variable: Travel Time Index)

	Coefficient Sign	
	Expected	Unexpected
Statistically Significant @ 5%	1 Nashville	1 New Orleans
Statistically Significant @ 10%, but not 5%	4 Allentown, Miami, Orlando, Providence	
Not Statistically Significant	44	24
Totals	49	25

The distribution of results for these two sets of 74 cases is almost random. Most of the results are not statistically significant in their support of the primary research hypothesis. The result that would support the primary research hypothesis that transit utilization or change in transit utilization had a statistically significant relationship with traffic congestion, specifically a statistically significant regression with an "expected" (that is, as transit usage increases, traffic congestion decreases) coefficient sign, was only six of 74 (8%) in one and five of 74 (7%) in the other, both at the 10% statistically significant level.

The two UZAs—Allentown and Miami— that do meet this level on both tests are hardly hotbeds of transit usage.

We attempted variations on the above, such as using the raw UPT and PM values, including multiple regressions, with no difference in the results; we could find no meaningful relationship. While a small number of UZAs did produce correlations with the correct sign and valid statistical significance test results, when these are reviewed as part of the entire body of results for the 74 UZAs, they appear to be just random noise and not meaningful.

While, as the old saying goes, "correlation is not causation," a complete ***lack*** of any correlation is very strong evidence of a ***lack*** of any causation.

It might be argued, "Yes, your numbers do not show that an increase in transit use does not decrease traffic congestion, but, without transit, traffic congestion would have gotten worse." This argument fails, however, for the following reasons:

- Our tests were not completed *only* to see if increases in transit use are associated with reductions in traffic congestion; our analysis included situations where transit use increased, decreased and did not change substantially over time. We were testing for any and all relationships between changes in transit use and changes in traffic congestion, finding no change that cannot be explained as simple randomness.
- If increases in transit use did have a measurable and consistent beneficial impact on traffic congestion, or *vice versa*, even if it only limited the rate of increase, our regression analysis would have noted it, if it had existed.
- For both of the transit variables that we report on in this paper, as well as for all the other transit variables we worked with, the statistical results that we obtained were the same: as transit use increased, traffic congestion *increased*. This was true nationally and for a substantial portion of the individual cases. While the national association was weak, and the distribution of the individual UZA associations verged on the random, overall, these statistical results, while certainly not definitive, can only be interpreted as working to disprove transit as a means of reducing traffic congestion.

Results for Road Independent Variables

The road independent variables—VMT/freeway lane-mile and VMT/arterial lane-mile—exhibited stronger relationships with TTI than the transit independent variables. (For the road analysis, the "expected" coefficient sign is that, as road utilization increases, traffic congestion increases, and *vice versa*.)

Table B3: Augmented Dickey-Fuller Regression Analysis of 74 UZAs—Distribution of Results (Independent Variance: Vehicle-Miles Traveled/Freeway Lane-Mile. Dependent Variable: Travel Time Index)

	Coefficient Sign	
	Expected	Unexpected
Statistically Significant @ .05	51	
Statistically Significant @ .05-.10	4	
Not Statistically Significant @ .1	17 Bakersfield, Raleigh, Oxnard, Orlando, Springfield, Rochester, Poughkeepsie, Jacksonville, Virginia Beach, Providence, Las Vegas, Sarasota, Fresno, Omaha, El Paso, Milwaukee, Charlotte	2 Albany, Lancaster
Totals	72	2

Table B4: Augmented Dickey-Fuller Regression Analysis of 74 UZAs—Distribution of Results (Independent Variance: Vehicle-Miles Traveled/Arterial Lane-Mile. Dependent Variable: Travel Time Index)

	Coefficient Sign	
	Expected	Unexpected
Statistically Significant @ .05	24	
Statistically Significant @ .05-.10	6	
Not Statistically Significant @ .10	35	9
Totals	65	9

The results for the freeway analysis are relatively strong, particularly as the UZAs that either had "unexpected" coefficients or were not statistically significant at 10% were generally the smaller UZAs in the population with lower levels of traffic congestion than the larger cities. These cities are more subject to the data reliability issues discussed in "A Note on the Data" below.

The arterial ADF results are only mildly supportive of its utility; many of the larger UZAs are not statistically significant. New York City, Boston, Atlanta and Detroit all had "unexpected" signs, while Chicago, Los Angeles, Philadelphia, Houston and Washington did not meet the 10% test.

The following table, B5 and B6, examine regressions for the "raw" data:

Table B5: "Raw Data" Regression Analysis of 74 UZAs—Distribution of Results (Independent Variance: Vehicle-Miles Traveled/Freeway Lane-Mile. Dependent Variable: Travel Time Index)

	Coefficient Sign	
	Correct	Incorrect
Statistically Significant @ .01	74	
Statistically Significant @ .01-.05		
Statistically Significant @ .05-.10		
Not Statistically Significant @ .1		
Totals	74	0

Table B6: "Raw Data" Regression Analysis of 74 UZAs – Distribution of Results Independent Variance: Vehicle-Miles Traveled/Arterial Lane-Mile Dependent Variable: Travel Time Index

	Coefficient Sign	
	Correct	Incorrect
Statistically Significant @ .01	61	2 Lancaster, Oxnard
Statistically Significant @ .01-.05	3 Bridgeport, Poughkeepsie	3 Cleveland, Riverside, Seattle
Not Statistically Significant @ .10	2 Boston, Kansas City	3 Dayton, Phoenix, Portland
Totals	66	8

The distribution of regression coefficients as follows:

Table B7: Distribution of Coefficients of Correlation (r^2)

	VMT/Freeway Lane-Mile	VMT/Arterial Lane-Mile
>.95	27	3
.90-.95	17	16
.85-.90	11	6
.80-85	6	6
.75-.80	5	3
.70-.75	2	4
.65-.70		3
.60-.65	2	5
.55-.60	1	6
.50-.55	1	1
.45-.50	1	1
.40-.45		1
.35-.40		3
.30-.45		2
.25-.30	1	2
.20-.25		1
.15-.20		1
.10-.15		
.05-.10		
<.05		2
Totals	74	66

Running multiple regressions on a UZA-by-UZA basis with both VMT/freeway lane-mile and VMT/arterial lane-mile as the independent variables for the individual UZAs did not "improve" the results significantly. After excluding seven UZAs where one of the single regressions did not produce a r^2 of at least .30 ("explaining" at least 30% of the change in TTI), and eight multiple regression runs produced a negative coefficient to be applied to the arterial VMT variables, only 24 of the remaining 59 multiple regressions explained at least 20%

of the difference from the higher of the two independent variables taken individually. We did not note a useful and consistent pattern of results, so multiple regression research with VMT/freeway lane-mile and VMT/arterial lane-mile was not pursued further.

Only two UZA VMT/freeway lane-mile correlation coefficients were lower than .5: Dayton at .498 and Tulsa at .271. Twelve UZA VMT/arterial lane-mile correlation coefficients were under .5, including six under .3, plus the eight with the coefficient with the “wrong” sign.

Thirteen of the 74 had higher correlation coefficients for VMT/arterial lane-mile than VMT/ freeway lane-mile: Albany, Bakersfield, Charlotte, El Paso, Jacksonville, Orlando, Pittsburgh, Providence, Tampa, Tucson, Tulsa, Virginia Beach and Washington, DC.

All of the coefficients for UZA VMT/freeway lane-mile were positive (as hypothesized), and tended to fall into a fairly narrow band, with two-thirds within $\pm$40% of the value of the coefficient for the least squares equation for the entire population.

Reviewing the VMT/freeway lane-mile and VMT/arterial lane-mile graphics above, the values for VMT/freeway tend to vary much less for any given TTI score than those for VMT/arterial. As a result, while the VMT/arterial lane-mile results are strong, the VMT/freeway lane-mile results are far stronger from a statistical relationship standpoint, and also more consistent with the logic behind our hypothesis, as discussed in the conclusion.

In the discussion of results in the body of this paper, we utilized the raw data, *not* the first difference data, primarily because the graphics of the raw data make the relationships readily apparent to readers unfamiliar with statistical techniques, while the graphics of first difference results would have no utility for this purpose.

We determined that the most useful transit data were PM/capita and UPT/capita, primarily due to the “logical” reason that this is the best measure of change in transit use over time, given that the results obtained with the other data were comparable.

