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Effect of Light-Rail Transit on Traffic in a Travel Corridor

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FINAL REPORT

Effect of Light-Rail Transit on Traffic in a Travel Corridor

NITC-RR-611

June 2014

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EFFECT OF LIGHT-RAIL TRANSIT ON TRAFFIC IN A TRAVEL CORRIDOR

Final Report

NITC-RR-611

by

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Allison Spain

for

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16. Abstract

This study seeks to quantify the effect of the University TRAX light-rail line on traffic near the University of Utah, providing quantitative data that can be used to shape future transportation policies aimed at reducing traffic congestion, energy consumption, air pollution, greenhouse gas emissions, and parking costs. Travel demand models have long been used to estimate and evaluate the effects of transportation improvements, like LRT investments, on network travel flows and times as part of long-range planning studies, using four-step models or more sophisticated urban simulation studies. However, these are usually ex ante studies. Few ex post evaluations have been done, and in this sense, the effects of transit on traffic volumes and associated energy consumption and air pollution have not been rigorously evaluated to support or refute the justification for subsidized transit. Such quantification is required for a comprehensive cost-benefit analysis. Our aim is to provide the first hard evidence of light-rail's impact on traffic in a travel corridor, to quantify the associated savings on energy consumption, air pollution, and parking costs, and to compare cost savings to transit subsidies.

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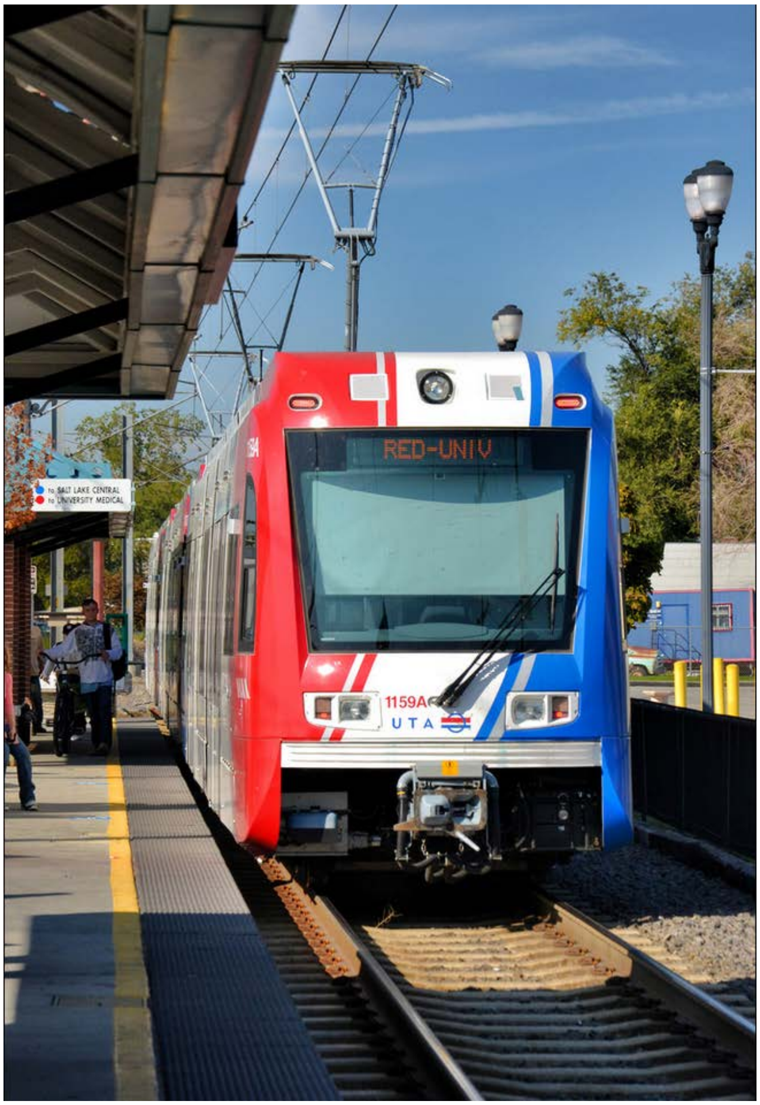

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Introduction

This study seeks to quantify the effect of the University TRAX light-rail line on traffic near the University of Utah, providing quantitative data that can be used to shape future transportation policies aimed at reducing traffic congestion, energy consumption, air pollution, greenhouse gas emissions, and parking costs. Initial studies conducted by the Utah Transit Authority (UTA) on data collected by the Utah Department of Transportation showed that traffic near the university has fallen to levels not seen since the 1980s, even as the number of students, faculty and staff at the university has increased. What is less clear is exactly why this occurred. The university is the second-largest traffic generator in the state, and concerted efforts to encourage commuters to use transit to and from the university have resulted in a large number of commuters adopting transit as a primary means of commuting. A survey conducted in 2005 found that nearly a quarter of students, faculty and staff at the university used transit as a primary mode of transportation to and from campus.

An audit ordered by the Utah State Legislature in 2008 found that transit passes issued to students, faculty and staff at educational institutions recovered just 8 percent of the cost of service. By comparison, other types of passes recovered an average of 24 percent of the cost of service. Determining the effect of the TRAX light-rail lines serving the University of Utah campus on traffic along parallel arterial streets will make it possible to quantify the savings in traffic congestion, energy consumption, air pollution and parking costs such subsidies provide, and allow a full evaluation of the partnership between the university and the UTA.

Travel demand models have long been used to estimate and evaluate the effects of transportation improvements, like LRT investments, on network travel flows and times as part of long-range planning studies, using four-step models or more sophisticated urban simulation studies. However, these are usually ex ante studies. Few ex post evaluations have been done, and in this sense, the effects of transit on traffic volumes and associated energy consumption and air pollution have not been rigorously evaluated to support, or refute the justification for subsidized transit. Such quantification is required for a comprehensive cost-benefit analysis. Transit is assumed to reduce traffic congestion, and alleviate the negative impacts of congestion. The introduction of TRAX light-rail service to the university provides a quasi-experiment from which we can quantify the before-and-after impacts of transit. Our aim is to provide the first hard evidence of light-rail's impact on traffic in a travel corridor, to quantify the associated savings on energy consumption, air pollution, and parking costs, and to compare cost savings to transit subsidies.

Literature Review

Many regions around the United States are developing LRT systems as an alternative to the automobile. LRT has become an attractive option because of its ability to be located in a variety of land use contexts, from suburbs to high-density central business districts. Living near LRT stations offers an array of benefits that have been measured through several studies. These benefits arise from lower transportation costs, changing development patterns, higher property values, and reducing air pollution.

Traffic

The statement "you can't pave your way out of congestion" is generally accepted. Litman (2010) identifies errors in the arguments for highway expansion to reduce traffic congestion. As an alternative, LRT has the potential to reduce regional traffic congestion because it does not (unlike highway expansion) induce additional regional vehicle miles traveled (VMT). Indeed, from recent studies, it has the opposite effect (Hyman and Mayhew 2002; Schrank, Eisele and Lomax 2012; Ewing et al. 2008; Cervero and Murakami 2010; Ewing et al. 2014).

The Texas A&M Transportation Institute's (TTI) 2012 Urban Mobility Report reports that in the 498 urban areas studied, there were approximately 56 billion passenger miles of travel on public transportation systems in 2011. Overall, if these riders were not handled on public transportation systems they would contribute an additional roadway delay of almost 865 million hours, or about a 15 percent increase in the total delay. Of the 865 million hours of potential extra delay, 816 million were estimated to be in 101 larger urban areas, including Salt Lake City and Provo-Orem.

Regional studies also show that LRT development affects vehicular traffic congestion. Research by Winston and Langer (2006) indicates that both motorists and truck congestion costs decline in a city as rail transit mileage expands. Garrett and Castelazo (2004) found that traffic congestion growth rates declined in several U.S. cities after LRT was established. A study of traffic congestion in Denver indicated that traffic within the zone of influence of the light-rail system increased 31 percent compared with 41 percent outside the zone of influence (Bhattacharjee and Goetz 2012). A study in Baltimore showed that congestion increased an average of 2.8 percent annually before light-rail, but only 1.5 percent annually after light-rail was implemented (Litman 2012). Litman (2012) also found that cities with rail systems have significantly higher per capita transit ridership and lower per capita vehicle ownership than cities with no rail transit service. Goldstein (2007) found that households located within walking distance to rail transit stations drive 30 percent less on average than those located in less transit-accessible locations.

However, Senior (2009) and Lee et al. (2013) questioned the effect of LRT on car ownership and car use. They argued that rail ridership increases come from bus trips that are diverted to rail. They concluded that light-rail was only somewhat successful in decreasing car use for journeys to work and made at best only a minimal impact on road congestion, partly because of the lack of coordinated car restraint policies. Duranton and Turner (2011) also found no evidence that public transportation relieves road congestion. They argued that whenever a driver shifts onto public transportation, another is going to use the open lane.

Air Pollution

TTI's 2012 Urban Mobility Report reports that 380 pounds of CO_2 were emitted per auto commuter during congestion in 2011, versus 160 in 1982. The effects of transit on air pollution and greenhouse gas emissions are subject to debate. Using structural equation modeling, Ewing et al. (2008) and Bailey et al. (2008) find that transit service reduces urban VMT and associated emissions both directly through mode shifts and indirectly through land use changes. In a holistic approach measuring the impacts of transit in Washington D.C., Los Angeles, and London, Parry and Small (2009) show the benefits of subsidizing urban transit: substantial reductions in congestion, pollution, and traffic accidents.

On the other hand, O'Toole (2008) questions the supposed reduction in energy and greenhouse gas emissions from public transportation. The substantial fossil fuel consumption by public transport does not guarantee that a city will save energy or meet greenhouse gas targets by investing in public transportation. Since public transportation generally uses diesel fuels and electricity, the mix of pollutants emitted by public transportation must be considered as an offset to automobile pollution reduction.

