Impact of TRAX and BRT on Traffic in a Travel Corridor

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Light Rail Transit (LRT)

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.

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

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Abstract

An important debate is taking place over the value of transit in easing traffic congestion. This study sought to quantify the effect of light rail transit (LRT) on traffic in a travel corridor and provide quantitative data that can be used to shape future transportation policies aimed at reducing traffic congestion, energy consumption, and air pollution. Using a quasi-experiment design and data before and after the University of Utah's TRAX LRT line was opened, we estimated that traffic on the street with LRT (400/500 South) decreased by 7,500 to 21,700 due to the availability of a high-quality transit serving destinations along the line, and, most important, the University of Utah. Traffic on 400/500 South decreased despite significant development in the corridor and expansion of the university. Based on our estimates, LRT along 400/500 South saves about 362,000 gallons of gasoline and prevents about 7 million pounds of CO_2 from being emitted each year.

Introduction

This study sought to quantify the effect of the University of Utah's TRAX light rail line on traffic near the university, providing quantitative data that can be used to shape future transportation policies aimed at reducing traffic congestion, energy consumption, air pollution, greenhouse gas (GHG) 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; in comparison, other types of passes recovered an average of 24 percent of the

Introduction-Literature Review

- Senior (2009) and Lee et al. (2013) 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) argued that whenever a driver shifts onto public transportation, another is going to use the **open lane**.

Quasi-Experimental Analysis

Treatment:

- The “treatment” in this quasi-experiment is the **2.3 miles extension of TRAX** from **downtown Salt Lake City to Rice-Eccles Stadium** in **December 2001**. 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.

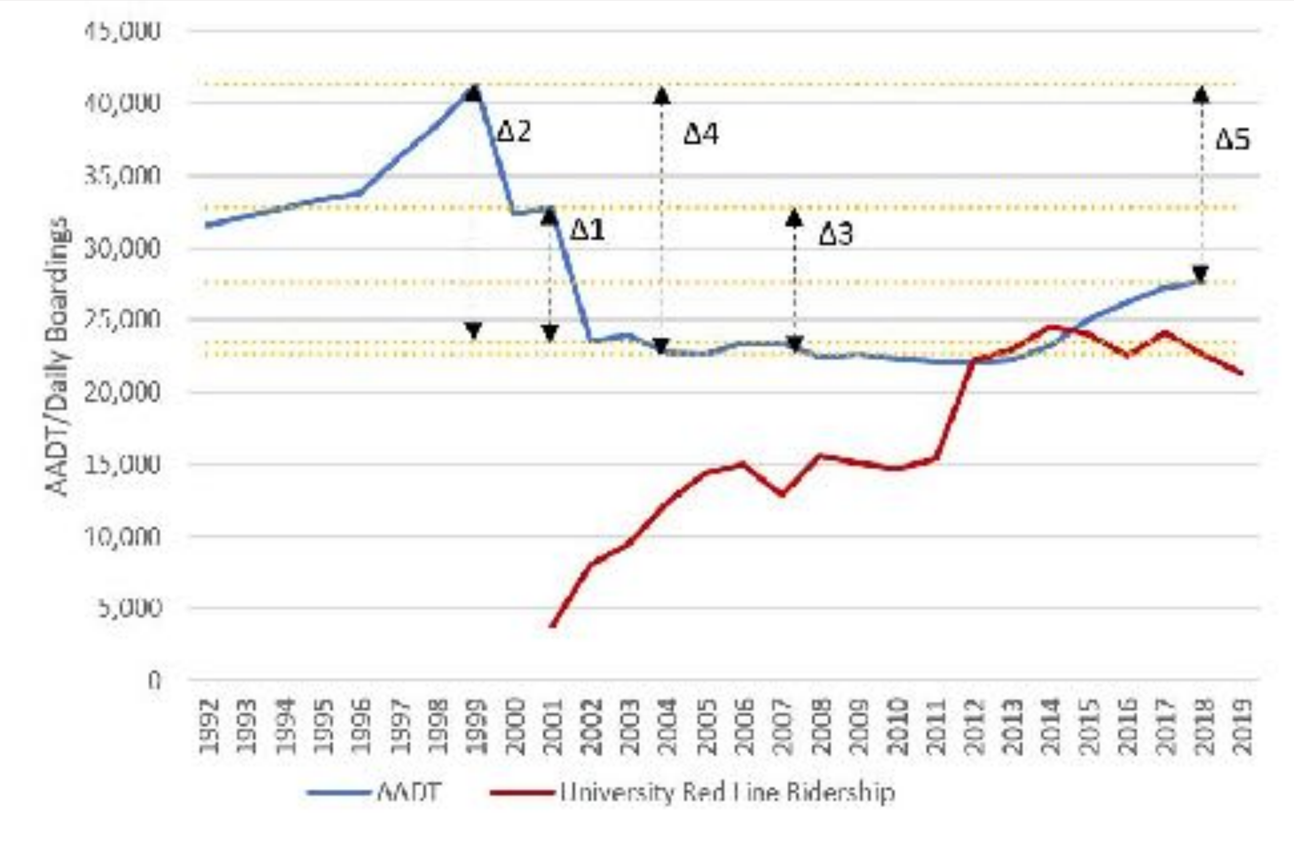
Traffic Counts

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.

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
2012	22,065	22,258
2013	22,200	22,915
2014	23,200	24,549
2015	25,000	24,027
2016	26,200	22,495
2017	27,278	24,124
2018	27,599	22,628
2019	-	21,264

Short-Term Impact: 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.**



Short-Term Impact: Pretest-Posttest without a Comparison Group

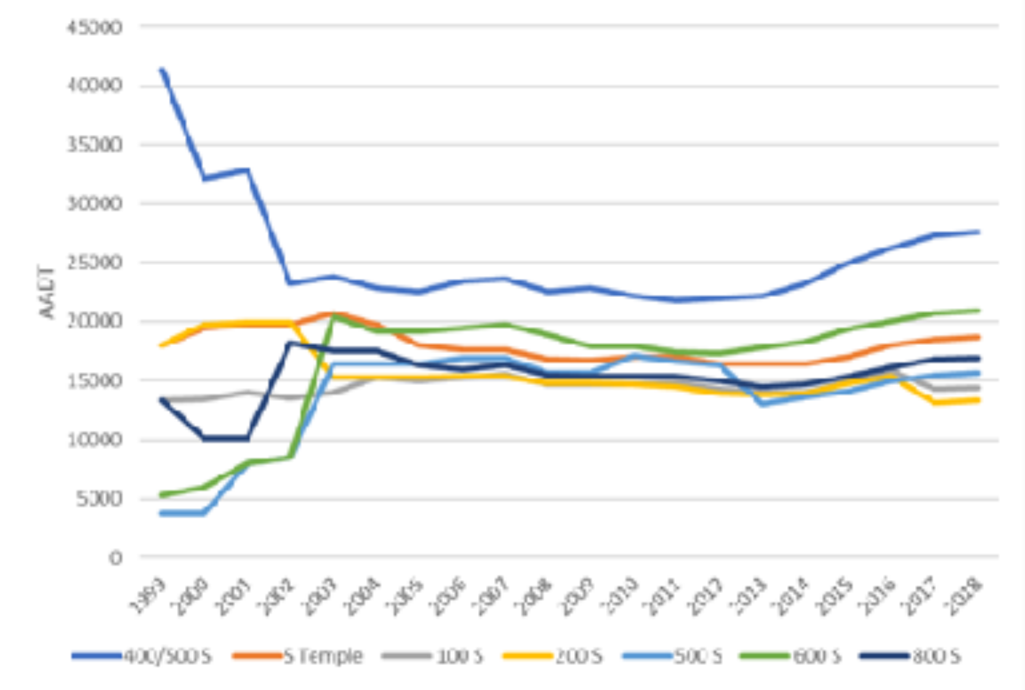
First, the AADT on 400/500 South was higher in prior years and had been **increasing** starting in 1992 and running through 1999. Construction of TRAX in 2000 and 2001, and the resulting disruption of traffic operations on 400/500 South, seem to have **depressed AADT**. If one assumes that the before 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**.