Appendix C

Appendix C: The Benefits of Public Transportation Service (As Summarized in the *2009 Urban Mobility Report*)

The *2009 Urban Mobility Report* summarizes the benefits of public transportation service in the report summary and in more detail in an appendix.[168] These are detailed in the following two exhibits, which are reproduced in full:

Table C1 (Exhibit B-37 in 2009 UMR) Delay Increase if Public Transportation Service Were Eliminated – 439 Areas

Population Group and Number of Areas	Population Group Average Annual Passenger-Miles of Travel (million)	Delay Reduction Due to Public Transportation	
		Hours of Delay (millions)	Percent of Base Delay
Very Large (14)	2,972	557.0	17.9
Large (29)	213	58.8	5.6
Medium (31)	55	12.8	4.2
Small (16)	16	1.5	2.8
90 Area Total	49,790	630.1	14.9
Other Areas (349)	6,032	15.8	2.8
All Areas	55,822	645.9	13.5

Table C2 (Exhibit B-38 in UMR) Effects of Public Transportation Service on the Travel Time Index – 90 Areas

Population Group and Number of Areas	Travel Time Index		
	Base (without public transportation)	With Public Transportation Effect	Reduction in TTI (points)
Very Large (14)	1.403	1.367	0.036 (4)
Large (29)	1.248	1.243	0.005 (1)
Medium (31)	1.145	1.143	0.002 (0)
Small (16)	1.102	1.101	0.001 (0)
90 Area Average	1.309	1.291	0.018 (2)

Note: A TTI "point" is 0.01 on the Travel Time Index

(The tables above discuss the "90 Area Total," referring to the 90 Urbanized Areas that were analyzed in detail in the *UMR*. In this paper, we analyzed only the 74 members of the "Very Large," "Large" and "Medium" population groups, those with populations over 500,000, omitting the 16 members of the "Small" group that were included in the *UMR*.)

We need to reconcile our conclusion—that changes in transit usage have had no significant impact on traffic congestion, as measured by TTI—with the presentation above by the *UMR* authors that, without transit, TTI scores would be higher: four points for Very Large, one point for Large UZA's and two points for the entire 90 areas.

In actuality, there is little, if any, conflict.

The first and most important reason can be found in the title of Exhibit B-37 of the UMR above, "Delay Increase if Public Transportation Service *Were Eliminated*" (emphasis added). The *UMR* authors calculated the impact on TTI if transit service were to be totally eliminated in the 90 UZAs studied, whereas our methodology tested the changes that *actually occurred* over the 26-year study period in each of the 74 UZAs. No change in transit service that actually occurred came remotely close to the complete elimination of transit service. (The largest decreases in UPT/capita among the 14 Very Large areas, which were, by far, the most impacted of the UZAs studied as shown in the Exhibits above, were Atlanta -42%, Detroit -38%, Chicago -30%, and San Francisco-Oakland -27%. The largest increases were Phoenix at +63% and Miami at +29%.)

Second, the impact on even the Very Large UZAs appears to be driven by a very large impact on New York City; most likely, the impact on the 13 other Very Large UZAs is significantly less.

Third, the *UMR* methodology for determining the impact on congestion if public transportation service were eliminated assumes that *all* trips taken on transit would be converted to vehicle-miles traveled on roads at a rate assuming a 1.25 average passenger load: 100 transit passenger-miles would convert to 80 added vehicle-miles.[169] The problem is, one of the most important reasons why people use transit is lack of access to an automobile, particularly the young (below the minimum driving age) and elderly, or the transportation-challenged due to economic, physical and/or other conditions. The American Public Transportation Association reported that only 45.4% of public transportation riders have a vehicle available when deciding to make a transit trip.[170] In the areas where transit is most heavily used, the percentages are significantly higher than the average, led by New York City, where only 44.3% of the households owned or otherwise have access to an automobile in 2000;[171] obviously, even in those households that did own one car, it would not be available for multiple household members to use at the same time.

The 100 transit passenger-miles: 80 vehicle-miles conversion ratio is questionable. We believe it is likely that the ratio would be significantly lower due to:

- Many more former transit riders than the *UMR* assumes would carpool—including substantial numbers with drivers already making similar trips.
- The rapid organization of the type of 300-carpool alternate group transportation service provided by the African-American community in Montgomery, Alabama in the transit system boycott following Rosa Parks's famous refusal to give up her bus seat—which is very similar in concept to what happens in transportation-dependent communities every time a major transit agency suffers a strike or other shutdown of service.[172]
- Many former transit trips would be by non-motorized means.
- Many former transit trips would not be taken—particularly as employees lost jobs they could no longer access.
- Over time, the population of the UZA, and travel within it, would be significantly reduced due to lack of mobility of the residents.

Another potential factor regarding the increase in TTI scores due to the disappearance of transit has to do with the way that transit use impacts the TTI scores as discussed in Appendix A, namely that transit use is given a "1.00" TTI score in all cases. Although it is not possible to determine if Exhibits B-37 and B-38 of the 2009 *UMR* results shown above were produced using the same calculus—"determine," in this case, meaning to find a discussion in the details of the *UMR* that makes a factual statement, one way or the other—it is certainly not unreasonable to believe that this may be the case. Let us examine how this might impact the TTI scores if it is.

In the prior appendix, for the Los Angeles UZA during the period, the average TTI for the period 2005–2007 is 1.50. If we assume that 4% of all trips during peak periods are on transit, we can use simple algebra to compute the TTI for roads alone:[173]

Table C2: Los Angeles UZA Calculation of Peak Period Road TTI

	Percentage	TTI	Extension
Total Travel	100.0%	1.50	1.50
Less: Transit	4.0%	1.00	.04
Road	96.0%	*1.52**	1.46

* Calculation: 1.46/96.0% = 1.52.

The way that the TTI calculation works, with transit always scored as "1.00" non-delayed transportation, if those currently using transit for their peak travel stopped using transit, the Los Angeles TTI score would increase from 1.50 to 1.52 *even if the former transit riders stayed home and did not take their former trips*. This is without considering a shift of former transit trips to autos on roads, which would presumably cause slowing of road traffic.

The calculus of the TTI, with its automatic no-congestion score for transit, makes it challenging to determine the impact of the cessation of transit on congestion, even if there was any real possibility that any major U.S. UZA would actually cease transit service.

The underlying assumption for the calculation, that transit service would disappear from any major American city, is extraordinarily unlikely, even if the government funding for such service were to disappear. Undoubtedly, within days, alternate transit service would spring up in a variety of different types, such as the *Publico*/Jitney route association service operated in San Juan and Atlantic City, as well as the type of one-person, I'm-on-my-way-to-work, might-as-well-see-if-anyone-will-pay-me-for-a-ride jitney service that the American streetcar industry moved heaven and earth—and many state legislatures—to wipe off the face of the planet when it became a serious competitor around 1914, and the rapid increase in operations of the many *sub rosa* transit systems already in existence.[174]

In the unlikely event that publicly funded transit service disappeared from a major American UZA, one development worth watching would be how quickly informal mobile electronic device-based carpooling matching—for free and for fee—would develop into large-scale mobility enablers. Universities and high schools would likely be among the first major communities to develop. While there is a legitimate government interest in preserving the safety of the riders, the operators and the public, the biggest question is, will government step in to license, regulate and tax such innovations to death, as occurred with jitneys almost a century ago?

Appendix D

Appendix D: Data and Study Limitations

As the analysis is being applied to a large, multi-year database originally generated from multiple sources, there are—as is usually the case—some minor errors in the data. In the following paragraphs, we note situations where the data may not be accurate and/or consistent for certain UZAs for certain years.

The Texas Transportation Institute draws its data from federal government sources, chiefly the Federal Highway Administration's (FHWA) Highway Performance Monitoring System and the Federal Transit Administration's (FTA) National Transit Database (NTD).[175] Additional data were obtained from other sources, including the American Public Transportation Association.[176]

FHWA (originally the Public Roads Administration) has been collecting and producing road-related statistical reports of all types for several decades and has been consolidating this data into its annual *Highway Statistics* series since 1945.[177] FTA (originally the Urban Mass Transportation Administration) has been collecting data from individual transit operators for the NTD since the 1979 reporting year.[178] Therefore, the first year of the time series data that was utilized in the TTI calculations—1982—was the fourth year of the NTD, but at least the fourth decade of FHWA road statistics.

In reviewing the details of the *UMR* database used for the TTI calculations, we noted that the total transit unlinked passenger trip and passenger-mile data were identical for each of the first three years for each UZA, which are obviously incorrect data. In most cases, the data reported were relatively consistent with the data reported for subsequent years. For our seven case studies, the most troublesome case was that of Dallas, where the data for reporting years 1982, 1983 and 1984 were only approximately 10% of that reported for 1985. In addition, in Los Angeles, the period 1982–1985 had the greatest growth in transit usage of any major U.S. city in a short period over the last several decades, but the constant data for the first three years of this period meant that this was not properly reflected in the TTI calculations and, therefore, its impact could not be properly analyzed.