From our literature review, we found no study that used a similar, carefully controlled research design to estimate the effects transit has on traffic, energy consumption, air pollution, and parking costs in a travel corridor.

Longitudinal Analyses and Natural Experiments

The vast majority of studies on travel and the built environment are cross sectional in nature, using travel data at a single point in time to explain travel behavior. The Transportation Research Board (TRB) report, Does the Built Environment Influence Physical Activity? Examining the Evidence, calls for longitudinal studies that use data for the same places over time to explain changes in behavior. These are rare because longitudinal data are rare. According to the TRB, "…most of the studies conducted to date have been cross sectional. Longitudinal study designs using time-series data are also needed to investigate causal relationships between the built environment and physical activity." The same need exists in studies of travel behavior.

The TRB report also calls for studies of so-called natural experiments, changes that occur naturally when some public or private action alters the built environment. If baseline data are available, the effect of the change can be quantified. "When changes are made to the built environment—whether retrofitting existing environments or constructing new developments or communities—researchers should view such natural experiments as 'demonstration' projects and analyze their impacts on physical activity." Again, the same opportunity exists when natural experiments alter travel behavior.

Such natural experiments occur every time a new transit line is built. Well-located transit lines will attract new development, changing the built environments of the station areas. We would expect to see a corresponding change in travel behavior.

UTA's Rail System

UTA's initial LRT line (the Blue Line) was opened in 1999. It runs from downtown Salt Lake City to Sandy, a suburban community in southern Salt Lake County. In August 2000, construction began on an extension from downtown to the University of Utah's southwest corner at the Rice-Eccles stadium (the Red Line). That line was opened in December 2001. The actual ridership of the University line far exceeded projected ridership. UTA projected 4,300 riders in the opening year and ended up with 7,500.

In May 2002, work began on an extension of the University TRAX line to the University Medical Center at the Northeast corner of campus. That line was opened in September 2003. This LRT Line received a grant for $241M dollars. UTA contributed $71M in local funds. The University Line was also funded at 80% level. Total cost was 118M. Finally, the Medical Center extension was funded at a 60/40 level. Total cost was $89M.

Since then, the UTA's LRT system (including commuter rail) has been expanded with:

August 2011 – 5.1-mile, four-station extension of the Green Line to the West Valley City Center

August 2011 – 10.6-mile, nine-station extension of the Red Line to Daybreak in South Jordan

April 2013 – 6-mile, six-station extension of the Green Line to the Salt Lake International Airport

August 2013 – 3.5-mile, three-station extension of the Blue Line to Draper

April 2008 – 44-mile, eight-station commuter rail of FrontRunner North

December 2012 – 45-mile, seven-station commuter rail extension of FrontRunner South

Each of these rail extensions represents a natural experiment, which can be studied for its impacts on travel within the rail corridor by comparing conditions before the extension to conditions after the extension. This study focuses on the University Extension because adequate time has passed since the extension for the full effects to be felt. The University Extension is also interesting because it has the highest ridership on the system (see Table 1). The system is free for students, as part of tuition and registration fees. Those holding tickets to all University of Utah home games can ride the TRAX for free. The University line has short headways during the peak period (15 minute headways). The university is a commuter school, and the TRAX line serves heavy traffic from the downtown hub and points south and west. There is local promotion by city government to use TRAX for air pollution reduction.

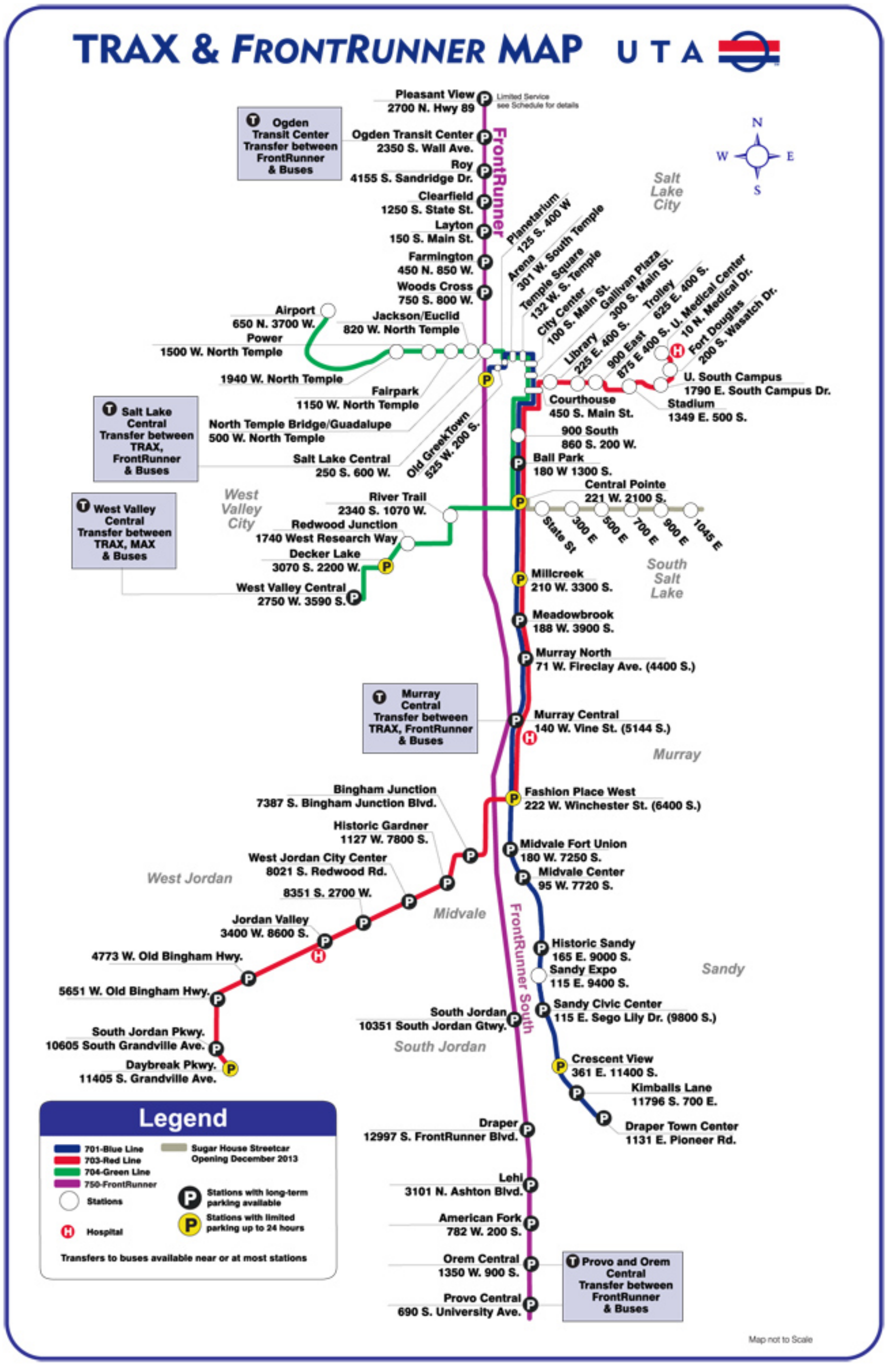

Figure 1. UTA Rail Systems Map

Table 1. Ridership on the UTA's Rail System (2012)

TRAX	Nov 2011 – Oct 2012
Blue Line	21,200
Red Line	22,200
Green Line	9,500

Quasi-Experimental Analysis

A quasi-experiment is an empirical study used to estimate the causal impact of an intervention on its target population. Quasi-experimental research designs share some characteristics with traditional experimental designs, such as the treatment to one group but not another. Where the two designs differ is in the lack of random assignment of subjects to treatment and control groups.

A causal inference from any quasi-experiment must meet the basic requirements for all causal relationships: that cause precedes effect; that cause covaries with effect; and that alternative explanations for the causal relationships are implausible (Shadish et al. 2002). Both randomized and quasi-experiments force the treatment to occur before the effect. Assessing covariation between cause and effect is easily accomplished in all experiments, usually using statistical analysis. To meet the third requirement, randomized experiments make alternative explanations implausible by ensuring that subjects are randomly distributed across experimental conditions. Without random assignment, quasi-experiments rely on statistical control variables and sample matching to show that alternative explanations are implausible.

The "Treatment"

The "treatment" in this quasi-experiment is the 2.3 mile extension of TRAX from downtown Salt Lake City to Rice-Eccles Stadium in December 2001 (see Figure 2). Year 2001 represents the last year before the initial treatment, and 2002 represents the first year after the treatment. Construction began on the 1.5-mile University Medical Center Extension in May 2002, and the line opened at the end of September 2003. This opening constitutes a second treatment. The last year before this treatment is 2003, and the first year after is 2004.