After TRAX operated, many new high-density apartment buildings and other developments in the corridor have led to a **slight increase in traffic** since the previous TRAX report, but AADT remains well **below its 1999 peak**. The 400 S corridor carried about **13,700 fewer VPD in 2018 than in 1999**, represented by Δ5, despite **new development in the corridor.**

	AADT on 400 South	Net Transit Ridership
Δ1 (2001-2002)	-9,300	7,200
Δ2 (1999-2002)	-17,900	7,100
Δ3 (2001-2004)	-10,100	12,800
Δ4 (1999-2004)	-18,700	12,000
Δ5 (1999-2018)	-13,700	22,000

Short-Term Impact: Pretest-Posttest without a Comparison Group

Second, traffic **increased** on **some streets parallel to 400/500 South between 2001 and 2004**, 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 by a net amount of **3,600 on parallel streets** between 2001 and 2004 . So most, but not all, of the reduction in AADT on 400 South appears to be due to TRAX.



Short-Term Impact: Pretest-Posttest without a Comparison Group

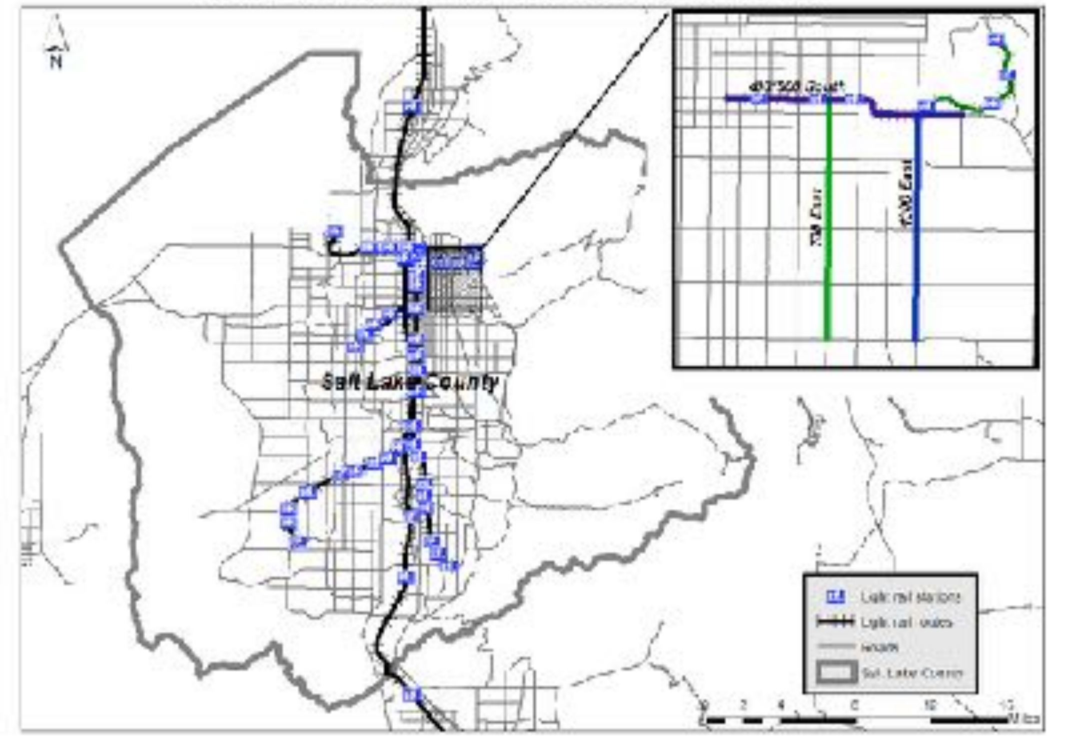
Third, the **net increase in transit ridership** is **less than 7,200 riders** because some of the riders were **diverted from buses**. There were six bus lines running along 400/500 South from 1999 to 2001, and the total daily ridership was approximately **3,000 passengers**. In August 2002, three bus 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**.

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**					

Pretreatment-Posttreatment with a Comparison Group

Comparison group

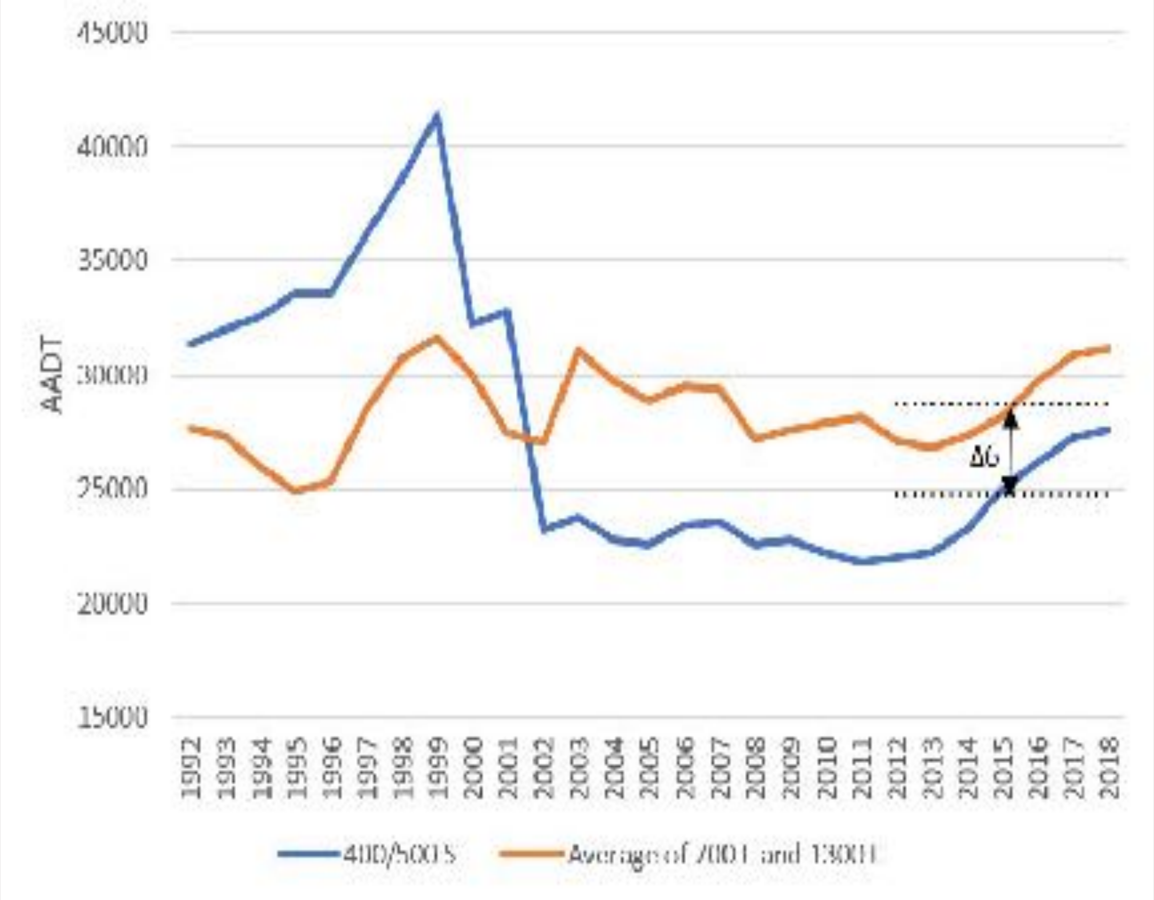


Long-Term Impact: Pretest-Posttest with a Comparison Group

- For the years 2012-2018, the average AADT on these **two north-south streets** was **4,000 VPD higher** than the AADT on **400 South**.