We also noted a small number of other obvious inconsistencies in the *UMR* database (such as those discussed in endnote 46.)

However, even where we have noted such questionable data, we have not altered any data obtained from the Texas Transportation Institute, nor have we excluded any data. Even in those cases where we had more accurate data, since the data reported in the *UMR* database are the data that were utilized to conduct the TTI calculations, it would be improper for us to attempt to "improve" it.

The researchers who developed the TTI database have worked with the basis of UZAs, which, unlike states and counties, frequently change their boundaries as settlement patterns evolve. The Census Bureau is constantly changing UZA boundaries as new suburbs are developed and sometimes combine or separate pre-existing UZAs.

Regardless, any researcher who has utilized the FHWA and FTA databases over the years, and the Texas Transportation Institute's usage of them, would conclude that they have been continually improving in data quality. In particular, NTD data quality has improved significantly over the last 15 years. While the TTI database is not perfect, it is very good; we believe that it is very useful and more than adequate for the purposes of this paper.

As a general rule, data for larger UZAs tend to be more accurate and consistent than for the smaller UZAs. Also, the road data tend to be more consistent than the transit data. The first few years of the transit data (1982–1985) are the most questionable.

Larger UZAs also tend to have larger TTI scores and greater ranges of TTI scores. For example, Los Angeles, the second largest UZA (by population) and the one with the highest TTI scores, had a range of TTI scores from 1.24 to 1.51 during the study period—a range of 28 points. Springfield (MA-CT), the 63rd largest UZA, had a range from 1.04 to 1.07, giving a range of only four points. This means that Los Angeles has seven times the precision in measurement of changes in congestion over Springfield, which makes measuring the effect of changes in independent variables on TTI, the dependent variable, far more viable. When this factor is included with the next, it becomes harder to show a meaningful relationship for smaller UZAs with less congestion and a narrow band of values.

Finally, all TTI scores are in even hundredths, such as 1.22. Unlike the other values reported which are rounded, 1.22 does *not* mean it could be 1.21512 or 1.22448; 1.22 means 1.22000 in each and every case. Obviously, when the calculations were performed by the Texas Transportation Institute, the results were not this "perfect," but these are the reported data and these are the data that we have used. That means that the non-rounded TTI score could be ±3.3% of the mean TTI score of 1.15 for the population, which could influence some of our analysis, but not in a manner that we can correct or calculate—or which we believe would significantly change any of our findings and conclusions.

Regression Variables

One standard rule about the use of regression is that you should not use the data in the dependent variable as an independent variable. In the production of this paper, we believe we likely violated this rule, with a specific purpose discussed below.

The authors of the *UMR* do not provide all the specific equations that are utilized in the calculation of TTI, although they do discuss the methodology in a fair degree of detail, including many of the specifics at what is at least a summary level. They also provide all the data that are both used and produced by the methodology to calculate TTI and the other performance indicators in the *UMR*. These are found in Appendix A, "Methodology for the 2009 Urban Mobility Report."

We believe that for the "transit" independent variables we used in this analysis—annual transit passenger-miles, unlinked passenger trips and urbanized area population—there is only a minor utilization in the TTI calculation. However, there is a more significant utilization of the "road" variables—freeway and arterial street vehicle-miles traveled and lane-miles.

Transit Variables

As is discussed in the previous section, transit use during peak periods is regarded as uncongested, and therefore there is no reason for any of the components of the transit variables to be utilized in the calculation of delay, with one exception.

The methodology for calculation of TTI can be thought of as a weighted average of the individual TTI scores for roads and transit. As is discussed below, the individual road TTI calculation is complex and involves many factors, not including any of the transit variables. The individual transit TTI scores are always 1.00, uncongested. No calculation is completed.

However, to do a weighted average, the relative weights for road and transit use must be determined. Here we believe it reasonable to assume that one or both of the transit utilization variables, passenger-miles and unlinked passenger trips, is used as part of the computation of the weighting factors. If this assumption is correct, then this element could appear as both independent and dependent variables in the regression analyses.

Regardless, the impact of such use would be very minor. (The New York City example below explains why.) If we use the *ACS* home-to-work transit use as a surrogate for peak-hour transit use, then the overall average transit mode split for the 74 UZAs studied was 8.7%. Only 16 of the 74 UZAs studied had transit percentages over 5%, and in only five cases was this percentage over 10%: New York City (31.0%), Washington (16.4%) San Francisco-Oakland (16.3%), Boston (12.5%) and Chicago (12.3%).

New York City, the UZA with the most transit usage, would be the UZA most impacted. In 2007, NYC's TTI score was 1.37. With 31.0% transit usage, this would produce the following weighted average TTI reverse-engineered calculation:

Road:	69.0% x 1.53/100 =	1.06
Transit:	31.0% x 1.00/100 =	.31
Total:		1.37

During the 26 years of the study period, the largest year-to-year change in transit passenger-miles was an 8.0% increase from 2006 to 2007.

During the same period, VMT/freeway lane-mile increased .7% and VMT/arterial lane-mile increased 2.5%. For the Roadway Congestion Index, the *UMR* uses a weighting factor ratio of 14,000:5,000 between freeway and arterial VMT.[179] If we apply these weightings to the increases in freeway and arterial VMT, we have a weighted increase in overall VMT of:

Freeway	.7% x 14,000 =		98
Road	2.5% x 5,000 =		125
Totals		19,000	223
Divided By:			19,000
Road Percentage Increase			1.2%

We now apply these growth factors to produce comparable 2006 mode splits:

Road	69.0% x 98.8% =	68.2%/96.7% =	70.5%
Transit	31.0% x 92.0% =	28.5%/96.7% =	29.5%
Total		96.7%	100.0%

Now, going back and replacing the 2007 modal split values with the ones just calculated above, we have:

Road:	70.5% x 1.53/100 =	1.079
Transit:	29.5% x 1.00/100 =	.295
Total:		1.374

So, in the UZA with the largest percentage of transit use (almost double that of number two Washington), in the two-year period with the greatest change in transit use, the change in TTI score from the mode split shift was approximately 1%.

For those UZAs with lower transit modal splits (all the rest), in years that do not have smaller changes in transit use (almost all of them), the impacts would be significantly smaller.

Therefore, while we concede that our regression methodology *does* violate the "same factor cannot be in both the independent and dependent variables in a regression analysis" rule, the impacts are miniscule and will be ignored.

Road Variables

As mentioned above, the authors of the *UMR* have not published the precise formulas that are used for the calculation of TTI, although there is a good general narrative explanation of the procedure. However, any reading of the

UMR Appendix A, *Methodology for the 2009 Urban Mobility Report*, shows multiple uses of both freeway and arterial VMT and lane-miles in the calculations of various factors, including some with freeway and arterial VMT/lane-mile.[180]

Clearly, our methodology is using elements of the same data in both the independent and dependent variables in its regressions completed with VMT/lane-mile. When this is completed, and particularly when the effective weighting of these factors in the dependent variable values is high, the resulting regression results are very "good."

We do not contest this; in fact, it is one of the main points we wish to make: for the majority of the UZAs studied—54 of 74, or 73%—freeway VMT/lane-mile explained at least 85% of the variance in results. Further, where traffic congestion tends to be worst in the 13 largest UZAs, all had freeway VMT/lane-mile r^2s of at least .85. The five largest all had r^2s of at least .95.

We completed the regression analysis of VMT/lane-mile against TTI not because there is any question of the impact the interactions between road use and road capacity have on traffic congestion, but rather to demonstrate that the single variable of freeway VMT/lane-mile can come close to duplicating the TTI scores, particularly for the larger cities that tend to be more congested. And one of the key reasons why changes in transit usage have no demonstrable impact on traffic congestion is that transit is a minor factor in surface transportation in urban areas, and no factor in freight movements. It is therefore overwhelmed by freeway VMT/lane-mile.

Statistical Limitations

While we worked with the best information available, we used certain statistical methods that are less than ideal. Tim Lomax, one of the principal authors of the TTI *Urban Mobility Report*, assisted us with technical inquiries during our research and analysis phase and reviewed our report to ensure we explained TTI metrics correctly. Three other reviewers also evaluated and commented on our statistical methods. While we addressed most of the statistical concerns, reviewers raised five statistical concerns that we chose not to change. We summarize these concerns below and then explain why we chose, despite the concerns, to use our original method.