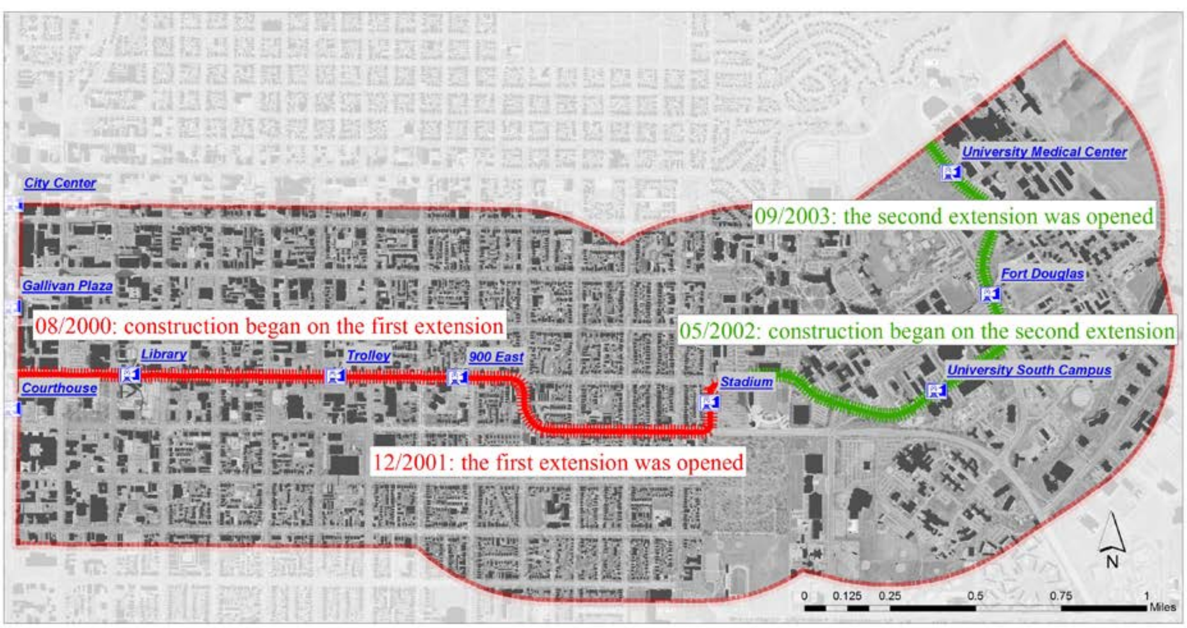

Figure 2. Timeline of the University TRAX Line

Traffic Counts

The traffic counts used in this evaluation were provided by the Utah Department of Transportation (UDOT). Traffic data are analyzed and combined from various traffic counters throughout the state to obtain annual average daily traffic (AADT) numbers along with other traffic statistics such as design hour volume and directional factor. The Traffic Monitoring Unit collects traffic count data (48 hour mobile traffic counts) on a sample basis throughout the state and maintains the permanent counters as well. The counts from these sources are used by the Traffic Analysis Unit to obtain AADT numbers.

Mobile counts are completed using Wavetronix radar counters, Timemark, and Peek manufactured counters and hoses. To assure UDOT's permanent counters are working correctly, the operator visually reviews the data, along with the vehicle stream, to confirm that the loops are working normally and that counts being viewed are correct. Traffic counts are taken on all state highways and all federal aid eligible roadways. There are also classification counts used to determine truck traffic and establish axle correction factors for volume counts.

All traffic data received in the office is checked to see that all hours are accounted for and that the site description matches where the count was taken. AADTs are then calculated using 102 permanent counters throughout the state to develop temporal factors (daily and monthly), and are then expanded to the approximately 5,381 short time counts (48 hour).

Annual average daily traffic on 400/500 South, from UDOT counts, is presented in Table 2.

Table 2. Annual Average Daily Traffic on 400/500 South and University Line Ridership

Year	AADT	University Line Ridership
1992	31,539	-
1993	32,133	-
1994	32,795	-
1995	33,408	-
1996	33,758	-
1997	36,247	-
1998	38,533	-
1999	41,347	-
2000	32,393	-
2001	32,801	3,836
2002	23,488	8,009
2003	23,916	9,441
2004	22,692	12,395
2005	22,667	14,410
2006	23,432	15,005

2007	23,432	12,877
2008	22,432	15,629
2009	22,644	15,099
2010	22,325	14,656
2011	22,112	15,357

Short-Term Impact of TRAX – Pretest-Posttest without a Comparison Group

Our first analysis uses the simplest quasi-experimental design, a one-group pre-treatment, post-treatment design with no comparison group. This can be diagrammed as follows, where the O is an observation and the X is a treatment. The "treatment" in this case is the opening of the University TRAX line.

$$O_1 \quad X \quad O_2$$

This research design is classified as a "weak" quasi-experimental design because it lacks a control or comparison group. "Adding a pretest provides weak information about the counterfactual inference about what might have happened to participants had the treatment not occurred…because [observation 1] occurs before [observation 2], the two may differ for reasons unrelated to treatment, such as maturation or history" (Shadish et al., 2002, p. 108). All of the difference in an outcome from before the treatment to after the treatment is attributed to the treatment itself.

In our case, all of the reduction in traffic on 400/500 South is attributed to the opening of the TRAX line. Maturation and history effects may be small if the pre-treatment date is immediately before TRAX opened, and the post-treatment date is immediately after TRAX opened. In this case, we can assume that the effect of the University TRAX line on traffic is just the drop in annual average daily traffic (AADT) on 400/500 South in the year before TRAX opened compared to the year after TRAX opened. This difference is Δ1 in Figure 3. The drop in AADT on 400/500 South was 9,300 vehicles per day (VPD) between 2001 and 2002. The line opened in December 2001, so we can assume that all of 2001 represents the before condition, and all of 2002 represents the after condition.

Several factors, however, complicate the picture. First, the AADT on 400/500 South was higher in prior years and had been increasing starting in 1992 and running through 1999. Construction of TRAX in 2000 and 2001, and the resulting disruption of traffic operations on 400/500 South, seem to have depressed AADT. If one assumes that the before condition is actually represented by AADT in 1999, the effect of TRAX is twice that estimated above, or Δ2. The decline in AADT between 1999 and 2002 was 17,900 VPD.

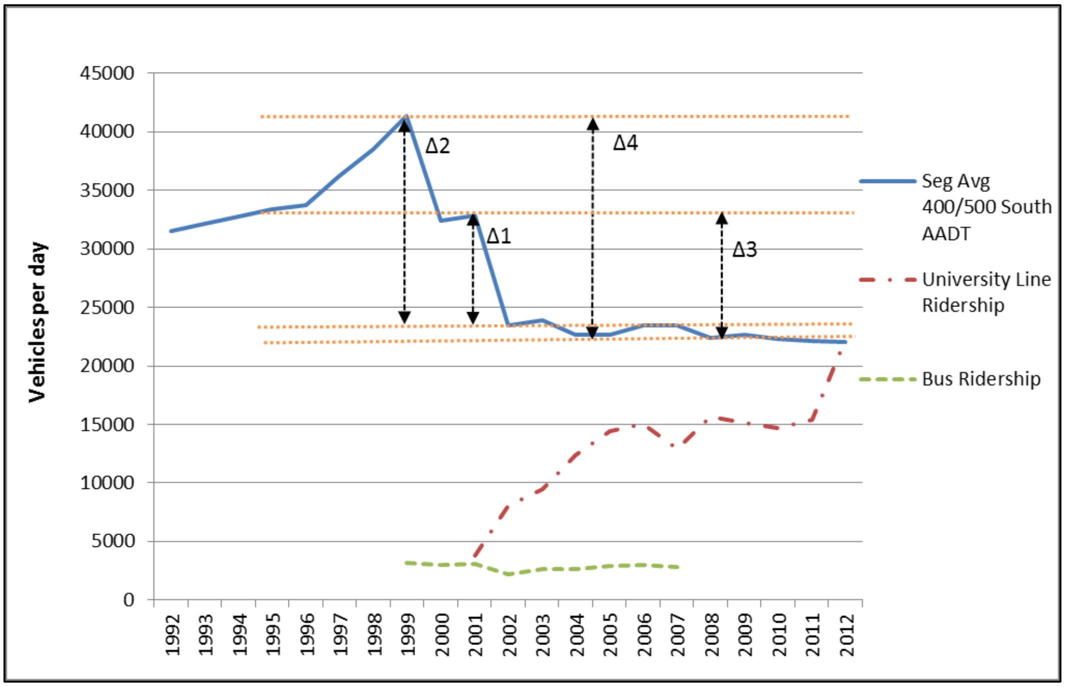

Figure 3. Average Daily Traffic on 400/500 South, TRAX Ridership along 400/500 South, and Bus Ridership along 400/500 South

Table 3. Effect of TRAX on Traffic on 400/500 South

	AADT on 400 South	Net Transit Ridership
Δ1	-9,300	7,200
Δ2	-17,900	7,100
Δ3	-10,100	12,800
Δ4	-18,700	12,000

Second, traffic increased on some streets parallel to 400/500 South between 2001 and 2002, suggesting that not all of the decline on 400/500 S was due to TRAX but some was due to diversion to parallel streets. AADT increased slightly on 1300 S and 2100 S between 2001 and 2002, and was essentially level on other parallel streets. So most, but not all, of the reduction in AADT on 400 South appears to be due to TRAX.

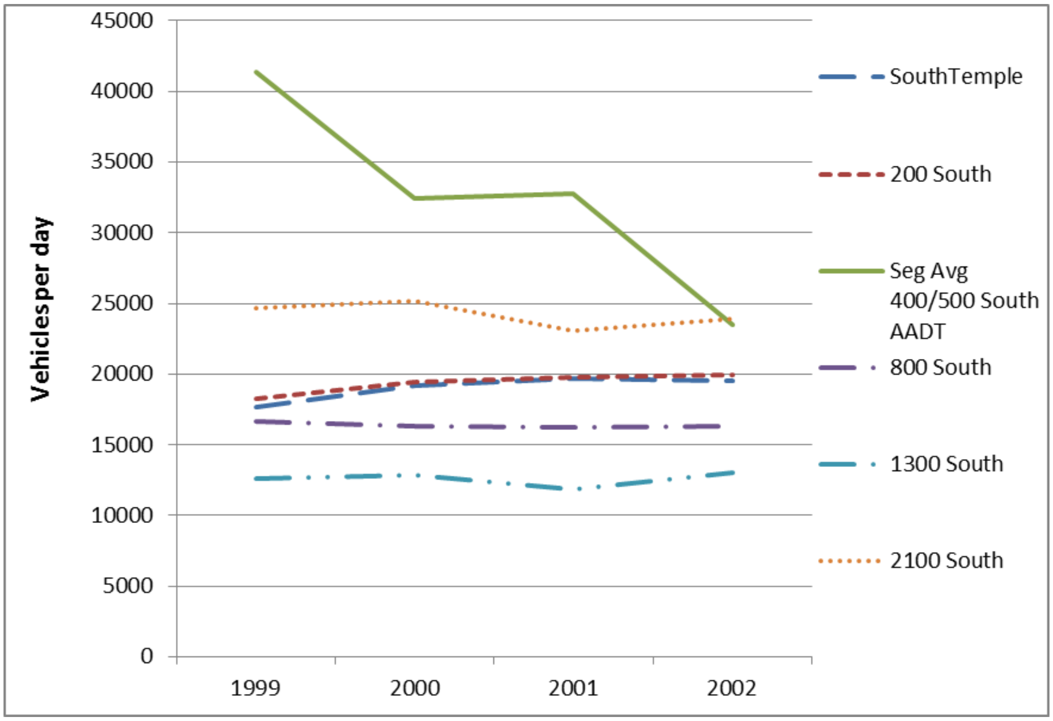

Figure 4. AADT on Streets Parallel to TRAX

Table 4. Change in AADT between 2001 and 2002

	Percentage Change in ADT from 2001 to 2002 (%)	Distance from 400 South (miles)
South Temple	-0.7	0.76
200 South	0.63	0.46
Seg Avg 400/500 South AADT	-28.39	0.00
800 South	0.67	0.84
1300 South	9.89	1.52
2100 South	3.54	2.64