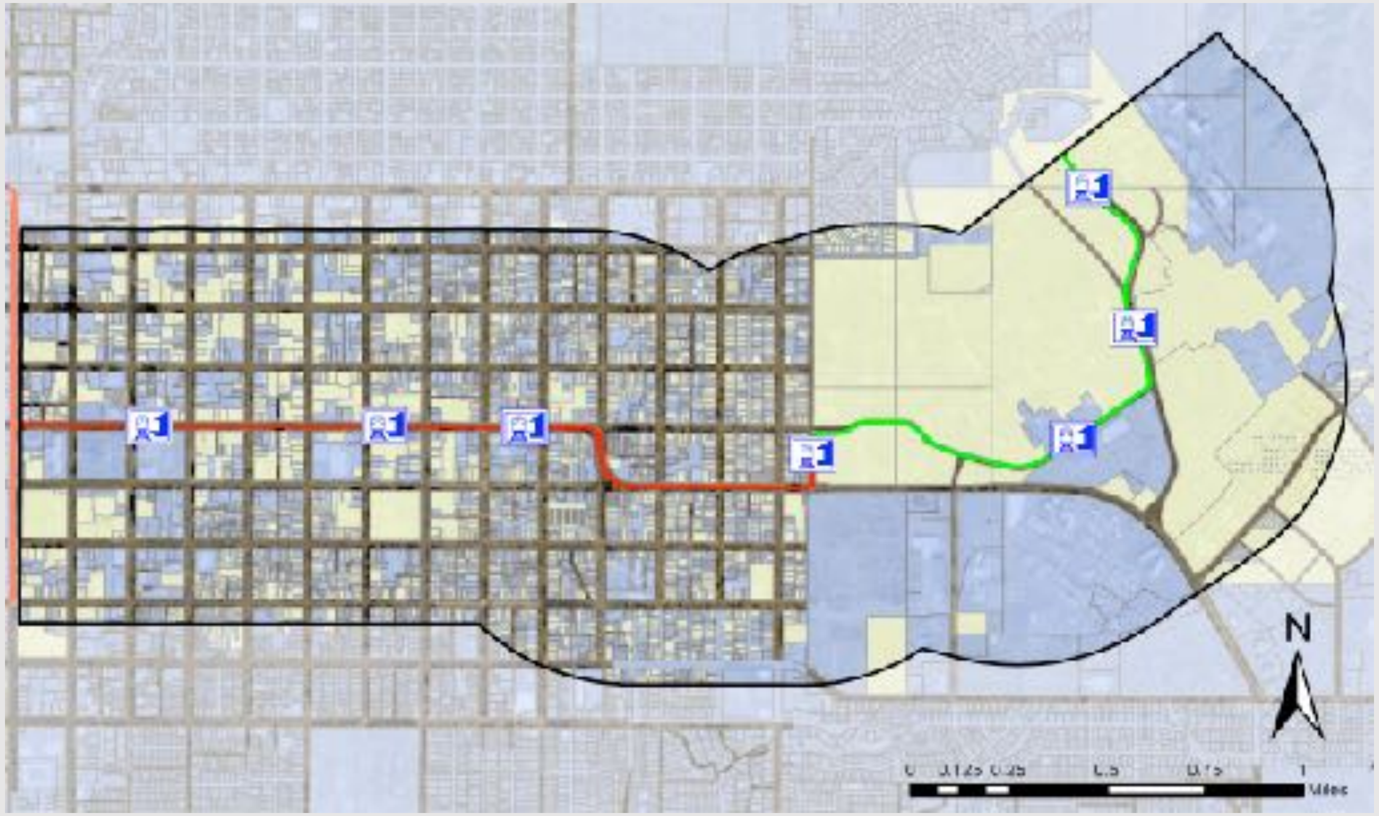
- The **net transit ridership increase** between 2001 and 2012-2018 is **19,400 passengers** per day.
(23,200 average for 2012-2018 minus 3800 for 2001)

- The **decline in AADT** on 400/500 South (**4,000VPD**) is **79 percent less** than the **increase in transit ridership.**



Land Use Change

Parcels that changed **between 2010 and 2020** (were developed, redeveloped, or cleared) are highlighted in yellow.



Changed

Land Use Change-Trip Generation

Energy and Emission Reduction

We chose a conservative estimate that is roughly mid-range, **7,800 vehicles per day**, for this summary of impacts. Of the **11,400 vehicle per day** drop in traffic on 400/500 South, some was diverted to parallel streets rather than TRAX. We have estimated diversion to parallel streets to be **3,600 VPD**. So the net reduction of traffic traveling the corridor would be **7,800 VPD.**

Estimate	Average Daily Traffic
Δ1: 2001-2002	9,300 VPD
Δ2: 1999-2002	17,900 VPD
Δ3: 2001-2004	10,100 VPD
Δ4: 1999-2004	18,700 VPD
Δ5: 1999-2018	13,700 VPD
Δ6: Estimated traffic reduction on 400 S due to TRAX compared parallel streets (700E, 1300E)	4,000 VPD
Δ7: Estimated traffic reduction based on land use analysis (1999-2009)	21,700 VPD
Δ8: Estimated traffic reduction based on land use analysis (2010-2018)	-4,200 VPD
Comprehensive estimated traffic reduction	**7,800 VPD**