Concern 1: Using a single congestion measure may not provide the richest data. U.S. metro areas have many different spatial structures. Using only one TTI metric to measure car-centric Houston with urban-growth-boundary constrained Portland may miss lurking variables. The average travel speed is relatively low in Portland because the metro area is trying to become denser to decrease average trip distance. While the average travel speed is significantly higher in metro areas with a dispersed development pattern such as Atlanta, Dallas and Houston, the average travel distance is longer. Since different metro areas can use TTI data in different ways, using only one data source may have limitations.

Explanation 1: Using many indicators is definitely superior to using one indicator. While trip length, in miles, is a useful indicator, it is not easy to obtain on a UZA-by-UZA, or city-by-city basis, and is not reported by the *UMR*.

Trip length, measured in time, is available through the U.S. Census Bureau, though the decennial census and the Census's American Community Survey (ACS). However, as it provides far fewer years of data than the *UMR* series, we chose to use TTI as our primary data source. (A comparison of TTI vs. ACS travel time for 2007 is included in Appendix I, "Some Notes on the 2009 Urban Mobility Report and its Methodology.")

The 2009 *UMR*, which we utilized for this paper, contains another congestion measure reported in the Texas Transportation Institute spreadsheets: "Roadway Congestion Index." While the results for these two indices are not identical, and vary from UZA to UZA, for the entire data set of 74 UZAs over 26 years, the values were highly correlated ($r^2 = .84$, $p[1,924] = 102.1$, $p = 0$). This indicates that for a macro study such as this, an analysis that used the Roadway Congestion Index would be very likely to produce very similar results to the TTI results.

Concern 2: Our primary hypothesis and null hypothesis regarding transit usage rely on the percentage of users who take transit. Since the number of people who take transit is small in most metro areas, any effect will be muted.

Explanation 2: True, but if a connection between change in transit utilization and TTI does exist, our methodology should detect and report it. Our finding that there is no significant relationship is the primary report conclusion.

Concern 3: The 74 UZAs create a data set that is related to other UZAs. As a result, the 1,900 data pairs are an artificial construct.

Concern 4: Another equally valid method would be to compare year-to-year changes rather than year-to-year values. This would also show whether traffic congestion decreases as transit riders increase.

Concern 5: The road variable VMT/lane-mile is what TTI used to develop the TTI values. There is a large amount of collinearity between these two measures (VMT/lane-mile and TTI value).

Concerns 3 and 5 raise valid questions about the variables. In some definitions, "collinearity" refers to a relationship between two or more independent variables. In this situation we are using only one independent variable.

In our analysis there was a concern about a similar issue, auto-correlation, where there may be a relationship between the values in the same independent variable over the series. To eliminate this issue, we utilized standard tests for auto-correlation, as discussed in Appendix B, "Statistical Methodology." We found that this condition did exist for both VMT metrics, but not the transit metrics. The time series shows the value increasing steadily from year to year. (VMT/freeway lane-mile is an example of a highway metric.) As a result the prior year value is a good predictor of the next year's value. After we used standard statistical methodologies to make this adjustment, we found strong relationships for most UZAs, and for the entire set of data for the 74 UZAs, for the two VMT metrics.

Concern 4 is correct; this is also a valid test. Our similar methodology is also valid; we used it because it made graphing the regression outputs easier to understand. We tested the suggested methodology for UPT as the independent variable and found no meaningful relationships; for the 74 UZAs, there were only eight r^2s over .10 and only one—Allentown, at .24—over .20.

About the Authors

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Mr. Rubin founded and directed the transit industry practice of what is now Deloitte & Touche, LLP, growing it to the largest in the accounting/consulting industry, and personally selling over $100 million worth of services. From 1989 to 1993 he was Controller-Treasurer of the Southern California Rapid Transit District. He has managed projects including financial, grant, performance, and contract audits; design and implementation of management information systems; construction project management oversight; long-term operating/capital/financial planning and modeling and preparation of bond official statements and tax revenue projections; grant applications and indirect cost allocation systems; fare collection security reviews; merger and reorganization; subsidy allocation; privatization and contracting, labor negotiation, expert/expert witness work, and many other types of projects.

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Endnotes

[1] Los Angeles County Transportation Commission (LACTC) (now Los Angeles County Metropolitan Transportation Authority [LA Metro]), Ordinance 16, presented to the voters as Proposition A in November 1980, a one-half cent sales tax for public transportation in Los Angeles County, now codified in MTA Administrative Code, Section 3-10-040, accessed October 12, 2009: www.metro.net/images/MTA%20Administrative%20Code%20Enactment.pdf

[2] American Public Transportation Association (APTA), press release, "Most Americans Link Increasing Investment in Public Transportation to Solving Congestion and a Better Quality of Life," March 12, 2003, accessed October 3, 2009: http://www.publictransportation.org/resources/releases/030312.asp

[3] *Light Rail Now*, "Minneapolis: First Car Runs on Hiawatha Light Rail Starter Line," June 2003, accessed September 22, 2009: http://www.lightrailnow.org/news/n_min002.htm

[4] Metropolitan Transit Authority of Harris County Houston (Houston Metro), *A Comprehensive Look at the Metropolitan Transit Authority of Harris County, Houston, Texas*, accessed January 12, 2010: http://www.ridemetro.org/AboutUs/Default.aspx

[5] Rebekah Richards, *Benefits of Public Transit,* accessed April 3, 2010: http://www.ehow.com/list_5991005_benefits-public-transit.html

[6] Paul M. Weyrich and William S. Lind, *Twelve Anti-Transit Myths: A Conservative Critique*, Free Congress Foundation for the American Public Transit (now Transportation) Association, July 2001, p. 12: http://www.apta.com/resources/reportsandpublications/Documents/how_transit_benefits.pdf

[7] Smart Growth America: "What is 'smart growth?' Smart growth is a better way to build and maintain our towns and cities. Smart growth means building urban, suburban and rural communities with housing transportation choices near jobs, shops and schools. This approach supports local economies and protects the environment," accessed September 21, 2011: http://www.smartgrowthamerica.org/what-is-smart-growth,

"Transportation choices" in the above context is generally meant to refer to transportation choices other than automobiles, primarily transit, but certainly including pedestrian travel, bicycling, with all being coordinated with transit-oriented development (TOD).

[8] Texas Transportation Institute, "Texas Transportation Institute Teams with INRIX," January 11, 2010, accessed March 31, 2013:

http://tti.tamu.edu/2010/01/11/texas-transportation-institute-teams-with-inrix/

Other traffic congestion and related measures are described, along with our rationale for preferring TTI for this study, in Appendix I, "Some Notes On The *2009 Urban Mobility Report* And Its Methodology."

9 David Schrank and Tim Lomax, *2009 Urban Mobility Report*, Texas A&M University/Texas Transportation Institute, http://mobility.tamu.edu/ums/, accessed July 8, 2009. This will hereinafter be referred to as "*UMR,*" On January 20. 2011, the *2011 UMR* was released and incorporates major changes in methodology, some of which will be discussed below. Accessed January 24, 2011:
http://mobility.tamu.edu/ums/media_information/press_release.stm,

We believe that these changes are an important part of the long-term process of continual improvements in the *UMR* series of reports; however, it incorporates some changes in data acquisition, namely the teaming arrangement with INRIX for data acquisition that could pose problems with the continuity and comparability of the data for the period prior to the change being made. We assert that the study of the data through 2007 in the 2009 *UMR* is significant to understand the relationship between transit utilization and traffic congestion during the subject period.

10 *UMR*, Exhibit 1., "Major Findings for 2009 – The Important Numbers for the 439 U.S. Urban Areas," p. 1.

11 23 USC 101(a)(37).

12 23 USC 101(a)(36).

13 Our statistical methodology, of course, tests for both positive and negative relationships; in this particular, the positive relationship being that an increase in transit use is associated with an increase in congestion, or *vice versa.*

14 Authors' calculations from *UMR* data.

15 *Ibid.*

16 U.S. Department of Transportation/Federal Transit Administration, National Transit Database ("*NTD*"), "Profiles" for these agencies, accessed December 12, 2009:
http://www.ntdprogram.gov/ntdprogram/data.htm

17 Erik Slotbloom, *Houston Freeways—A Historical and Visual Journey* (Cincinnati: C.J. Krehbiel, 2003).

[18] Metropolitan Transit Authority of Harris County, Texas, "Facts and History," accessed February 16, 2010: http://www.ridemetro.org/AboutUs/Default.aspx

[19] J. H. McDonald, *Handbook of Biological Statistics* (second edition), Sparky House Publishing, 2010, "Student's t-test," pp. 118-122, accessed September 16, 2013: http://udel.edu/~mcdonald/statttest.html

[20] Author's calculation from *UMR data*.