Third, the reduction in VPD is greater than the net change in transit ridership of 7,200 riders. This net number is simply the ridership on TRAX in 2002 less the drop in bus ridership on routes along 400/500 South between 2001 and 2002. How could the impact of TRAX be greater than the net number of transit riders, even assuming that every TRAX rider would have driven a single-occupant vehicle (SOV)? On the subject of bus ridership, there were six bus lines running along 400/500 South from 1999 to 2001, and the total daily ridership was approximately 3,000 passengers. In August 2002, three bus lines were dropped, and two more were added. Total bus ridership declined, but only marginally. This is treated as a slight offset against TRAX ridership (see Table 5).

Table 5. Bus Ridership on 400/500 South

Criteria: west-east direction; through 400/500 south																
Line	Line Name	1999	2000	2001	2002		2003	2004	2005	2006	2007		2008	2009	2010	2011
					2002.08	2002.08					2007.08	2007.08				
13	CANYON RIM	460	495	462	353											
14	EAST MILLCREEK	606	686	604	454	704	687	724	778	806	708					
29	WASATCH BLVD VIA U. OF UTAH	459														
52	UNIVERSITY OF UTAH	1109	1061	1088	739											
54	OLYMPUS COVE	93	299	435												
55	UOFU/DAVIS CTY./WEBER ST.					1089	1176	1193	1221	1222	1147					
71	CENTERVILLE VIA ORCHARD DRIVE					228	260	244	311	398	340					
73	HIGHWAY 89 EXPRESS	333	367	386	374	420	455	443	525	543	554					
129	UOFU/FOOTHILL DRIVE NITE RIDE	131	127	104	59	66	65	54	51	66	53					
228	FOOTHILL BLVD / 2700 EAST															Y
455	U OF U/DAVIS COUNTY/WSU											Y	Y	Y	Y	Y
471	CENTERVILLE VIA ORCHARD DRIVE											Y	Y			
473	SLC - OGDEN HWY 89 EXPRESS											Y	Y	Y	Y	Y
					1978	2506										
	SUM	**3191**	**3034**	**3080**	**2242**		**2642**	**2658**	**2887**	**3035**	**2802**					

If one adds the net transit ridership increase between 2001 and 2002 to the net increase in AADT on parallel streets (mainly 1300 South and 2100 South), one arrives at a number roughly equivalent to the drop in AADT on 400/500 South. Specifically, the decline in AADT on 400/500 South (9,300) is roughly equal to the increase in transit ridership (7,200) plus the increase in AADT on parallel streets (2,100). This simple accounting gives a rough order of magnitude estimate of TRAX's impact on traffic.

Medium-Term Impact of TRAX – Pretest-Posttest with a Comparison Group

Figure 3 shows that TRAX ridership continued to increase after 2002. Part of that increase is doubtless due to the extension of the University TRAX line to the U of U Medical Center in late September 2003. This extension added three stops and 1.5 miles to the line. You can see a small dip in AADT on 400 South between 2003 and 2004. You can also see a bump up in TRAX ridership between 2003 and 2004. However, TRAX ridership also increased between 2002 and 2003, before the extension opened, and after 2004, when the full line was in operation. Ridership doesn't level off until 2008-2011. The dip in 2007 is likely due to issues with a passenger counting system that UTA implemented in 2007, as well as construction in downtown Salt Lake City and consumers' willingness to pay higher prices for gasoline, according to an article from the Deseret News (Warburton, 2007).

New transit lines often have a break-in period when travel patterns evolve as riders "discover" the new transit option. To estimate the longer-term impact of TRAX on traffic, we need to account for general trends in the study area. This requires a more sophisticated quasi-experimental design, a design that includes both a pre-treatment observation and a control or comparison group. According to the "bible" of quasi-experimental design, Shadish, Cook, and Campbell's *Experimental and Quasi-Experimental Designs for Generalized Causal Inference,* "The joint use of a pretest and a comparison group makes it easier to examine certain threats to validity [causal inference]. Because the groups are nonequivalent by definition, selection bias is presumed to be present. The pretest allows exploration of the possible size and direction of that bias…." (Shadish et al., 2002, p.138).

This is typically done by seeing if the treatment and control groups differ significantly before the treatment. The absence of pre-treatment difference in a quasi-experiment doesn't prove that selection bias is absent, but it makes it less likely. In particular, it reduces the likelihood of a statistical problem called regression-to-the-mean. Regression-to-the-mean is the statistical tendency of values above the mean in one period to gravitate downward toward the mean in the next period, and those below the mean in one period to gravitate upward toward the mean in the next period.

Ideally, we would match 400 South with another street that is very similar to 400 South before the University TRAX line opened. It would be a street not particularly affected by the line. The two streets that mostly closely match 400 South are 700 East and 1300 East (see Figure 5). These are north-south streets that intersect TRAX but do not offer park-and-ride options, and hence, should not be appreciably affected by the opening of the University TRAX line. Like 400 South, 700 East is a six-lane arterial serving the northeast quadrant of the city. However, 700 East carried significantly more traffic, even before TRAX. Like 400 South, 1300 East serves the university directly. However, 1300 East only had four lanes before the opening of TRAX, and carried much less traffic. Interestingly, it now carries almost as much traffic as 400 South, yet is down to three lanes south of campus after a "road diet" narrowing in 2009.

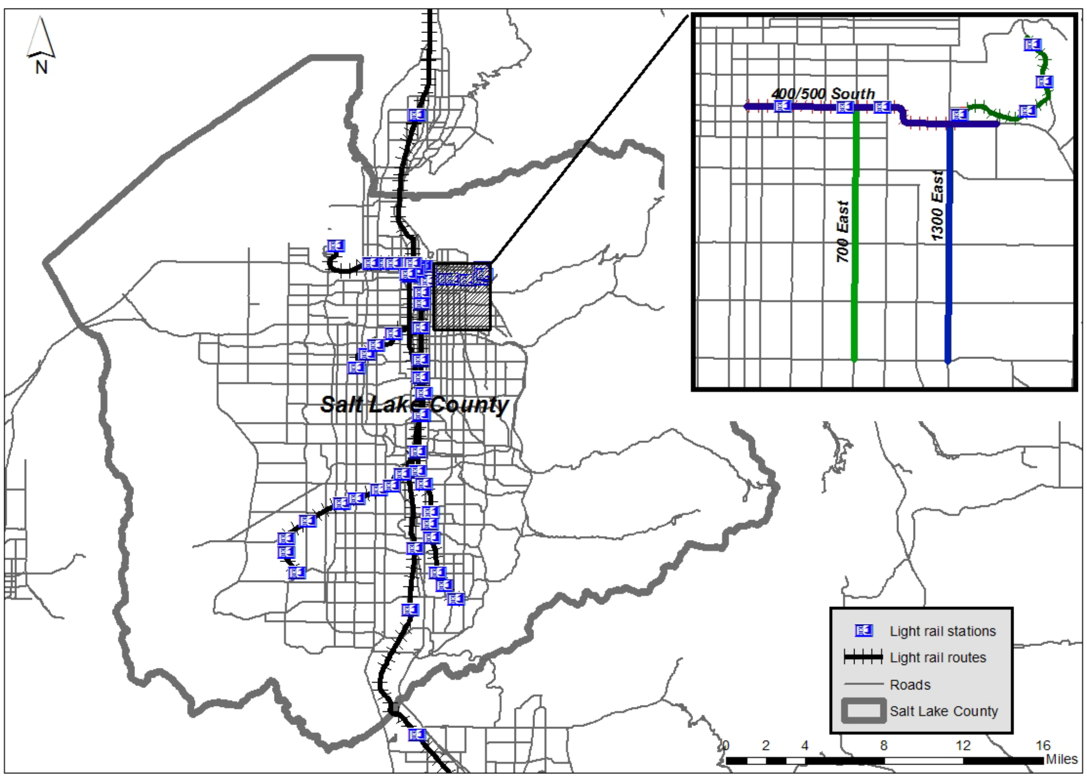

Figure 5. 400/500 South and Comparison Roads (700 East and 1300 East)

Although neither 700 East or 1300 East is a perfect match to 400 South, it turns out, however, that the average AADT on these two streets was virtually identical to the AADT on 400 South before the University TRAX line opened. We will use this average as our control in this quasi-experimental analysis. As can be seen in Figure 6, the average AADT for the two streets dips after 2001, as it does on 400

South. But it doesn't dip as far. It is not clear why traffic volumes would decline on these two streets, but this trend needs to be accounted for in a pretest-posttest design with a comparison group. Assuming the counterfactual that traffic on 400 South would have tracked exactly with these two streets in the absence of TRAX, Δ5 becomes our estimate of the reduction in traffic on 400 South due to TRAX. For the years 2006-2012, the average AADT on these two north-south streets was 7,500 VPD higher than the AADT on 400 South. This is less than our estimates in a simple pre-treatment, post-treatment comparison of traffic on 400 South, and represents a better estimate than attainable with the simpler design.