Energy and Emission Reduction

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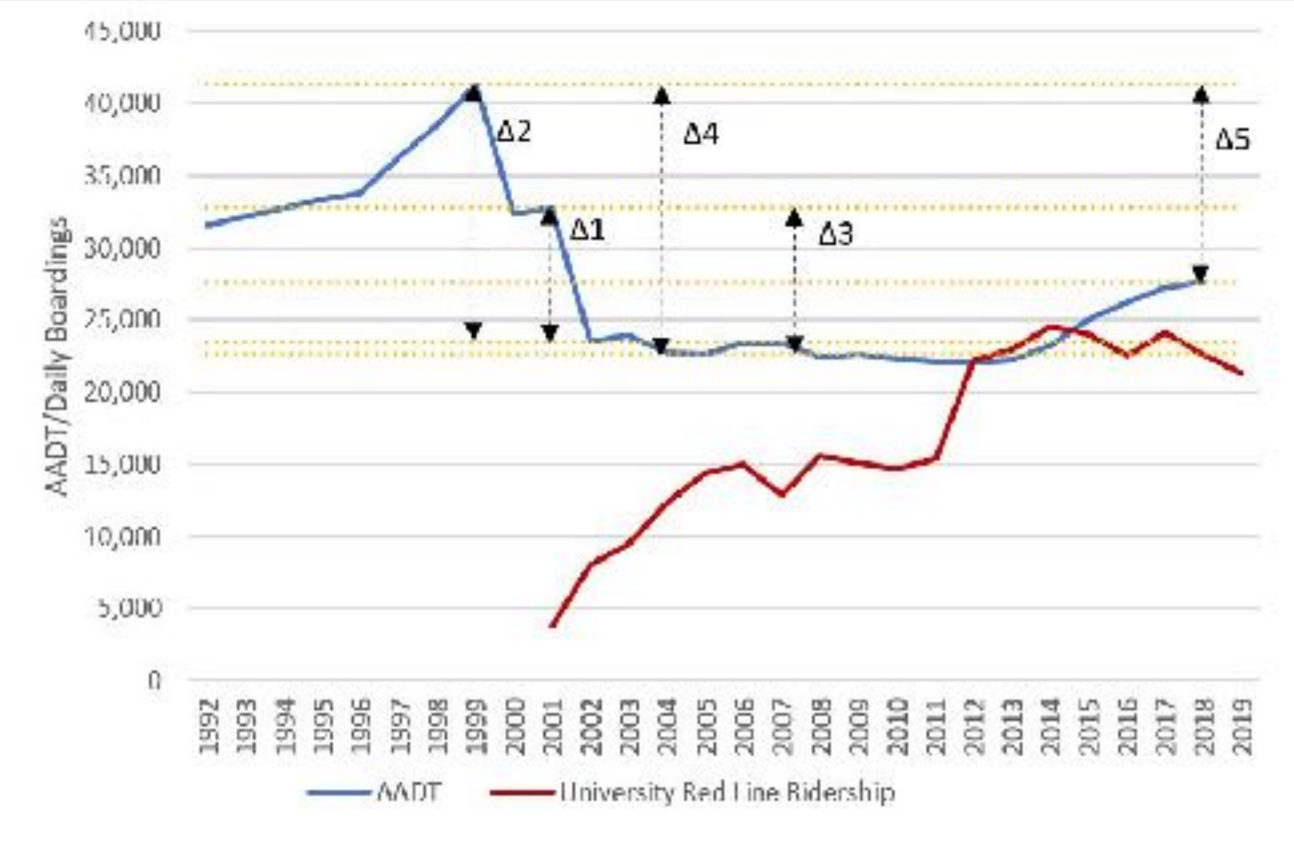
Pollutant/ Fuel	Emission & Fuel Consumption Rates (per mile driven)	Traffic Reduction	Calculation	Daily Reduction of Emission & Fuel Consumption	Annual Reduction of Emission & Fuel Consumption
VOC	1.034 grams (g)	7,800 vehicles per day (vpd)	(1.034 g/mi) x (2.3 mi) x (7800 vpd)x (1 lb./454 g)	**40.86 lb.**	**14,900 lb.**
THC	1.077 g		(1.077 g/mi) x (2.3 mi) x (7800 vpd)x (1 lb./454 g)	**42.56 lb.**	**15,600 lb.**
CO	9.400 g		(9.400 g/mi) x (2.3 mi) x (7800 vpd)x (1 lb./454 g)	**371.44 lb.**	**135,600 lb.**
NO_X	0.693 g		(0.693 g/mi) x (2.3 mi) x (7800 vpd)x (1 lb./454 g)	**27.38 lb.**	**10,000 lb.**
CO_2	368.4 g		(411.4 g/mi) x (2.3 mi) x (7800 vpd)x (1 lb./454 g)	**16,300 lb.**	**5,933,700 lb.**
Gasoline Consumption	0.04149 gallons (gal)		(2.3 mi) x (7800 vpd)/ (21.6 mi/gal)	**830.56 gal**	**303,200 gal**

Transit-Oriented Development vs. Transit-Adjacent Development

Our **first** analysis uses the simplest quasi-experimental design, a **one-group pre-treatment, post-treatment design with no comparison group.**



Luxury Apartments with Auto Owners

If it works for LRT, why not BRT?

Bus Rapid Transit (BRT)

Introduction

This study seeks to quantify the before and after effect of implementing a **new Provo-Orem Bus Rapid Transit (BRT) line on traffic volume**, transit ridership, nearby land-use, trip generation, automobile travel time, traffic safety, parking supply and occupancy, and vehicle emissions **near the Brigham Young University and Utah Valley University**, providing quantitative data that can be used for future transportation policies aimed at reducing traffic congestion.

Introduction-Literature Review

- Most of the previous research focused on **operational performance, project implementation, or economic development impacts**.

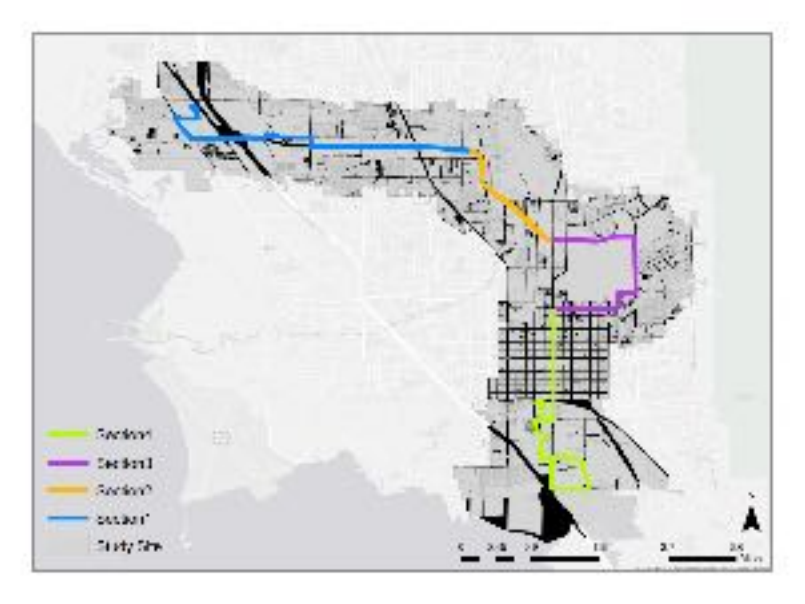
- **Limited and unclear** exploration of **BRT's impact on traffic volumes**, automobile travel times, and crash rates.

- Some people still have doubts about the potential of BRT because of the social stigma of bus-based transit (Cervero, 1998).

Quasi-Experimental Analysis

Treatment:

- The "treatment" in this quasi-experiment is the **10.5 miles of Provo-Orem BRT** from **Orem Intermodal Center to Provo Intermodal Center** in **August 2018** (Full operation started December 2018). The year **2017** represents the **last year before the initial treatment**, and **2019** represents the **first year after the treatment**.