[21] *UMR*.

[22] *Ibid.*

[23] NTD "profiles" for each reporting agency for each year have both annual and working weekday unlinked passenger trips; dividing the former by the latter generates the annual-to-weekday conversion factor for unlinked passenger trips, which we assume to be roughly similar to that for passenger-miles.

Author's calculation from *NTD* "Profiles" for Metro-North Commuter Railroad Company, MTA Long Island Rail Road, MTA New York City Transit, New Jersey Transit Corporation, New York City Department of Transportation, and Port Authority Trans-Hudson, which together accounted for over 91% of the NYC passenger-miles reported by *UMR*. The calculation was the division of the total annual unlinked passenger trips by the average weekday passenger trips. Accessed April 30, 2010: http://www.ntdprogram.gov/ntdprogram/data.htm

[24] U.S. Department of Transportation, Bureau of Transportation Statistics, *Pocket Guide to Transportation 2010* ("*Pocket Guide*"), Tables 4-1, "Vehicle-Miles: 1990–2007," pp. 17, and 4-3, "Passenger-Miles: 1990–2007," accessed April 30, 2010: http://www.bts.gov/publications/pocket_guide_to_transportation/2010/pdf/entire.pdf

[25] Federal Highway Administration, *Highway Statistics 2007*, Table HM-72 (hereinafter '*FHWA*'), "Selected Characteristics." (The *UMR* does not report total VMT; this report is derived from the source data for the *UMR*.) Accessed October 28, 2008: http://www.fhwa.dot.gov/policyinformation/statistics/2007/xls/hm72.xls

[26] California Legislative Analyst, *HOV Lanes in California: Are they Achieving Their Goal?*, pp. 3 and 10, accessed March 31, 2013: http://www.lao.ca.gov/2000/010700_hov/010700_hov_lanes.pdf

[27] Environmental Protection Agency, "Urbanized Area Map Results for Illinois—Illinois Overview—Population for Storm Water Entities as Defined by the 2000 Census" (hereinafter "*EPA-(name of State*), and *EPA-Indiana*, accessed April 17, 2010: http://www.epa.gov/npdes/pubs/illinois.pdf & http://www.epa.gov/npdes/pubs/indiana.pdf

[28] *APTA 2009*, Table 3, "50 Largest Transit Agencies Ranked by Unlinked Passenger Trips and Passenger-miles, Report Year 2007," Table 24, "50 Largest Bus Agencies Ranked by Unlinked Passenger Trips and Passenger-miles, Report Year 2007," and Table 30, "Heavy Rail Agencies Ranked by Unlinked Passenger Trips and Passenger-miles, Report Year 2007."

[29] Chicago Transit Authority, accessed April 24, 2010: http://www.transitchicago.com/riding_cta/systemguide/buses.aspx

[30] Metra, website home page, accessed April 24, 2010: http://metrarail.com/metra/en/home.html

In addition to the 11 Metra commuter rail lines, the "South Shore" line, operated by the Northern Indiana Commuter Transportation District, is the last of the American electric interurbans, running into Chicago from South Bend, Indiana. Accessed April 24, 2010: http://www.nictd.com/

[31] APTA, *2009 Public Transportation Fact Book* (hereinafter "*APTA 2009*"), Table 29, "Commuter Rail Agencies Ranked by Unlinked Passenger Trips and Passenger-miles, Report Year 2007," accessed November 22, 2009: http://www.apta.com/gap/policyresearch/Documents/APTA_2009_Fact_Book.pdf

[32] *APTA 2007*, Table 3, Table 24, Table 25, "50 Largest Vanpool Operators," accessed November 2, 2009.

[33] *NTD*, annual "profiles" for CTA, Metra and Pace for the study period.

[34] *EPA-Texas*, accessed April 17, 2010: http://www.epa.gov/npdes/pubs/texas.pdf

[35] DART, *Financial Statements – Years Ended September 30, 2009 and 2008 and Independent Auditors' Report*, Note 1, "Organization and Significant Accounting Policies," accessed April 13, 2010. http://www.dartnet.org/debtdocuments/DARTFinancialStatements2009.pdf

[36] DART, website, "About DART" and "Schedules," accessed April 13, 2010: http://www.dart.org/default.asp

[37] *APTA 2009*, Table 3, Table 24, Table 31, "Light Rail Agencies Ranked by Unlinked Passenger Trips and Passenger-miles, Report Year 2007," and Table 25.

38 *NTD* “Profiles,” 2007.

39 DART, *Financial Statements.*

40 *APTA 2009*, Table 29.

41 *EPA-Texas*, accessed April 17, 2010: http://www.epa.gov/npdes/pubs/texas.pdf

42 Metro, *Comprehensive Annual Financial Report, October 1, 2008-September 20, 2008,* Notes to the Financial Statements 1, “Summary of Significant Accounting Policies,” accessed April 19, 2010: http://www.ridemetro.org/AboutUs/Publications/Pdfs/2008-AnnualReport.pdf

43 Metro, “A Comprehensive Look at the Metropolitan Transit Authority of Harris County, Houston, Texas,” accessed April 12, 2010: *http://www.ridemetro.org/AboutUs/Default.aspx*

44 *APTA 2009*, Table 3, Table 24, Table 31, “Light Rail Agencies Ranked by Unlinked Passenger Trips and Passenger-miles, Report Year 2007,” and Table 25.

45 *UMR.*

46 There are examples of other major decreases—Dayton, 2000-2007, 1.13➔1.09 (31% decline); Honolulu, 1996–2000, 1.21➔1.18 (14%); Milwaukee, 2002–2006, 1.15➔1.12 (20%); and Saint Louis, 2000–2007, 1.20➔1.13 (35%)—but only Saint Louis was as large in percentage terms and none followed a period of rapid increase in freeway VMT and TTI as in Houston.

However, in some of these, there appears to be some question regarding the data time series.

The Dayton reduction appears to be a caused primarily by an 18% reduction in VMT/arterial lane-mile due to a 22% increase in arterial lane–miles, a rather remarkable occurrence that may cause the arterial lane-mile time series to be questioned, particularly given the small 7% growth in UZA square miles over this period.

In Honolulu, the period of decline is one of actual reduction in both freeway and arterial VMT, which, along with minor increases in freeway and arterial lane-miles, led to actual reductions in VMT per lane-mile for both.

Milwaukee saw increases in both freeway and arterial lane-miles (11% and 12%, respectively, with a 2% increase in UZA square miles), which led to decreases in VMT per lane-mile for both—and this again causes some questioning of the lane-mile data.

Saint Louis showed a 28% increase in freeway lane-miles and a 29% increase in arterial lane-miles, which again appears questionable given the 13% increase in UZA square miles over the period.

47 The argument can certainly be made that, during this period of TTI reduction, the Houston economy was in very poor condition due to the reduction in oil prices that led to downturns in every local economic segment from retail to real estate (see, for example, Federal Reserve Bank of Dallas, Houston Branch, *Houston Business-A Perspective on the Houston Economy*, June 2003, "1982-90: When Times Were Bad In Houston," accessed April 22, 2010:
http://www.dallasfed.org/research/houston/2003/hb0304.html)

However, the way in which downturns in economic condition have a positive impact on congestion (or act to slow the worsening of congestion) is to reduce VMT as the economic conditions that drive VMT lead to less driving. Undoubtedly, during this period, which the Federal Reserve measures from the local economic activity peak reached in March 1982 until this level of economic activity was reached again in 1990, the economic slow-down *did* reduce VMT growth. However, with the exception of the change from 1984 to 1985, VMT increased in every year during this period, and the overall rate of increase for Houston from 1982 to 1990 was a 45% increase for freeway VMT and a 16% increase for arterial VMT. For the 14 "very large" (over 2,000,000 population in 2007) *UMR* UZAs, the average rates of growth for VMT during this period were 51% and 25%, respectively.

Therefore, even in this period of severe economic downturn in Houston, the rates of increase in VMT were only slightly less than those for Houston's peers, and there *was* substantial growth in both VMT factors during this period.

During the "Phase II" period above, 1986–1993, when Houston freeway and arterial VMT grew by 26% and 24%, respectively, the "very large" UZAs grew by 31% and 21%, respectively.

48 *UMR*, except where otherwise noted.

49 Slotboom, *Houston Freeways*, page 66.

50 Slotboom, *Houston Freeways*, page 69, referencing the 1965 California Division of Highways (now CalTrans) California Freeway and Expressway System map. Urbanized area freeway plans were very fluid in the decades

immediately after World War II; this map was a fair representation of the total regional design at an important point in time.