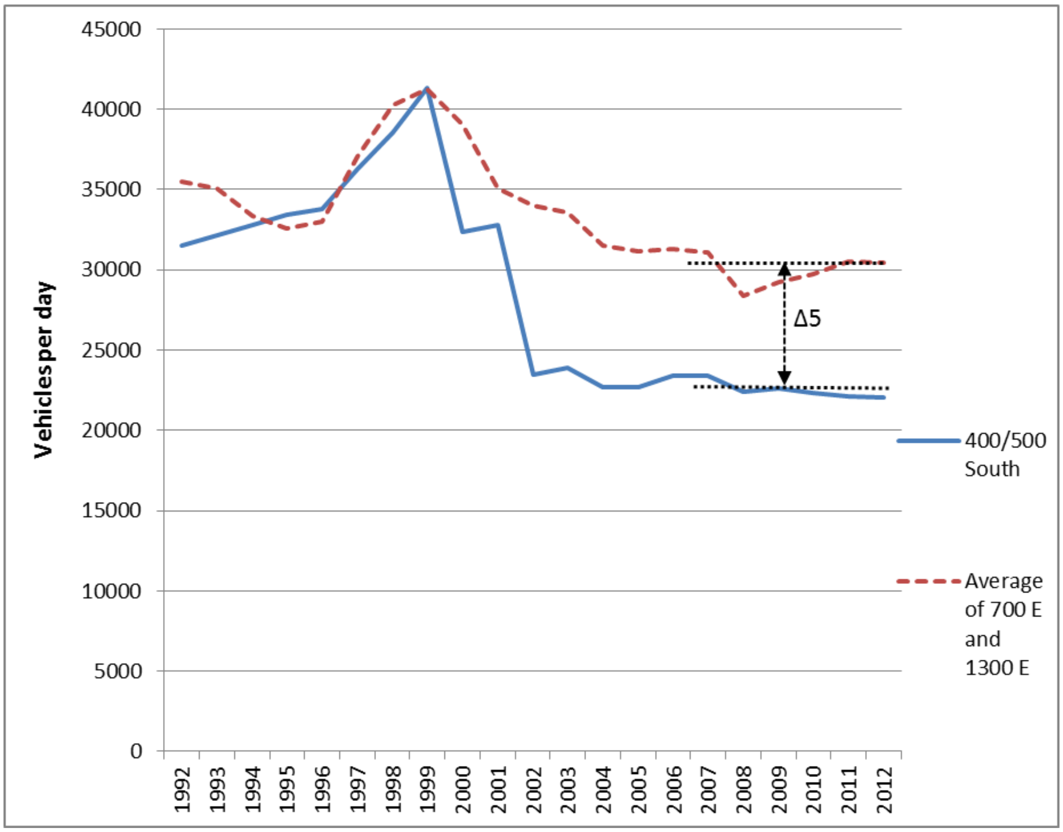

Figure 6. Average AADT on 700 East and 1300 East

We can check this long-run estimate of TRAX's impact on 400 South's traffic against transit ridership. The net transit ridership increase between 2001 and 2006-2012 is 12,700 passengers per day (15,800 average for 2006-2012 minus 3,100 for 2001). Specifically, the decline in AADT on 400/500 South (7,500) is 41 percent less than the increase in transit ridership. This simple accounting comparison makes the estimate of TRAX's impact seem plausible. The drop in AADT on 400/500 South would necessarily be less than the increase in transit ridership since not every transit trip replaces a drive-alone vehicle trip.

Land-Use Changes

A final quasi-experimental analysis assumes that, without TRAX, traffic on the 400/500 South would have increased proportionally with development in the corridor, or more specifically, increased proportionally with traffic generated by that development. For this analysis, the corridor is assumed to extend a half-mile north and south of 400/500 South, to South Temple on the north and 800 South on the south (see Figure 7). Parcels that changed between 1999 and 2009 (were developed, redeveloped, or cleared) are highlighted in yellow.

Figure 7. Parcels that Changed between 1999 and 2009 (highlighted in yellow)

We were able to identify changes by comparing aerial photos for 1999 and 2009, parcel-by-parcel, and also by comparing tax assessor records for the two years. Building floor area is available from tax assessor records only for 2009. Building floor area in 1999 was set equal to that in 2009 where the building footprint didn't change. Where the footprint did change, floor area in 1999 was estimated from the 1999 aerial photo assuming buildings were single story.

Building floor area changes in the 400/500 South corridor are summarized in Table 6. The appendix has a complete list of parcels that experienced changes. The vast majority of the changes involved construction on vacant land (99 of 269 parcels). And the vast majority of new development was commercial, followed by public and then other (which includes parking lots).

Table 6. Changes of Building Floor Area by Land-Use Type between 1999 and 2009 for Parcels that Changed

	1999	***2009***	***changes***
Residential	48,300	794,000	745,800
Commercial	1,712,200	4,870,500	3,158,400
Public	10,854,100	13,445,000	2,590,900
Other (e.g., parking lots)	46,800	3,500	-43,400
Total building square footage	12,661,400	19,113,000	6,451,700

Table 7 provides a summary of total development in the corridor, by land-use type, in 1999 and 2009. The gross floor area of all buildings increased from 50,567,600 square feet to 57,019,200 square feet over the decade, an increase of 6,451,700 square feet or 12.8 percent. It is impossible to say how much of that additional development was due to TRAX. However, we can say that the corridor became more developed over the decade, concurrent with the opening of TRAX, and that surprisingly, traffic on 400/500 South actually declined despite increased development in the corridor. We are aware of no similar finding in the literature.

Table 7. Total Building Floor Area in the 400/500 South Corridor by Land-Use Type

	1999	***2009***	***changes***
Residential	11,173,000	11,918,800	745,800
Commercial	19,851,100	23,009,400	3,158,400
Public	16,424,000	19,014,900	2,590,900
Other	3,119,500	3,076,100	-43,400
Total building square footage	50,567,600	57,019,200	6,451,700

Using trip-generation rates from the Institute of Transportation Engineers' (ITE) *Trip Generation* report, we estimated total trips generated by properties within the 400/500 South Corridor.[1] Trip generation totals by land-use type are presented in Table 8. Trips rates from ITE actually refer to trip ends, either origins or destinations. Trips beginning in the corridor and destined outside are counted only once. Trips beginning outside the corridor and destined inside are also counted only once. Those beginning and ending within the corridor are counted twice. And those simply traveling through the corridor, with origins and destinations outside, aren't captured at all with our method. Hence there is no simple one-to-one relationship between trips generated within the corridor, and traffic on 400/500 South.

Table 8. Total Trip Generation by Land-Use

	1999	***2009***	***Changes***
Residential	77,000	86,200	9,200
Commercial	834,500	861,000	26,500

[1] For University of Utah trip generation, we categorized university buildings into four classes: hospital, university housing, research park and main campus. Trip rates are 16.5 per 1000 square feet for the hospital, 6.11 per 1000 square feet for the research park, 1.71 per student, and 8.96 per employee for the main campus. For university housing, the trip rate depends on the type of the housing, such as dorms, apartments and family houses. Total trip generation for the main campus is shown below.

	Students		Employees		Trips
	Number	Trip rate	number	Trip rate	
1999	25,781	1.71	3,070	8.96	71,600
2009	29,284	1.71	3,582	8.96	82,200

Public	226,100	276,500	50,400
Other	500	4,400	3,900
Total	1,138,100	1,228,100	90,000

Nonetheless, we can assume that in the absence of TRAX, there would be rough proportionality between traffic generated within the corridor and non-thru traffic on 400/500 South. If the former increases by 7.9 percent, as we have calculated, it is reasonable to assume that traffic on the main east-west street through the corridor would also increase by 7.9 percent. The regional travel model predicts that 1.4 percent of the traffic on 400/500 South is thru-traffic, leaving 98.6 percent (40,800) as local.[2] So for our last estimate of TRAX's impact on traffic, we assume a counterfactual that local traffic on 400/500 South would have increased by 7.9 percent in the absence of TRAX, from 40,800 in 1999 (98.6 percent of actual count) to 44,000 in 2009 (1.079*40,800). The difference between this estimate for 2009 and our estimate of actual local traffic volume in 2009 (22,300), 21,700 (44,000-22,300) is the estimated effect of TRAX. It is shown as Δ6 in Figure 8. Note that these numbers explicitly exclude thru-traffic between State Street on the west and Guardsman Way on the east.