***4 Sections**
Section 1: W & E University Parkway **(Principal Arterial)**
Section 2: N University Parkway **(Principal Arterial)**
Section 3: E University Parkway, 900 E, E 700 N **(Minor Arterial, Major Collector)**, **Narrow road width, few exclusive lanes*
Section 4: N University Avenue **(Principal Arterial, Minor Arterial, Major Collector)**

Traffic Counts

- ***Traffic Volume:*** Annual average daily traffic (**AADT**) provided by Utah Department of Transportation (**UDOT**)
- ***Transit Ridership:*** **Transit ridership** data provided by Utah Transit Authority (**UTA**)
- ***Weighted Annual Average Daily Traffic (AADT) calculation:***

Why used this?: A) To account for the **difference in the segments' length.**

$$Weighted\ AADT = \frac{\left(\sum_{k=1}^{n} AADT_k \times Length_k\right)}{\sum_{k=1}^{n} Length_k}$$

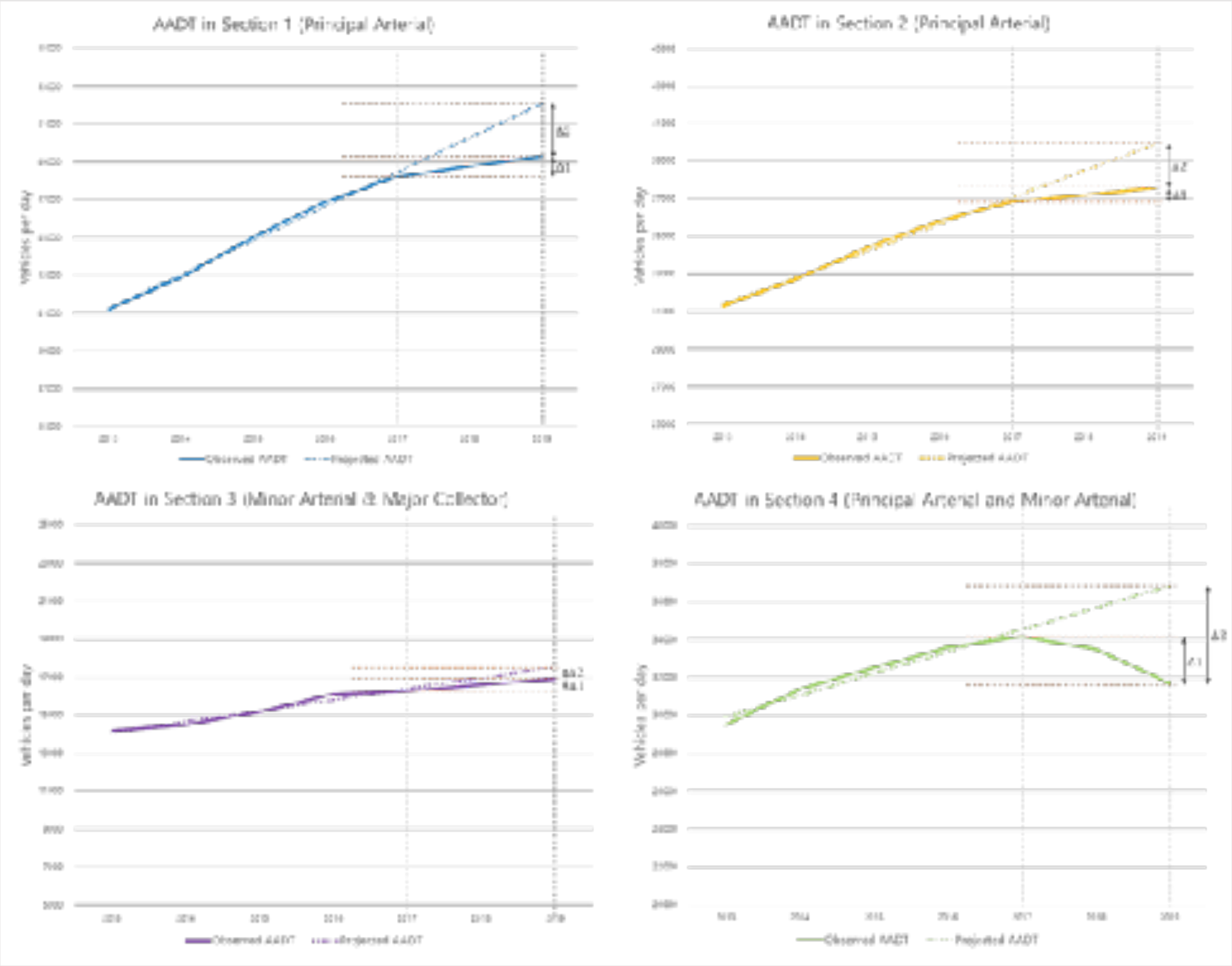
Year	2013	2014	2015	2016	2017	2018	2019
AADT (Section 1)	41,218	42,900	45,057	46,898	48,258	48,774	49,292
AADT (Section 2)	31,283	32,710	34,425	35,853	36,853	37,215	37,587
AADT (Section 3)	14,456	14,913	15,651	16,440	16,665	17,002	17,308
AADT (Section 4)	29,507	31,402	32,507	33,610	34,159	33,499	31,690
Total Bus Ridership	4,400	4,749	5,636	5,892	6,010	9,496	15,770
BRT Ridership						3,314	9,462
Other Bus Ridership						6,182	6,308

Pretest-Posttest without a Comparison Group & Interrupted Time Series

First, **A simple comparison** between **observed traffic volumes** before BRT (**2017**) to observed traffic volumes after BRT (**2019**)
 # However, this is ***not a valid estimate*** *because it* ***ignores the general increases pattern***

Second, **Interrupted time series,** assumes the trends in traffic on BRT segments from **2013 to 2017 (before BRT) continue through to 2019 after BRT** was in place.

Pretest-Posttest without a Comparison Group & Interrupted Time Series

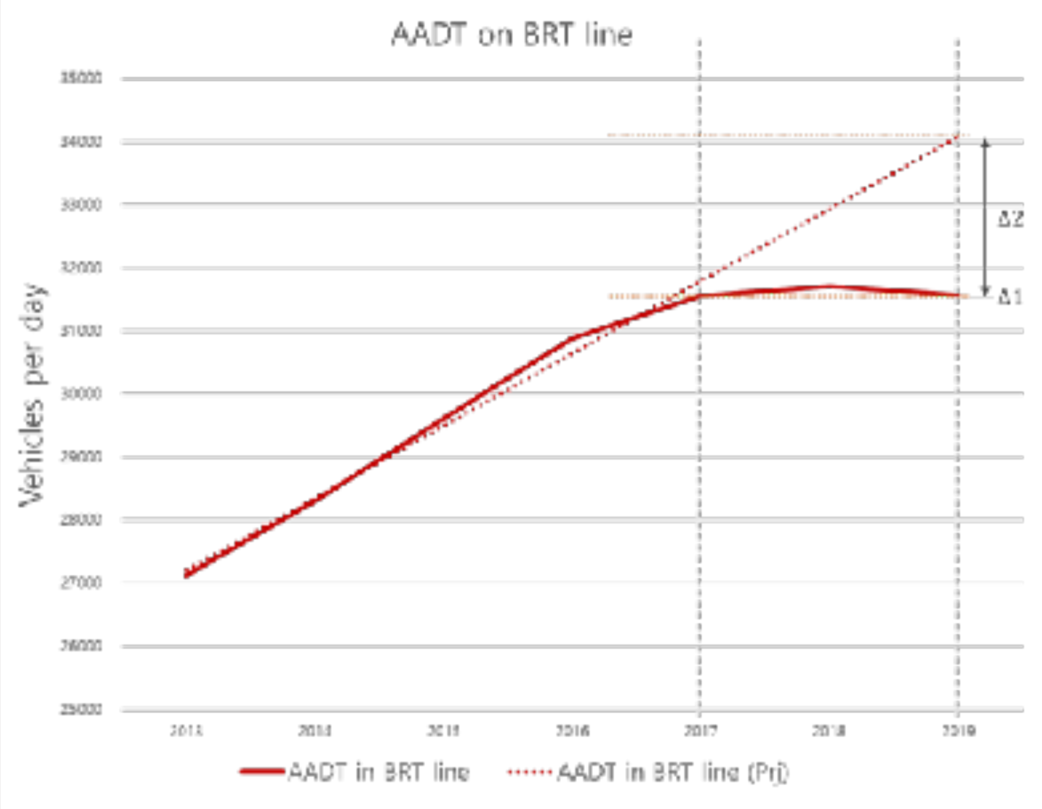


	Change in Weighted Average AADT from 2017 to 2019	
	Absolute Change	Percentage (%)
S1	1035	2.14%
S2	734	1.99%
S3	642	3.95%
S4	-2469	-7.23%