51 Eric Richardson, "66 Years Ago Today: Design for 'Four Level' Interchange Unveiled," April 21, 2010, blogdowntown, referenced April 28, 2010: http://blogdowntown.com/2010/04/5294-66-years-ago-today-design-for-four-level

52 Slotboom, *Houston Freeways*, pp. 103–110.

53 Orange County Transportation Authority, 91 Express Lanes, accessed April 28, 2010: http://www.octa.net/91_overview.aspx

Orange County Transportation Corridor Agencies, accessed April 28, 2010: https://www.thetollroads.com/home/index.htm

54 Slotboom, *Houston Freeways*, pp. 315–321.

55 Texas Department of Transportation, *Building A Legacy … the IH10 West Katy Freeway Story*, accessed May 2, 2010: http://www.katyfreeway.org/GrandOpening/Katy_Video_Booklet.pdf

56 *EPA-California*, accessed April 17, 2010: http://www.epa.gov/npdes/pubs/california.pdf

57 California Public Utilities Code §§130050-51, accessed April 15, 2010: http://www.leginfo.ca.gov/cgi-bin/waisgate?WAISdocID=6893964060+1+0+0&WAISaction=retrieve

58 *UMR,* and FTA, NTD "Profile" for LA Metro, 2007.

59 *APTA 2009*, Table 3, Table 24, Table 30, Table 31 and Table 26.

60 "The Red Cars of Los Angeles," accessed April 12, 2010: http://www.usc.edu/libraries/archives/la/historic/redcars/

61 MTA press release, "Stations Along Historic El Monte Busway Get Facelifts, New Art and Amenities For Riders," April 26, 2006, accessed April 4, 2013: http://www.metro.net/news/simple_pr/stations-along-historic-el-monte-busway-get-faceli/

62 Author's calculations from vehicle/vehicle occupancy data provided by Caltrans District 7 (Los Angeles and Ventura Counties).

63 MTA, "Edward R. Roybal Gold Line Eastside Extension," accessed March 30, 2013: http://www.metro.net/projects/eastside/

[64] MTA, "Metro Expo Line, accessed March 30, 2013: http://www.metro.net/projects/exposition/

[65] Author's personal files as former Chief Financial Officer of SCRTD and Metro press release archive: http://www.metro.net/news/toc/

[66] "Joint powers are exercised when the public officials of two or more agencies agree to create another legal entity or establish a joint approach to work on a common problem, fund a project, or act as a representative body for a specific activity," California State Legislature/Senate Local Government Committee, *Governments Working Together—A Citizen's Guide to Joint Powers Agreements*, August 2007, accessed March 30, 2013: http://www.calafco.org/docs/Senate_LG_JPA_Report.pdf

[67] Metrolink, Metrolink Service Map, accessed April 27,2010: http://www.metrolinktrains.com/map/map.php

[68] *APTA 2009*, Table 29.

[69] FTA, NTD "Profile" for Metrolink, 2007.

[70] *APTA 2009*, Table 3, Table 24, and Table 25.

[71] FTA, NTD "Profile" for OCTA, 2007.

[72] FTA, NTD "Profile" for Metrolink, 2007.

[73] These statistics and comparisons are for the UZAs. The city of New York, at 27,100 persons/square mile, is far denser than the city of Los Angeles, at 8,208 – and New York County (Manhattan), at 70,828, is far denser still. (Census Bureau, "State and County Quick Facts" for 2006, accessed April 22, 2010: http://quickfacts.census.gov/qfd/index.html)

However, the Los Angeles UZA is remarkable, within the U.S., for its consistency of population density due to two factors: (a) a very large number of non-central business district major business centers, such as those in Century City, Glendale, Long Beach, Pasadena, Warner Center, etc., and (b) extremely dense suburban residential patterns.

[74] Eric Eidlin, "What Density Doesn't Tell Us About Sprawl," *Access*, fall 2010, Number 37, accessed February 1, 2010: http://www.uctc.net/access/37/access37sprawl.pdf

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[76] Wendell Cox, “Work Trip Walkability In US Metropolitan Areas—Neighborhood Maximum Jobs-Housing Balance Index: 1990,” accessed May 3, 2010: http://www.demographia.com/db-jhbal1990walk.htm

[77] Ian Lovett, “To Fight Gridlock, LA Synchronizes Every Red Light,” *The New York Times*, April 1, 2013, accessed April 2, 2013: http://www.nytimes.com/2013/04/02/us/to-fight-gridlock-los-angeles-synchronizes-every-red-light.html?smid=go-share&_r=4&

[78] FTA (then Urban Mass Transportation Authority [UMTA]), *Data Tables for the 1985 National Transit Database Section 15 Report Year*, SCRTD/Metro Section 15/National Transit Database reports to UMTA/FTA for 1982-2002; NTD “Profiles” for Metro for subsequent years. The data in the graph do not adjust for labor actions against SCRTD that shut down operations for five days in the 1983 reporting year [SCRTD/MTA have June 30 fiscal year ends], 12 days in 1995 [MTA operated approximately one third of its transit service with management personnel during this action] 33 days in 2001, and 35 days in 2004. Michael H. Cimini and Charles J. Muhl, “Los Angeles Strike Ends,” *Monthly Labor Review*, Volume 114, 1994, accessed May 7, 2010: http://www.questia.com/googleScholar.qst;jsessionid=L1YSCghH8vwjj47ZDJf9rnzsVKTjpBbV2hM7nyLPJ8mVJlX7vLQd!1893792638!1707999068?docId=5000287759,

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[79] LACTC Ordinance 16, presented to the voters as Proposition A, November 1980 election.

[80] SCRTD Section 15 reports to UMTA, 1982 and 1985.

[81] Author’s personal files as Chief Financial Officer of SCRTD during this period.

[82] Ibid. During this period, through other actions of LACTC, former SCRTD transit lines with ridership of approximately 10 million annual riders were transferred to other Los Angeles County transit agencies. Adjusting for these shifted riders, SCRTD ridership declined approximately 25%. (Author’s personal files.)

[83] LA Metro, fiscal year 1995 Budget Proposal documentation.

[84] *Labor/Community Strategy Center et al v Los Angeles County Metropolitan Transportation Authority et al*, [No. 94-5936 TJH (MCX)] (*L/CSC v MTA*).

[85] From the first year of Section 15/NTD reporting in 1979 to well into the CD period, SCRTD/Metro bus service had the highest average passenger load of any major city bus operator in the nation. As a result of the CD overcrowding reduction service, Metro average bus passenger loads fell to second highest, after NYC.

[86] *NTD*, SCRTD/LACTC/LA Metro, Environmental Impact Statements/Reports for various rail lines, comparisons of projected new transit riders to total rail riders.

[87] "Comments of Thomas A. Rubin to the California State Assembly Select Committee on Rail Transportation," Los Angeles, April 25, 2008.

[88] *EPA-New York*, *EPA-New Jersey*, and *EPA-Connecticut*, accessed April 17, 2010:
http://www.epa.gov/npdes/pubs/newyork.pdf
http://www.epa.gov/npdes/pubs/newjersey.pdf
http://www.epa.gov/npdes/pubs/connecticut.pdf

[89] *UMR*.

[90] *APTA 2009*, Tables 28 and 29, *APTA 2009*, Tables 3, 24, and 30.

[91] Ibid., Tables 2 and 3.

[92] Ibid., Tables 3 and 24.

[93] Ibid., Tables 3 and 29.

[94] Ibid., Tables 3 and 29.

[95] Ibid., Tables 3 and 24.

[96] Nassau Inter-County Express, accessed March 30, 2013:
http://www.nicebus.com/

[97] *APTA 2009*, Table 30.

[98] Ibid., Tables 3, 24, 25, 29, and 31.

[99] Ibid., Table 30.

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NYC data from the *UMR*, U.S. national data from APTA *2009 Public Transportation Fact Book*, Table 2, "National Totals, Report Year 2007," accessed November 3, 2010: http://www.apta.com/gap/policyresearch/Documents/APTA_2009_Fact_Book.pdf

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102 Mark Seaman, Allison L.C. de Cerreño and Seth English-Young, *From Rescue to Renaissance: The Achievements of the MTA Capital Program 1982-2004*, December 2004, NYU Wager Rudin Center for Transportation Policy & Management, accessed June 14, 2010: http://wagner.nyu.edu/news/rescue.pdf

103 Ibid., pp. *i*, *iii*, *iv*, 1, 9, 10, 16, 17, 27, 29, 30–31, 35, and 36.

104 Seth Faison, "3,000 Subway Riders, Cards in Hand, Test New Fare System," *The New York Times*, June 2, 1993, retrieved May 14, 2010: http://query.nytimes.com/gst/fullpage.html?res=9F0CE7DC143BF931A35755C0A965958260,
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105 Michael Markowitz, "NYC Subway Token, 1953–2003," *Gotham Gazette* , April 28, 2003, retrieved May 14, 2010: http://www.gothamgazette.com/article//20030428/202/362.