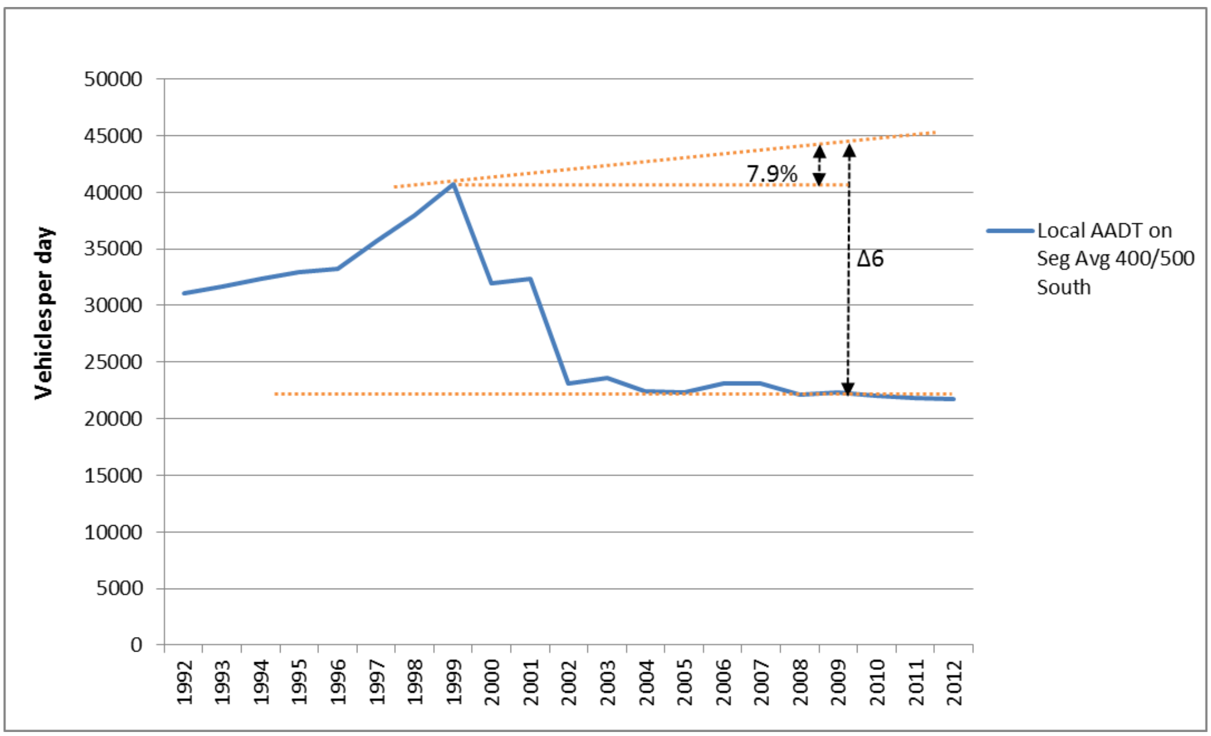

Figure 8. Local AADT on 400/500, Estimated Local Traffic on 400/500 Based on the Trip Generation between 1999 and 2009

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[2] The regional model shows that there are about 2,200 trips a day between downtown (defined as the area between State and I-15 and South Temple and 900 South) and the area east of Guardsman Way and North of 900 South. This accounts for 1.4% of the east/west trips within ½ mile of 400 South.

Energy and Emission Reduction

To summarize, we have six estimates of the impact of TRAX on average daily traffic on 400/500 South, all based on different assumptions and different time frames (see Table 9). We chose a conservative estimate that is roughly mid-range, 14,000 vehicles per day, for this summary of impacts.

Table 9. Estimates of Traffic Reduction on 400/500 South Due to TRAX

Estimate	Average Daily Traffic Reduction
Δ1	9,300
Δ2	17,900
Δ3	10,100
Δ4	18,700
Δ5	7,300
Δ6	21,700

With the traffic decrease on 400/500 South, there is less fuel consumed and less pollution emitted. According to EPA data, the average emissions and fuel consumption for passenger cars are shown in Table 10. Multiplying the reduction in vehicle miles by the fuel consumption and pollutant emissions per vehicle mile in Table 10, we obtain the results in Table 11. Due to TRAX, 1,300 gallons of gasoline are saved and 26,100 pounds of CO_2 emission aren't emitted each day. Annually, this translates to saving 487,700 gallons of gasoline and not emitting 9,537,000 pounds of CO_2.

Table 10. EPA Average Emissions and Fuel Consumption for Passenger Cars

Pollutant/Fuel	Emission & Fuel Consumption Rates (per mile driven)
VOC	1.034 grams (g)
THC	1.077 g
CO	9.400 g
NO_X	0.693 g
CO_2	368.4 g
Gasoline Consumption	0.04149 gallons (gal)

Source: Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks, EPA, http://www.epa.gov/otaq/consumer/420f08024.pdf.

Table 11. Effect of TRAX on Energy Consumption and Emission Reduction

Pollutant /Fuel	Emission & Fuel Consumption Rates (per mile driven)	Traffic Reduction	Calculation	Daily Reduction of Emission & Fuel Consumption	Annual Reduction of Emission & Fuel Consumption
VOC	1.034 grams (g)	14000 vehicles per day (vpd)	(1.034 g/mi) x (2.3 mi) x (14000 vpd)x (1 lb./454 g)	73.34 lb	26,800 lb.
THC	1.077 g		(1.077 g/mi) x (2.3 mi) x (14000 vpd)x (1 lb./454 g)	76.39 lb.	27,900 lb.
CO	9.400 g		(9.400 g/mi) x (2.3 mi) x (14000 vpd)x (1 lb./454 g)	666.70 lb.	243,300 lb.
NO_X	0.693 g		(0.693 g/mi) x (2.3 mi) x (14000 vpd)x (1 lb./454 g)	49.15 lb.	18,000 lb.
CO_2	368.4 g		(368.4 g/mi) x (2.3 mi) x (14000 vpd)x (1 lb./454 g)	26,100 lb.	9,537,000 lb.
Gasoline Consumption	0.04149 gallons (gal)		(2.3 mi) x (14000 vpd)/ (24.1 mi/gal)	1,300 gal	487,700 gal

The University of Utah also saves substantially on parking spaces and associated costs. Assuming half of the reduction in traffic on 400/500 South are trips made to the university, and the average cost of a surface parking space is $4,000 (Litman, 2013),[3] the savings on construction costs alone total $4,000 per space times 6,000 spaces, or $23.6 million. The annual operating and maintenance cost savings (again, according to Litman, 2013) would total $282 per space times 6,000 spaces, or $ 1.7 million annually.

Conclusion and Discussion

There is an important debate over the value of LRT for mitigation of traffic congestion, energy consumption, and air pollution. To accurately assess LRT effect on traffic it is necessary to use a quasi-experiment analysis. A cross sectional analysis (of the sort that is so common in ridership modeling) can only establish correlation, not causal inference). This study provides some of the strongest evidence to date of LRT effects on traffic, energy consumption, and air pollution. We found other studies in our literature review that also attempt to measure and quantify the impacts of LRT on traffic congestion, but none of these other studies used a controlled quasi-experimental research design. Our quasi-experiment focuses on the "treatment" of introducing the 2.3 mile extension of the TRAX system with service continuing from Downtown Salt Lake City to the Rice-Eccles Stadium on the University of Utah campus in December 2001, and the additional 1.5 mile extension to the University Medical Center September 2003.

In the short-term analysis, we found that between 2001 and 2002, after the introduction of the "treatment", the AADT on 400/500 South decreased by 9,300 vehicles per day (VPD). This is roughly equal to the increase in transit ridership (7,200) and the increase in AADT on parallel streets (2,100). When this comparison was drawn out to 1999, we found that the decrease in AADT was 17,900 VPD.

[3] In Litman's (2013) report, the cost was reported as 1997 U.S. Dollars. In this report, we converted the costs to 2012 U.S. Dollars by Consumer Price Index (CPI). The CPI has increased by 1.43 times from 1997 to 2012.

TRAX ridership had been growing prior to the extension of the line to the Rice-Eccles Stadium, but it continued to increase after 2002 before leveling off during 2008-2012.

In the medium-term analysis, we compared two streets that we consider to be comparable to 400/500 South before the University TRAX line opened: 1300 East and 700 East, which virtually had identical average AADT to 400/500 South. The results showed that the average AADT on these two streets was 7,500 VPD higher than the AADT on 400/500 South after the TRAX line opened (between 2006 and 2012).

In the final quasi-experimental analysis, the building square footage increased 12.8 percent between 1999 and 2009 in the half-mile buffer around 400/500 South. Accordingly, 7.9 percent new trips are generated by these new developments on the corridor. Our estimates indicated that VPD should have been 44,000 on this corridor, but instead we found this number to be 22,300. Therefore, because of TRAX, the VPD is reduced by 21,700. Based on our estimates, LRT along 400/500 South saves almost 500,000 gallons of gasoline and prevents almost 10 million pounds of CO_2 from being emitted each year.

AADT on 400/500 South has been relatively steady since 2005. The theory of induced traffic suggests that, in the very long-term, the road will fill to capacity due to redevelopment in the corridor and additional development in the region. However, the university is not planning to expand its enrollments, and there is only so much redevelopment that can occur within the corridor given the normal useful lives of buildings (hundreds of years for residential properties, decades for nonresidential properties). Perhaps the best chance for redevelopment is the conversion of surface parking lots to active uses with structured parking, which has already begun to occur (for example, at Trolley Square). Nonetheless, we would be hard pressed to project when traffic volumes will begin to increase in the corridor, and see no evidence of it through 2012, 10 years after line was extended to the University Medical Center.

This study is subject to important caveats. One is in regard to the external validity of this study, or lack thereof. We cannot guarantee that LRT would have the same effect on traffic at other locations given that our study area (from downtown Salt Lake City to University of Utah) is unique. The University of Utah is a major center of employment for Salt Lake City and the surrounding county, and students and staff have free access to TRAX. Locations with employers who do not subsidize the cost of riding LRT may not see the ridership levels and decreases in vehicle travel trips that the university does.

More important is a caveat related to internal validity. Our design is quasi-experimental, not experimental, and hence we must be careful not to overstate our ability to draw causal inferences. The dip in traffic on 400/500 South could, theoretically, be due to some cause other than the extension of TRAX to the university. There are numerous threats to the validity of the simple pre-intervention, post-intervention comparison without a control group (Shadish et al. 2002). The two control groups used in this quasi-experimental design (parallel streets in Figure 4 and perpendicular streets in Figure 6) are not, of course, a perfect match with 400/500 South, the treated street. Other factors (such as different redevelopment patterns in their corridors) could cause them to have different traffic patterns than 400/500 South in the absence of TRAX. “A counterfactual is something that is contrary to fact. In an experiment, we observe what did happen when people received a treatment (in this case, the availability of LRT service). The counterfactual is knowledge of what would have happened to those same people if they simultaneously had not received treatment. An effect (of a treatment) is the difference between what did happen and what would have happened" (Shadish et al. 2002, p. 5). We cannot actually observe a counterfactual, but instead select a control group that comes as close to representing the counterfactual as possible. What would have happened in the absence of LRT in the transit corridor? We have simply chosen streets that serve the same quadrant of the region (NE Salt Lake City), and should be affected by the same forces when it comes to traffic. In a quasi-experimental design like this one, the control group (actually comparison group) is never identical to the experimental group. If it were, this would be a true experiment. Also, we have estimated traffic reduction several ways, in an attempt to bound likely impacts of TRAX. That is, we have established several counterfactuals for purposes of the quasi-experiment. The different estimates are all in the same "ballpark."