	The 2019 Gap between Observed Value and Predicted Value based on 2013-2017	
	Relative Change	Percentage (%)
S1	-2805	**-5.38%**
S2	-2352	**-5.89%**
S3	-624	**-3.56%**
S4	-5152	**-13.98%**

**Section 1,2: near UVU (Enrollment increased), Section 4: near BYU*
**Section 3: narrow road width, few exclusive lanes*

Pretest-Posttest without a Comparison Group & Interrupted Time Series



	Change in Weighted Average AADT from 2017 to 2019	
	Absolute Change	Percentage (%)
	2	0.01%

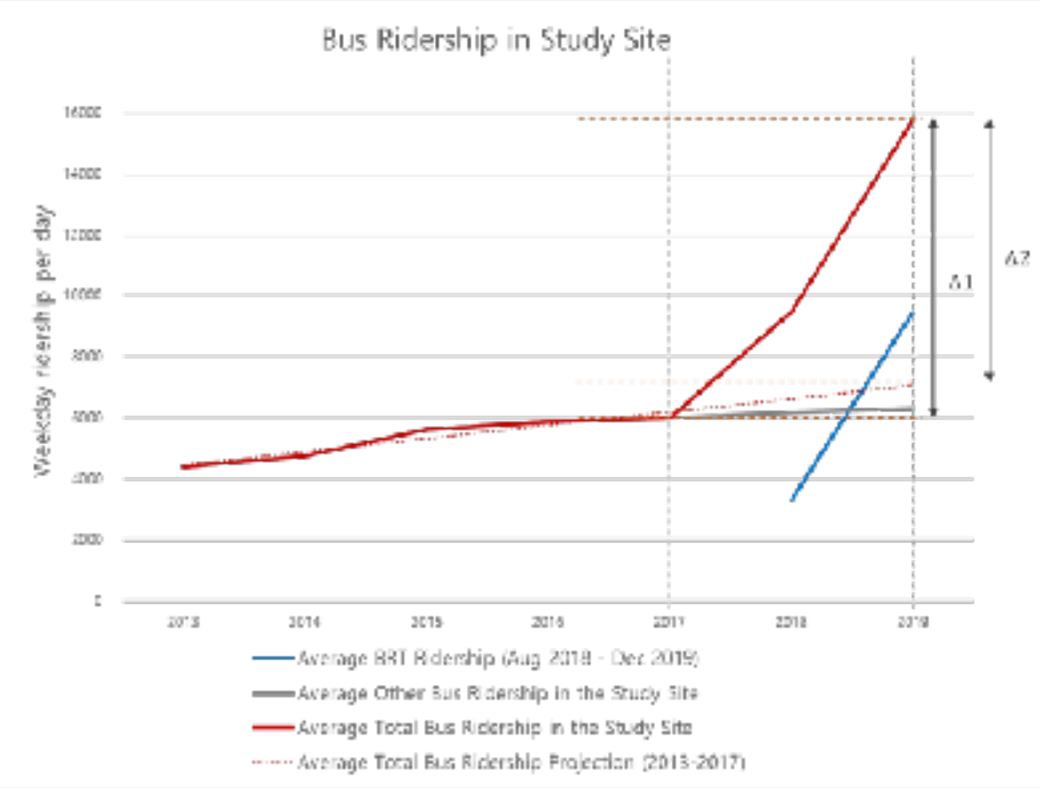
	The 2019 Gap between Observed Value and Predicted Value based on 2013-2017	
	Absolute Change	Percentage (%)
	-2514	**-7.38 %**

- As a result of a simple comparison between 2017 and 2019, increasing by only **0.01 percent or 2 vehicles per day (vpd)**

- As a result of an interrupted time series, traffic volume on the BRT segments is **2,514 vehicles per day lower (-7.38%) than one would expect based on the preexisting trend.**

**Traffic volume change in Corridor (2017: 20617VPD, 2019: 20712VPD, Interrupted Time Series: -1514 VPD or -6.81%)*

Pretest-Posttest without a Comparison Group & Interrupted Time Series



	Total bus ridership change in study area from 2017 to 2019	
	Absolute Change	Percentage (%)
	9760	162.4%

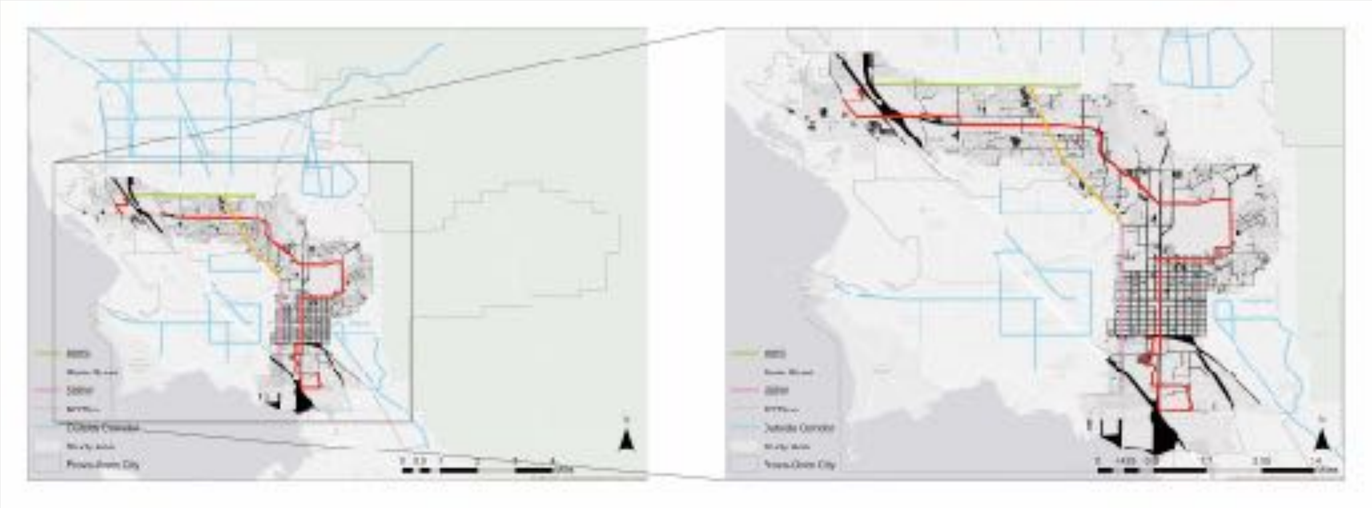
	The 2019 Gap between Observed Value and Predicted Value based on 2013-2017	
	Relative Change	Percentage (%)
	8687	**122.7%**

- Meanwhile, transit ridership in the corridor increased by **8,687 passengers per day (122.66%) more than expected with the introduction of BRT**, which accounts for the effective reduction of vehicular traffic on the streets that comprise the BRT alignment.