106 Fare revenue and UPT from *NTD*, inflation adjustment factor is Consumer Price Index-All Urban Consumers, New York-Northern New Jersey-Long Island, NY-NY-CT-PA, Series Id: CUURA101SA0, CUUSA101SA0, accessed May 12, 2010: http://www.bls.gov/cpi/

[107] APTA, *2010 Public Transportation Fact Book, Appendix A: Historical Tables*, Table 1, "Unlinked Passenger Trips by Mode," accessed May 14, 2010: http://apta.com/resources/statistics/Documents/FactBook/2010_Fact_Book_Appendix_A.pdf

[108] *EPA-Oregon* and *EPA-Washington*, accessed April 17, 2010: http://www.epa.gov/npdes/pubs/oregon.pdf and http://www.epa.gov/npdes/pubs/washington.pdf

[109] Tri-Met, *2009 Annual Report*, Footnote 1, "Organization and Summary of Significant Financial Policies," p. 14, accessed May 9, 2010: http://trimet.org/pdfs/publications/TriMet_2009_Annual_Report.pdf

[110] *APTA 2009*, Tables 3, 24, 25, and 31.

[111] Tri-Met, "MAX Light Rail Project History," accessed May 18, 2010: http://trimet.org/about/history/maxoverview.htm

[112] "Portland Streetcar," accessed May 18, 2010: http://www.portlandstreetcar.org/

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[114] FTA, *NTD*, 2007 "Profiles" for C-TRAN and Tri-Met.

[115] *Oregon Encyclopedia*, "Mount Hood Freeway," accessed May 12, 2010: http://oregonencyclopedia.org/entry/view/mt__hood_freeway/

[116] Oregon Transportation Institute, "HOV Lane/Light Rail Comparison," accessed May 12, 2010: http://www.portlandfacts.com/OTI/webdoc4.htm, Detailed traffic information is not available, but it is likely that, in the present day, the HOV lane would have carried more transportation than the light rail line does.

For our current purposes, the two most relevant indicators are "passengers pass a point" and "transportation work," which, in this instance, means passenger-miles on a mile of guideway, both during the peak hour, as explained below.

For light rail, TriMet operates a total of 18 trains on this segment on three light rail lines (Blue Line, 10; Green Line, 4; and Red Line, 4) between 7:00 a.m. and 8:00 a.m. in a westbound direction towards the Portland CBD. (TriMet, "Maps and Schedules," accessed May 12, 2010: http://trimet.org/schedules/index.htm). Assuming all trains are two-car consists, that would be 36 cars per hour and, assuming an average load of 75 (approximately all seats occupied, no standees), that would be 2,700 passengers/hour past a point. Assuming an average speed of 30 mph, including stops, each mile of light rail guideway would produce 81,000 peak-hour passenger-miles.

The HOV lane was originally opened as HOV-3 (three passenger minimum occupancy to use), but was later changed to HOV-2 when HOV-3 did not generate sufficient traffic to use the available capacity. We will do the calculations both ways, but, by this time, there is a strong likelihood that use of the HOV lane would be operated as HOV-3.

For HOV-2, we will assume average vehicle occupancy of 2.1; for HOV-3, 3.1. These could be increased if bus routes utilized the HOV lane. Assuming 1,000 vehicles an hour, which is conservative, HOV lanes of this type can approach 1,600 vehicles an hour without significant possibility of entering stop-and-go conditions. That would be 2,100 and 3,100 passengers, respectively, past a point. Assuming 55 mph average speed, the passenger-mile products would be 115,500 and 170,500, respectively.

Three of the four indicators—all but passengers past a point with HOV-2—favor the HOV lane. As the assumptions are specifically tailored to favor light rail, in the real world, the results would likely be more favorable to the HOV lanes.

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122 Metro, “What is Metro,” accessed May 12, 2010: http://www.oregonmetro.gov/discover/

123 Metro, “The Metro Charter,” accessed May 12, 2010: http://www.oregonmetro.gov/index.cfm/go/by.web/id=211/level=3

124 Ibid.

125 Effective 09/08/10, Referenced February 18, 2011: http://library.oregonmetro.gov/files//chap308.rtfp_clean_eff._090810.pdf,

Ibid., Table 3.08-2, p. 32.

[126] Transportation Research Board, *Highway Capacity Manual 2000* (*HCM 2000*), "Quality and Levels of Service," pp. 2-2/3.

[127] *HCM 2000*, "LOS," pp. 23-2/3.

[128] TRIP *Oregon's Transportation Chokepoints: The Top 50 Chokepoints and Remedies for Relief*, May 2010, accessed May 12, 2010: http://www.tripnet.org/Oregon_Chokepoints_Report_051310.pdf

[129] Oregon Department of Transportation, U.S. Department of Transportation/Federal Highway Administration and Federal Transit Administration, Washington State Department of Transportation, C-Tran, Metro, Tri-Met, and RTC, *Final Environmental Impact Statement and Final Section 4(f) Evaluation: Columbia River Crossing, Interstate 5 Columbia River Crossing Project*, September 2011, Exhibit 2.2-2, "Locally Preferred Alternative Columbia River Crossing Cross-section," pp. 2–7. http://www.columbiarivercrossing.org/FileLibrary/FINAL_EIS_PDFs/CRC_FEIS_Chapter2_S2.1_River_Crossing_and_Highway_S2.2_Transit.pdf

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136 *ACS*, ECONorthwest for Metro, “Preliminary Financial Analysis for the Metro 2035 RTP (regional transportation plan) Update,” December 2006, Table 4-3, “Summary of Estimated Total Costs for Road and Transit in the Region, by OM&P (Operating, M) and Capital Improvements, 2007-2035, pp. 4–9, accessed July 14, 2010: http://library.oregonmetro.gov/files/rtp_preliminary_financial_analysisfinal.pdf

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138 “Memorandum for the Record—Meeting in the President’s Office—Interim Report on the Interstate Highway System, April 6, 1960, 10:35 AM.,” April 8, 1960, accessed February 26, 2010: http://eisenhower.archives.gov/Research/Digital_Documents/InterstateHighways/New%20PDFs/1960_04_08_Meeting.pdf

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[142] VRE, "Station Map," accessed May 13, 2010:
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[143] Montgomery County Ride On, accessed April 1, 2013:
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[144] WMATA, *WMATA Facts*, accessed May 3, 2010:
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[146] FTA, "Washington DC Metrorail Construction," accessed May 8, 2010:
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[147] For example, Metro LA received $640.50 million against the $1,310.82 (49%) cost of the Red Line MOS-3 North Hollywood (FTA, *Annual Report on New Starts—Proposed Allocations of Funds for Fiscal Year 200*, p. A-66) and the Central Puget Sound Transit Authority (dba Sound Transit) received $500 million against the $2.491.6 million (20%) of the Central Link Initial Segment (ibid., p. A-209).

[148] *UMR.*

149 Todd Littman, *Congesting Costing Critique—Critical Evaluation of the "Urban Mobility* Report," Victoria Transportation Institute, March 25, 2013, accessed April 4, 2013: http://www.vtpi.org/UMR_critique.pdf

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150 *UMR 2009*, Table of Contents, p. iii, accessed April 4, 2013: http://www.providenceviaduct.com/resources/2-existing_conditions/Urban_Mobility_Report_2009.pdf

151 For the *UMT 2009* version that was utilized for this paper, we have APTA, "Public Transit Saved 646 Million Hours in Travel Delay in 2007—Texas Transportation Institute's New Congestion Report Drives Home the Value of Public Transportation to Help Alleviate Congestion," July 8, 2009, accessed April 4, 2013: http://www.apta.com/mediacenter/pressreleases/2009/Pages/090708_transit_saved.aspx

152 *2009 UMR*, Exhibit 1, Major Findings for 2009, The Important Numbers for the 439 U.S. Urban Areas, p. 1.