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Appendix 1

Complete list of parcels that experienced changes between 1999 and 2009

The university's buildings are classified as hospital, university housing, research park, and main campus. The trip generation is calculated as a whole in one parcel for each category.

*: for university housing, the trip rate depends on the type of the housing, such as dorms, apartments and family houses.

**: for the main campus, the trip rate is 1.71 per student, and 8.96 per employee.

	1999				2009			
Parcel ID	Land use	Total sqft	Trip rate	Trips	Land use	Total sqft	Trip rate	Trips
9334520142000[2]	public	3221620	16.5	53156.73	public	4774036	16.5	78771.56
16031000042000[2]	public	1054563	*	10236.9	public	1845098	*	20788.77
16033000022000[2]	commercial	1567984	8.11	12716.35	commercial	2090991	8.11	16957.94
16042000020000[2]	public	6147259	**	71592.71	public	6197695	**	82170.36
16051530020000	residential	3380	9.57	19.14	other	0	0	0
16051530030000	residential	2993	9.57	232.75	other	3462	0	0
16051530060000	other	0	0	0	residential	2082	9.57	9.57
16051610010000	other	0	0	0	residential	4734	19.14	19.14
16051620160000	other	0	0	0	residential	2144	9.57	9.57
16052010052000	commercial	11302	11.01	124.4	commercial	17865	11.01	196.7
16052520130000	other	0	0	0	residential	3877	9.57	9.57
16053010250000	other	41914	0	0	commercial	90278	42.94	3876.5
16053380010000	other	0	0	0	residential	1624	5.81	5.81
16053380020000	other	0	0	0	residential	1399	5.81	5.81
16053380030000	other	0	0	0	residential	1399	5.81	5.81
16053380040000	other	0	0	0	residential	1259	5.81	5.81
16053380050000	other	0	0	0	residential	1399	5.81	5.81
16053380060000	other	0	0	0	residential	1399	5.81	5.81
16053380070000	other	0	0	0	residential	1399	5.81	5.81
16053380080000	other	0	0	0	residential	1259	5.81	5.81
16053380090000	other	0	0	0	residential	1399	5.81	5.81
16053380100000	other	0	0	0	residential	1399	5.81	5.81
16053380110000	other	0	0	0	residential	1259	5.81	5.81
16053380120000	other	0	0	0	residential	896	5.81	5.81
16053380130000	other	0	0	0	residential	896	5.81	5.81
16053820130000	residential	0	0	9.57	residential	1970	9.57	9.57
16053820140000	residential	0	0	0	residential	1730	9.57	9.57
16053820170000	other	0	0	0	residential	1898	9.57	9.57

16053820180000	other	0	0	0	residential	1730	9.57	9.57
16053820190000	other	0	0	0	residential	1898	9.57	9.57
16054260060000	residential	0	0	0	residential	1507	9.57	9.57
16054260310000	other	0	0	0	residential	3558	9.57	9.57
16061040180000	public	18343	27.92	512.13656	other	0	0	0
16061040210000	public	13013	27.92	363	other	0	0	0
16061260060000	public	19842	27.92	553	other	0	0	0
16061270230000	other	0	0	0	public	16295	9.11	148.44
16061270240000	public	8000	9.11	72.88	public	19436	9.11	177
16061280080000	public	20516	27.92	572.80672	other	0	0	0
16061510290000	commercial	16263	11.01	116	commercial	160716	11.01	1769
16061520780000	other	0	0	0	commercial	398580	8.92	3202.28
16061560800000	commercial	10537	11.01	116.01237	commercial	114326	11.01	1258.729
16061820190000	other	0	0	0	residential	132748	98.85	98.85
16062040250000	commercial	0	0	0	commercial	67274	3.71	860.72
16062050170000	public	164654	27.92	4597.1397	public	133833	27.92	3736.617
16061780210000	commercial	1763	496.12	874.7	other	0	0	0
16062290290000	other	0	0	0	residential	1456	9.57	9.57
16062290300000	other	0	0	0	residential	1304	9.57	9.57
16062290310000	other	0	0	0	residential	1456	9.57	9.57
16062290320000	other	0	0	0	residential	1456	9.57	9.57
16062290330000	other	0	0	0	residential	1223	9.57	9.57
16062290340000	other	0	0	0	residential	1243	9.57	9.57
16062290350000	other	0	0	0	residential	1464	9.57	9.57
16062290360000	other	0	0	0	residential	1304	9.57	9.57
16062290370000	other	0	0	0	residential	1456	9.57	9.57
16062290380000	other	0	0	0	residential	1460	9.57	9.57
16062290390000	other	0	0	0	residential	1212	9.57	9.57
16062530500000	commercial	1962	42.94	84.24828	commercial	5356	42.94	229.9866
16062810020000	commercial	49708	102.24	5082.1459	commercial	55252	102.24	5648.964
16062830090000	commercial	3773	50	188.65	other	0	0	0
16063100010000	other	0	0	0	residential	1190	11.01	13.1019
16063100020000	other	0	0	0	residential	863	11.01	9.50163
16063100030000	other	0	0	0	residential	1012	11.01	11.14212
16063100040000	other	0	0	0	residential	1519	11.01	16.72419
16063100050000	other	0	0	0	residential	1263	5.81	5.81
16063100060000	other	0	0	0	residential	1013	5.81	5.81
16063100070000	other	0	0	0	residential	1013	5.81	5.81
16063100080000	other	0	0	0	residential	1557	5.81	5.81
16063100090000	other	0	0	0	residential	1391	5.81	5.81
16063100100000	other	0	0	0	residential	1391	5.81	5.81

16063100110000	other	0	0	0	residential	795	5.81	5.81
16063100120000	other	0	0	0	residential	1018	5.81	5.81
16063100130000	other	0	0	0	residential	763	5.81	5.81
16063100140000	other	0	0	0	residential	1018	5.81	5.81
16063100150000	other	0	0	0	residential	763	5.81	5.81
16063100160000	other	0	0	0	residential	582	5.81	5.81
16063100170000	other	0	0	0	residential	582	5.81	5.81
16063100180000	other	0	0	0	residential	1018	5.81	5.81
16063100190000	other	0	0	0	residential	1018	5.81	5.81
16063100200000	other	0	0	0	residential	1018	5.81	5.81
16063100210000	other	0	0	0	residential	975	5.81	5.81
16063100220000	other	0	0	0	residential	1394	5.81	5.81
16063100230000	other	0	0	0	residential	1018	5.81	5.81
16063100240000	other	0	0	0	residential	582	5.81	5.81
16063100250000	other	0	0	0	residential	1018	5.81	5.81
16063100260000	other	0	0	0	residential	975	5.81	5.81
16063100270000	other	0	0	0	residential	1018	5.81	5.81
16063100280000	other	0	0	0	residential	1136	5.81	5.81
16063100290000	other	0	0	0	residential	1391	5.81	5.81
16063100300000	other	0	0	0	residential	1391	5.81	5.81
16063100310000	other	0	0	0	residential	1391	5.81	5.81
16063100320000	other	0	0	0	residential	795	5.81	5.81
16063100330000	other	0	0	0	residential	1018	5.81	5.81
16063100340000	other	0	0	0	residential	763	5.81	5.81
16063100350000	other	0	0	0	residential	1018	5.81	5.81
16063100360000	other	0	0	0	residential	763	5.81	5.81
16063100370000	other	0	0	0	residential	582	5.81	5.81
16063100380000	other	0	0	0	residential	582	5.81	5.81
16063100390000	other	0	0	0	residential	1018	5.81	5.81
16063100400000	other	0	0	0	residential	1018	5.81	5.81
16063100410000	other	0	0	0	residential	1018	5.81	5.81
16063100420000	other	0	0	0	residential	975	5.81	5.81
16063100430000	other	0	0	0	residential	693	5.81	5.81
16063100440000	other	0	0	0	residential	1394	5.81	5.81
16063100450000	other	0	0	0	residential	774	5.81	5.81
16063100460000	other	0	0	0	residential	1018	5.81	5.81
16063100470000	other	0	0	0	residential	582	5.81	5.81
16063100480000	other	0	0	0	residential	1018	5.81	5.81
16063100490000	other	0	0	0	residential	975	5.81	5.81
16063100500000	other	0	0	0	residential	1018	5.81	5.81
16063100510000	other	0	0	0	residential	1136	5.81	5.81