**Front Runner's Ridership in Provo and Orem were excluded from this analysis.*
But the ridership was increased by 590 (3,161 in 2017, 3,751 in 2019)

Pretest-Posttest without a Comparison Group & Interrupted Time Series

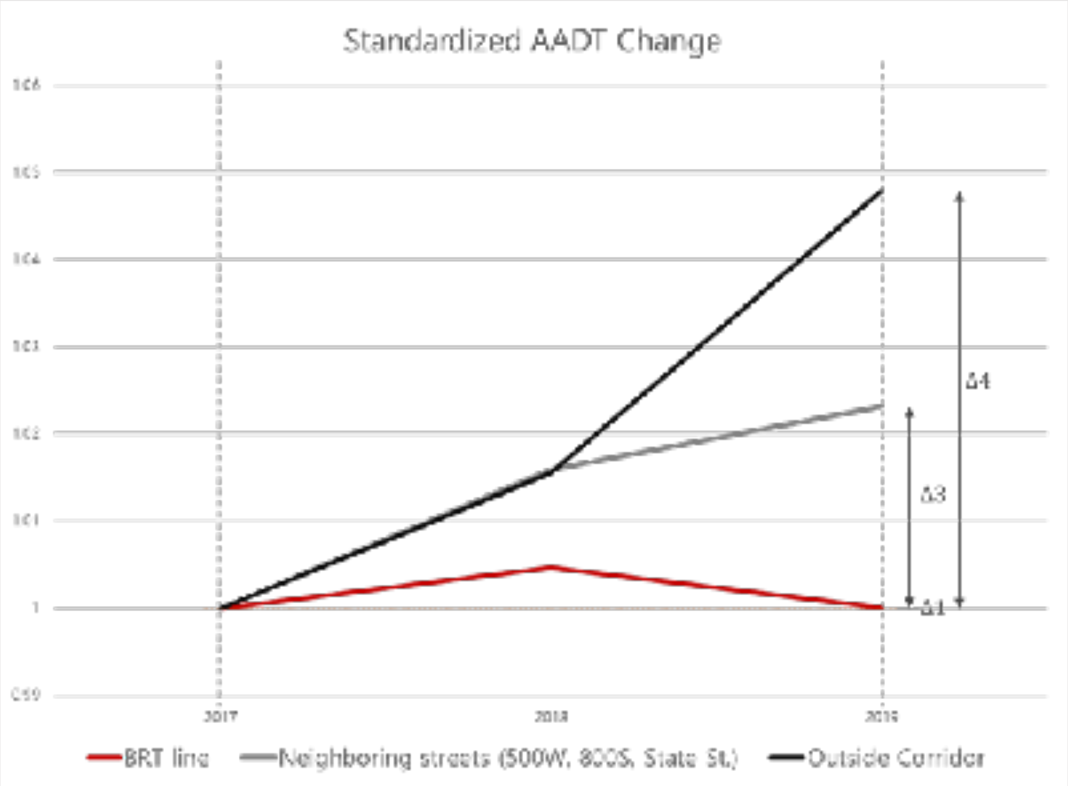
Third, The third quasi-experimental design is called a **before-after design with a control group**, which assumes that **traffic volume on the BRT route** would increase by **as much as** the percentage increases in **traffic outside of the BRT corridor**



1. Outside corridor:
The outside corridor is located **outside the 0.5-mile buffer area from BRT**. This area is assumed to be little affected by BRT.

2. Neighboring streets (500W, 800S, and State Street):
The neighboring streets are located within or just outside the **0.5 miles** buffer area from BRT. These roads are **parallel with BRT line** and possible streets to **detour.**

Pretest-Posttest without a Comparison Group & Interrupted Time Series



	Change in Weighted Average AADT from 2017 to 2019	
	Absolute change	Percentage (%)
BRT line ()	2	0.01 %
Neighboring Streets ()	647	2.31 %
Outside Corridor ()	1252	4.79 %

	Difference in Differences	
	Absolute change	Percentage (%)
Neighboring Streets () - BRT line () : *(Estimated Bypass)*	**-645**	**-2.30 %**
Outside Corridor () - BRT line ()	**-1250**	**-4.78 %**

- As a result of before-after design with a control group, first, the **BRT line AADT decreased** about **2.30 percent or 645 vpd relative to neighboring streets.**

- Second, the **BRT line AADT decreased** about **4.78 percent or 1250 vpd relative to the rest of the cities of Provo and Orem**.

Land Use Change

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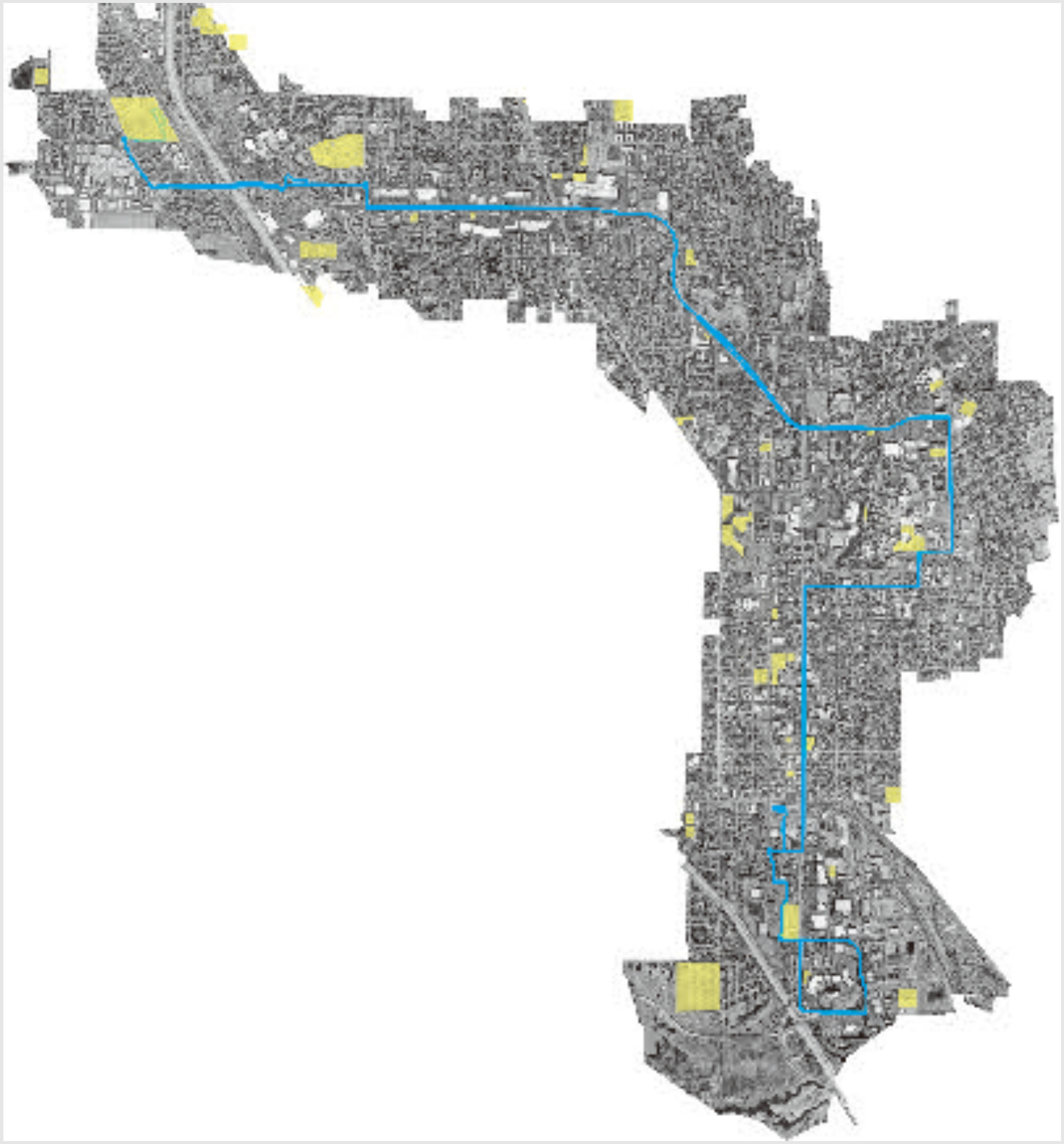

Parcels that changed **between 2017 and 2019** (were developed, redeveloped, or cleared) are highlighted in yellow.