153 In recent years, INRIX®'S *National Transit Scorecard* has quickly come to prominence among serious students of congestion. Based on GPS-enabled commercial fleet vehicles, such as taxis, airport shuttles, service delivery vans, and long haul trucks, this provides what INRIX® describes as "… the ability to generate the most comprehensive congestion analysis to date, covering the nation's largest 100 metropolitan areas." (*National Transit Scorecard* 2009, accessed December 15, 2009:) http://scorecard.inrix.com/scorecard/request.asp

However, this time series begins with 2006, which makes it far less useful for our purposes than the *UMR* database going back to 1982. In general, the INRIX® and TTI scores and rankings tend to be very similar.

The Texas Transportation Institute and INRIX® announced they would be working jointly on annual reports in the future. (INRIX®, press release, "Texas Transportation Institute Teams with INRIX," January 11, 2010,

accessed February 3, 2010:
http://www.inrix.com/pressrelease.asp?ID=91)

And the 2011 and later *UMRs* does include INRIX® data.

TomTom began publishing U.S. and world-wide data, beginning with first quarter 2012:
http://www.tomtom.com/en_us/congestionindex/

Another important transportation data source is the National Household Travel Survey, sponsored by the Federal Highway Administration. However, this is directed toward the collection of detailed data about the specific trips that household members take by mode of transportation and, as a result, the data are not easily utilized for analysis of change in congestion, particularly since NHTS is administered only periodically (2009, 2001, 1995, 1990, 1983, 1977, 1969) and it includes intercity travel, which is not comprehended by the current project. National Household Travel Survey home page, accessed March 3, 2010:
http://nhts.ornl.gov/index.shtml

Finally, the *UMR* itself includes another measure of freeway congestion, the "Roadway Congestion Index" (RCI), which is defined as "Urban area estimates of vehicle miles of travel (VMT) and lane-miles of roadway (Ln-Mi) are combined in a ratio using the amount of travel on each portion of the system. The combined index measures conditions on the freeway and arterial street systems according to the amount of travel on each type of road." While the RCI would appear to be useful for our analysis, we elected to utilize the TTI instead, primarily because the TTI has become the primary metric utilized by the Texas Transportation Institute itself and because TTI has become far better known, and more widely utilized in both the professional and popular literature. As the *UMR* itself states, "Early versions of the Urban Mobility Report used the roadway congestion index as a primary measure. While other measures that define congestion in terms of travel time and delay have replaced the RCI, it is still used as part of the calculation of delay." (*UMR*, p. A-4).

[154] U.S. Department of Commerce, Census Bureau, "American Community Survey—About the ACS," accessed July 13, 2009:
http://www.census.gov/acs/www/SBasics/

[155] The ACS home-to-work commute data is obtained from the answers to the questions 31–34 on the ACS survey (English language questionnaire, accessed July 13, 2009):
http://www.census.gov/acs/www/Downloads/SQuest09.pdf

[156] *2009 UMR*, Appendix A, "Methodology for the 2009 Urban Mobility Report," pp. A-2 and A-3.

[157] Ibid., p. A-1.

[158] Ibid., pp. A-2 and A-18.

[159] *2009 UMR*, p. B-43.

After the Texas Transportation Institute-INRIX™ cooperative agreement was implemented, transit appears to have been eliminated from the actual calculation of TTI and other *UMR* statistics. In the most recent (2012) *UMR*, there is no mention of transit data of any type being utilized for any calculation in Appendix A Methodology, nor is there any mention of transit data being thus utilized in the main report, except for the following from p. 22 of the main report:

Future Changes

There will be other changes in the report methodology over the next few years. There is more information available every year from freeways, streets and public transportation systems that provides more descriptive travel time and volume data. Congested corridor data and travel time reliability statistics are two examples of how the improved data and analysis procedures can be used. In addition to the travel speed information from INRIX, some advanced transit operating systems monitor passenger volume, travel time and schedule information. These data can be used to more accurately describe congestion problems on public transportation (emphasis added) *and roadway systems.*

Accessed April 1, 2013:
http://mobility.tamu.edu/ums/report/

[160] *2009 UMR*, p. 19.

[161] Confirmed via e-mail exchange with Tim Lomax, July 13-14, 2009.

[162] ACS, Number of Commuters: B08301, "Means of Transportation to Work—Workers 16 Years and Over;" Commute Minutes: B08136, "Aggregate Travel Time to Work of Workers By Means of Transportation to Work—Workers 16 Years and Over Who Did Not Work At Home," accessed July 13, 2009:
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[163] J.W. Bates, *Definition of Practices for Bus Transit On-Time Performance: Preliminary Study*, Transportation Research Board, Transit Research Circular No. 300, 1986.

[164] MTA, Report to the Board of Directors, "Amend the FY09 Budget to Add Ten Additional Transit Operations Supervisors for Vehicle Operations

Support," June 18, 2008, accessed July 14, 2009: http://www.metro.net/board/Items/2008/06_June/20080618F&BItem18.pdf

165 Some rail transit, such as streetcar service, operates in the same street lanes as are utilized by the "rubber tire" modes listed above and, therefore, is subject to traffic congestion and incident delays; however, for the instant purpose all rail modes, including streetcar and other modes that are subject in varying degrees to road delays, were included in the non-road percentage of transit trips. In both cases, these are relatively small components of the trips on the specific modes.

166 Author's calculations from data contained in Federal Transit Administration, National Transit Database 2007, Table 19:Transit Operating Statistics Supplied and Consumed, accessed October 20, 2008: http://www.ntdprogram.gov/ntdprogram/data.htm,

Census Bureau, ACS 2007, for U.S. and New York-Newark, NY-NJ-CT Urbanized Area Urban Area, respectively, accessed August 14, 2009: http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=01000US&-ds_name=ACS_2007_1YR_G00_&-_lang=en&-_caller=geoselect&-format= http://factfinder.census.gov/servlet/ADPTable?_bm=y&-context=adp&-qr_name=ACS_2007_1YR_G00_DP2&-ds_name=ACS_2007_1YR_G00_&-tree_id=307&-redoLog=true&-_caller=geoselect&-geo_id=40000US63217&-format=&-_lang=en

NY UZA total population 16,842,923, U.S. total population 301,621,159.

167 *2012 UMR*, Appendix A Methodology, p. A-21 *et seq.*

168 *UMR*, "Summary of the Mobility Effects of Public Transportation," pp. B-49/50, *UMR*, Exhibit 1, "Major Findings for 2009 – the Important Numbers for the 439 U.S. Urban Areas," p. 1, and "Benefits of Public Transportation Service," p. 14.

169 *UMR*, Exhibit B-36, "Changes to Urban Mobility Report Methodology," p. B-48.

170 APTA, *A Profile of Public Transportation Passenger Demographics and Travel Characteristics Reported in On-Board Surveys, May 2007*, p. 98, accessed May 13, 2010: http://www.apta.com/resources/industryresearch/Documents/transit_passenger_characteristics_07.pdf,

For a more detailed critique of the *UMR* methodology for measuring the impact of transit on traffic congestion, see Wendell Cox and Randal O'Toole, *The Contribution of Highways and Transit to Congestion Relief: A*

Realistic View (Washington D.C.: The Heritage Foundation, January 27, 2004) accessed May 14, 2010: http://www.heritage.org/Research/Reports/2004/01/The-Contribution-of-Highways-and-Transit-to-Congestion-Relief-A-Realistic-View

171 Census Bureau.

172 Rosa Parks Facts.com, *Rosa Parks and the Montgomery Bus Boycott*, accessed May 14, 2010: http://www.rosaparksfacts.com/montgomery-bus-boycott.php

173 This data are not available from *UMR*, but 6.23% of all home-to-work trips are taken on transit, *ACS*.

174 Atlantic City Jitney Association, accessed Mary 12, 2010: http://www.jitneys.net/501/index.html, Park Woodworth and Robert Behnke, *Smart Jitney/Community-Enhanced Transit Systems*, pp. 6-7, 2006 APTA Bus and Paratransit Conference, accessed May 15, 2010: faculty.washington.edu/jbs/itrans/minerva31.doc,
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175 *UMR*, "What is the Source of Data for This Report," p. B-2, *UMR*, "Mobility Benefits of Public Transportation Service," p. B-42.

176 *UMT*, "Revisions to the Public Transportation Methodology," pp. B-44-5.

177 FHWA (Public Roads Administration/Federal Work Agency), *Highway Statistics 1945*, 1947, accessed April 3, 2010: http://isddc.dot.gov/OLPFiles/FHWA/013228.pdf

178 FTA, National Transit Database, "What is the NTD Program," accessed April 3, 2010: http://www.ntdprogram.gov/ntdprogram/ntd.htm

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180 See, for example, *UMR* pp. A-4, A-5, A-10, and A-13.

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