16063100520000	other	0	0	0	residential	1391	5.81	5.81
16063100530000	other	0	0	0	residential	1391	5.81	5.81
16063100540000	other	0	0	0	residential	1391	5.81	5.81
16063100550000	other	0	0	0	residential	795	5.81	5.81
16063100560000	other	0	0	0	residential	1018	5.81	5.81
16063100570000	other	0	0	0	residential	763	5.81	5.81
16063100580000	other	0	0	0	residential	1018	5.81	5.81
16063100590000	other	0	0	0	residential	763	5.81	5.81
16063100600000	other	0	0	0	residential	582	5.81	5.81
16063100610000	other	0	0	0	residential	582	5.81	5.81
16063100620000	other	0	0	0	residential	1018	5.81	5.81
16063100630000	other	0	0	0	residential	1018	5.81	5.81
16063100640000	other	0	0	0	residential	1018	5.81	5.81
16063100650000	other	0	0	0	residential	975	5.81	5.81
16063100660000	other	0	0	0	residential	693	5.81	5.81
16063100670000	other	0	0	0	residential	514	5.81	5.81
16063100680000	other	0	0	0	residential	774	5.81	5.81
16063100690000	other	0	0	0	residential	1064	5.81	5.81
16063100700000	other	0	0	0	residential	582	5.81	5.81
16063100710000	other	0	0	0	residential	1018	5.81	5.81
16063100720000	other	0	0	0	residential	975	5.81	5.81
16063100730000	other	0	0	0	residential	1018	5.81	5.81
16063100740000	other	0	0	0	residential	1147	5.81	5.81
16063100750000	other	0	0	0	residential	1391	5.81	5.81
16063100760000	other	0	0	0	residential	1391	5.81	5.81
16063100770000	other	0	0	0	residential	1391	5.81	5.81
16063100780000	other	0	0	0	residential	795	5.81	5.81
16063100790000	other	0	0	0	residential	1018	5.81	5.81
16063100800000	other	0	0	0	residential	633	5.81	5.81
16063100810000	other	0	0	0	residential	1066	5.81	5.81
16063100820000	other	0	0	0	residential	763	5.81	5.81
16063100830000	other	0	0	0	residential	582	5.81	5.81
16063100840000	other	0	0	0	residential	582	5.81	5.81
16063100850000	other	0	0	0	residential	1018	5.81	5.81
16063100860000	other	0	0	0	residential	1018	5.81	5.81
16063100870000	other	0	0	0	residential	1018	5.81	5.81
16063100880000	other	0	0	0	residential	975	5.81	5.81
16063100890000	other	0	0	0	residential	693	5.81	5.81
16063100900000	other	0	0	0	residential	1394	5.81	5.81
16063100910000	other	0	0	0	residential	774	5.81	5.81
16063100920000	other	0	0	0	residential	1018	5.81	5.81

16063100930000	other	0	0	0	residential	582	5.81	5.81
16063100940000	other	0	0	0	residential	1018	5.81	5.81
16063100950000	other	0	0	0	residential	975	5.81	5.81
16063100960000	other	0	0	0	residential	1018	5.81	5.81
16063100970000	other	0	0	0	residential	1147	5.81	5.81
16063100980000	other	0	0	0	residential	1391	5.81	5.81
16063100990000	other	0	0	0	residential	1391	5.81	5.81
16063101000000	other	0	0	0	residential	1403	5.81	5.81
16063101010000	other	0	0	0	residential	795	5.81	5.81
16063101020000	other	0	0	0	residential	1018	5.81	5.81
16063101030000	other	0	0	0	residential	763	5.81	5.81
16063101040000	other	0	0	0	residential	1066	5.81	5.81
16063101050000	other	0	0	0	residential	763	5.81	5.81
16063101060000	other	0	0	0	residential	582	5.81	5.81
16063101070000	other	0	0	0	residential	647	5.81	5.81
16063101080000	other	0	0	0	residential	1018	5.81	5.81
16063101090000	other	0	0	0	residential	1018	5.81	5.81
16063101100000	other	0	0	0	residential	1018	5.81	5.81
16063101110000	other	0	0	0	residential	975	5.81	5.81
16063101120000	other	0	0	0	residential	693	5.81	5.81
16063101130000	other	0	0	0	residential	1394	5.81	5.81
16063101140000	other	0	0	0	residential	774	5.81	5.81
16063101150000	other	0	0	0	residential	1054	5.81	5.81
16063101160000	other	0	0	0	residential	582	5.81	5.81
16063101170000	other	0	0	0	residential	1054	5.81	5.81
16063101180000	other	0	0	0	residential	975	5.81	5.81
16063101190000	other	0	0	0	residential	1018	5.81	5.81
16063101200000	other	0	0	0	residential	1147	5.81	5.81
16063101210000	other	0	0	0	residential	1403	5.81	5.81
16063300190000	public	135978	27.92	3796.5058	public	327159	27.92	9134.279
16063310130000	public	50276	27.92	1403.7059	public	45123	27.92	1259.834
16063510230000	commercial	0	0	0	commercial	1685831	8.92	6913
16063760220000	commercial	18724	33.34	624.25816	commercial	124854	33.34	4162.632
16063770150000	residential	5173	98.85	511.35105	residential	76694	98.85	7581.202
16063790010000	commercial	407	9.57	9.57	commercial	0	0	0
16064020030000	commercial	3038	11.01	33.44838	other	0	0	0
16064070410000	commercial	1385	156.48	216.7248	commercial	12175	156.48	1905.144
16064260090000	residential	18351	9.57	78.56	residential	324605	4.2	1058.4
16064270380000	residential	12555	9.57	162.41	other	0	0	0
16064270390000	commercial	12873	90.06	1159.3424	commercial	14503	90.06	1306.14
16064340090000	commercial	4336	50	216.8	other	0	0	0

16064660010000	other	0	0	0	residential	1034	5.81	5.81
16064660020000	other	0	0	0	residential	1034	5.81	5.81
16064660030000	other	0	0	0	residential	1034	5.81	5.81
16064660040000	other	0	0	0	residential	1034	5.81	5.81
16064660050000	other	0	0	0	residential	1034	5.81	5.81
16064660060000	other	0	0	0	residential	1034	5.81	5.81
16064660070000	other	0	0	0	residential	1034	5.81	5.81
16064660080000	other	0	0	0	residential	1034	5.81	5.81
16064660090000	other	0	0	0	residential	1034	5.81	5.81
16064660100000	other	0	0	0	residential	1034	5.81	5.81
16064660110000	other	0	0	0	residential	1034	5.81	5.81
16064660120000	other	0	0	0	residential	1034	5.81	5.81
16064660130000	other	0	0	0	residential	1034	5.81	5.81
16064660140000	other	0	0	0	residential	1034	5.81	5.81
16064660150000	other	0	0	0	residential	1034	5.81	5.81
16064660160000	other	0	0	0	residential	1034	5.81	5.81
16064660170000	other	0	0	0	residential	1034	5.81	5.81
16064660180000	other	0	0	0	residential	1034	5.81	5.81
16064660190000	other	0	0	0	residential	1034	5.81	5.81
16064660200000	other	0	0	0	residential	1034	5.81	5.81
16064660210000	other	0	0	0	residential	1034	5.81	5.81
16064660220000	other	0	0	0	residential	1034	5.81	5.81
16064660230000	other	0	0	0	residential	1034	5.81	5.81
16064660240000	other	0	0	0	residential	1034	5.81	5.81
16064660250000	other	0	0	0	residential	1034	5.81	5.81
16064660260000	other	0	0	0	residential	1034	5.81	5.81
16064660270000	other	0	0	0	residential	1034	5.81	5.81
16064660280000	other	0	0	0	residential	1034	5.81	5.81
16064660290000	other	0	0	0	residential	1034	5.81	5.81
16064660300000	other	0	0	0	residential	1034	5.81	5.81
16064660310000	other	0	0	0	residential	1034	5.81	5.81
16064660320000	other	0	0	0	residential	1034	5.81	5.81
16064660330000	other	0	0	0	residential	1034	5.81	5.81
16064660340000	other	0	0	0	residential	1034	5.81	5.81
16064660350000	other	0	0	0	residential	1034	5.81	5.81
16064660360000	other	0	0	0	residential	1034	5.81	5.81
16064660370000	other	0	0	0	residential	1034	5.81	5.81
16064660380000	other	0	0	0	residential	1034	5.81	5.81
16064660390000	other	0	0	0	residential	1034	5.81	5.81
16064660400000	other	0	0	0	residential	1034	5.81	5.81
16064660410000	other	0	0	0	residential	1034	5.81	5.81

16064660420000	other	0	0	0	residential	1034	5.81	5.81
16064660430000	other	0	0	0	residential	1034	5.81	5.81
16064660440000	other	3204	9.57	9.57	residential	0	0	0
16064770270000	commercial	659	11.01	7.25559	commercial	1662	11.01	18.29862
16071030190000	commercial	3742	89.95	336.5929	commercial	4837	89.95	435.0882
16071040070000	commercial	3706	156.48	579.91488	commercial	26027	156.48	4072.705
16071270120000	other	0	0	0	public	3053	27.92	85.23976
16071270130000	other	0	0	0	public	752	27.92	20.99584
16071270210000	other	0	0	0	public	1855	27.92	51.7916
16071270220000	other	0	0	0	public	1446	27.92	40.37232
16071270230000	other	0	0	0	public	1822	27.92	50.87024
16071270240000	other	0	0	0	public	2424	27.92	67.67808
16071270250000	other	0	0	0	public	1050	27.92	29.316
16071290450000	other	0	0	0	residential	1256	9.57	9.57
16071290460000	other	0	0	0	residential	1242	9.57	9.57
16071290470000	other	0	0	0	residential	1668	9.57	9.57
16071290480000	other	0	0	0	residential	1668	9.57	9.57
16071290490000	other	0	0	0	residential	1242	9.57	9.57
16071290500000	other	0	0	0	residential	1242	9.57	9.57
16071290510000	other	0	0	0	residential	1242	9.57	9.57
16071290520000	other	0	0	0	residential	1668	9.57	9.57
16071290530000	other	0	0	0	residential	1668	9.57	9.57
16072030100000	other	1708	0	0	residential	1720	9.57	9.57
16081090010000	other	0	0	0	residential	1084	5.81	5.81
16081090020000	other	0	0	0	residential	1084	5.81	5.81
16081090030000	other	0	0	0	residential	1084	5.81	5.81
16081090040000	other	0	0	0	residential	1084	5.81	5.81
16081260280000	residential	0	0	0	residential	4793	23.275	23.275
16081340010000	residential	0	0	0	residential	2280	9.57	9.57
16081340020000	residential	0	0	0	residential	2280	9.57	9.57
16081340030000	residential	0	0	0	residential	2280	9.57	9.57
16081340040000	residential	0	0	0	residential	2280	9.57	9.57
16081340050000	residential	0	0	0	residential	2280	9.57	9.57
16081340060000	residential	0	0	0	residential	2280	9.57	9.57
16081340070000	residential	5803	9.57	19.14	residential	0	0	0
16091260120000	public	0	0	0	public	73877	10.02	740.3

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