Land Use Change-Trip Generation

Total Trip Generation by Land Uses that have changed (2017-2019)

Land-Use Type	2017	2019	Changes
Residential	20,225	25,551	**5,326**
Commercial	168,559	180,867	**12,309**
Total	188,784	206,419	17,634

Residential Area's Trip Generation Change

Land-Use Type (Residential)	2017	2019	Trip Generation Change From 2017 to 2019
Single detached housing	1916	3237	1322
Single attached housing	1718	1680	-38
Multifamily housing	16592	20633	4042
Total	20225	25551	5326

Estimated BRT's traffic reduction based on Land Use Analysis (2017-2019)

$$\Delta 5 = 2450 \approx \overset{a}{31567} * \overset{b}{0.986} * (1 + \overset{c}{0.093}) - \overset{d}{31570}$$

A: AADT on the BRT line 2017
B: Share of local traffic by regional model
C: Increased by land use
D: Actual local AADT on the corridor in 2019

Energy and Emission Reduction

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We chose a conservative estimate that is roughly mid-range, **1,500 vehicles per day**, for this summary of impacts. Of the at least **2,100 vehicles per day** drop in traffic along the BRT line, some was diverted to parallel streets rather than BRT. We have estimated diversion to parallel streets to be up to **600 VPD**. So, the net reduction of traffic traveling the corridor would be **1,500 VPD.**

Estimate	**Average Daily Traffic Reduction**
Reduce vehicular traffic on the different sections of BRT	from 624 to 5,152 VPD
Traffic Volume Reduction - *Interrupted Time Series* (Observed Value - Predicted Value)	2,514 VPD (-7.38%)
Traffic Volume Reduction - *Difference in Difference* (BRT line - Outside Corridor)	1,250 VPD (-4.78%)
Traffic Volume Change - *Difference in Difference* (BRT line – Neighboring Streets):*Estimated bypass*	645 (-2.30 %)
Estimated traffic reduction based on land use analysis (2017-2019)	2,450 VPD
Comprehensive estimated traffic reduction	**1,500 VPD**

Energy and Emission Reduction

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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)	1,500 vehicles per day (vpd)	(1.034 g/mi) x (10.96 mi) x (1500 vpd)x (1 lb./454 g)	**37.44 lb.**	**13,667 lb.**
THC	1.077 g		(1.077 g/mi) x (10.96 mi) x (1500 vpd)x (1 lb./454 g)	**39.00 lb.**	**14,235 lb.**
CO	9.400 g		(9.400 g/mi) x (10.96 mi) x (1500 vpd)x (1 lb./454 g)	**340.39 lb.**	**124,241 lb.**
NOX	0.693 g		(0.693 g/mi) x (10.96 mi) x (1500 vpd)x (1 lb./454 g)	**25.09 lb.**	**9,160 lb.**
CO2	368.4 g		(368.4 g/mi) x (10.96 mi) x (1500 vpd)x (1 lb./454 g)	**13,340 lb.**	**4,869,209 lb.**
Gasoline Consumption	0.04149 gallons (gal)		(10.96 mi) x (1500 vpd)/ (24.1 mi/gal)	**682.16 gal**	**248,988 gal**

Conclusion

Light-Rail Transit: University TRAX

Treatment	2.3 miles extension of TRAX	Completed in Dec 2001
	1.5 miles extension of TRAX	Completed in Sep 2003

Traffic	Δ1: 2001-2002	9,300 VPD
	Δ2: 1999-2002	17,900 VPD
	Δ3: 2001-2004	10,100 VPD
	Δ4: 1999-2004	18,700 VPD
	Δ5: 1999-2018	13,700 VPD
	Δ6: Estimated traffic reduction on 400 S due to TRAX compared parallel streets (700E, 1300E)	4,000 VPD
	Δ7: Estimated traffic reduction based on land use analysis (1999-2009)	21,700 VPD
	Δ8: Estimated traffic reduction based on land use analysis (2010-2018)	-4,200 VPD
	Comprehensive estimated traffic reduction	**7,800 VPD**

Transit Ridership	Net transit ridership increase (1999-2004 / between 2001 and 2012-2018)	**7,200 / 19,400 passengers per day**

Trip Generation (1999-2009 / 2010-2020)	**Residential: 9,200 / 11,100** **Commercial: 26,500 / 29,600**

Annual Reduction of Emission & Fuel Consumption (1999-2009 / 2010-2020)	**Gasoline: 362,300 / 303,200 gallons** **CO2: 7,084,600 / 5,933,700 pounds**

Bus Rapid Transit: Utah Valley Express

Treatment	10.5 miles of BRT	Completed in Aug 2018

Traffic	Reduce vehicular traffic on the different sections of BRT	from 624 to 5,152 VPD
	Traffic Volume Reduction - *Interrupted Time Series* (Observed Value - Predicted Value)	2,514 VPD (-7.38%)
	Traffic Volume Reduction - *Difference in Difference* (BRT line - Outside Corridor)	1,250 VPD (-4.78%)
	Traffic Volume Change - *Difference in Difference* (BRT line – Neighboring Streets):*Estimated bypass*	645 (-2.30 %)
	Estimated traffic reduction based on land use analysis (2017-2019)	2,450 VPD
	Comprehensive estimated traffic reduction	**1,500 VPD**

Bus Ridership	Net Bus Ridership increase - *Interrupted Time Series* (2017-2019)	**8,687 passengers per day (122.66%)**

Trip Generation (2017-2019)	**Residential: 5,326** **Commercial 12,309**

Annual Reduction of Emission & Fuel Consumption (2017-2019)	**Gasoline: 248,988 gallons** **CO2: 4,869,209 pounds**

Discussion

University TRAX line v. Provo-Orem BRT line (UVX)

1. **Traffic reduction results:** -7,800 VPD v. -1,500 VPD
2. **Length:** 42.5 miles (Treat: 3.8 miles extension) v. 10.5 miles (New construction)
3. **Transit Ridership:** Red line- about 20,000 (2019) v. UVX- about 10,000 (2019)

Reasons: 1. **BRT-Lite** (lower limit of BRT)**:**
Only **half of the alignment** consisted of **exclusive bus lanes.**
University TRAX: Full exclusive lanes.
2. **Parking Permit Prices**: UU ($145 / semester)
v. BYU ($60 / semester) and UVU ($65 / semester),

Limitation: 1. Long term (1999-2019) v. Short term monitoring (2017-2019):
Insufficient time to obtain general trend in BRT's traffic effect.
2. Limitation of quasi-experimental research design.
3. Slightly different approach was used to measure traffic reduction

Thank you

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