

PULLMAN TRANSIT EXPRESS ROUTES PILOT STUDY

FINAL PROJECT REPORT

by

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16. Abstract The impacts of transit re-routing on ridership levels is evaluated using a difference-in-difference regression. Re-routing brought increased service frequency and reduced transit time, both of which are known to induce transit demand. Results show, re-routing caused ridership levels to increase on routes that were re-routed by 161%. Furthermore, this increase in ridership does not appear to come from a substitution away from alternative (non-re-routed) routes.					
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
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TABLE OF CONTENTS

Disclaimer.....	i
Technical Report Documentation Page	ii
SI* (Modern Metric) Conversion Factors.....	iii
List of Figures	v
List of Tables	vi
Executive Summary.....	7
CHAPTER 1. Introduction	8
CHAPTER 2. Literature Review.....	8
CHAPTER 3. Data.....	18
CHAPTER 4. Analysis And Results	22
CHAPTER 5. Conclusions	23
References	24

LIST OF FIGURES

Figure 3.1 Pullman Transit Boardings (2019 & 2020)	18
Figure 3.2 Daily Boardings	19
Figure 3.3 Hourly Boardings.....	20
Figure 3.4 Total Boardings by Route (2019-2022)	21
Figure 3.5 Weekly Boardings	22

LIST OF TABLES

Table 1 Travel Time Variables	Error! Bookmark not defined.
Table 2 Ridership and Socio-Economic Variables	Error! Bookmark not defined.
Table 3 In Sample Prediction Performance	Error! Bookmark not defined.
Table 4 Out of Sample Prediction Performance	Error! Bookmark not defined.

EXECUTIVE SUMMARY

There are two Express Routes serving the City of Pullman transit system where demand is greatest. Historically, these routes have been overwhelmed by the number of riders during these peak hours and have had to skip patrons waiting at stops because the express busses on these routes were already at capacity. Due to cost constraints, Pullman transit cannot simply add more busses to fulfill this demand, so a re-route of the two express routes was implemented starting August 19th, 2021. These re-routes cut much of the express busses distance with the goal of increasing frequency for riders while staying safe and in budget.

The objective of this project is to provide targeted information on the impacts of the Express Routes Pilot Program to the transportation planners at Pullman Transit and WSU Transportation Services. The Express Routes Pilot Program is an attempt to improve the frequencies and capacities of the Express system, by re-routing the existing routes to a central drop off location and adding a campus shuttle.

Results show, re-routing caused ridership levels to increase on routes that were re-routed by 161%. Furthermore, this increase in ridership does not appear to come from a substitution away from alternative (non-re-routed) routes.

CHAPTER 1. INTRODUCTION

Pullman Transit is the leading rural transit system throughout Washington and within the region, providing over 1.4 million rides annually. Like most transit networks, Pullman Transit is faced with challenging questions in their effort to meet service demands and community needs in a financially sustainable way.

There are two Express Routes serving the City of Pullman transit system where demand is greatest. Historically, these routes have been overwhelmed by the number of riders during these peak hours and have had to skip patrons waiting at stops because the express busses on these routes were already at capacity. Due to cost constraints, Pullman transit cannot simply add more busses to fulfill this demand, so a re-route of the two express routes was implemented starting August 19th, 2021. These re-routes cut much of the express busses distance with the goal of increasing frequency for riders while staying safe and in budget.

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To address this excess demand without using additional resources, Pullman Transit has implemented a Pilot Program that re-routes these two express routes to cover roughly half the distance. Before the re-route, the express busses ran through campus, but now after the re-route, they only briefly stop at the north side of campus (near Beasley Coliseum) and head back north towards the residential areas. The goal is that commuters get to campus quicker, and then they can simply walk the rest of their journey once they get to campus. The objective of this research is to determine the efficacy of the Pilot Program (rerouting) in meeting demand during peak hours.

CHAPTER 2. LITERATURE REVIEW

There are three primary drivers of transit ridership: the built environment, socioeconomic factors, and transit/station characteristics (Sun et al., 2016). (definition) A lot of literature stresses the importance of built environment on ridership. However, in our context, it is not an aspect of service quality within the control of the transit agency directly. The main aspect that can be changed is stop placement which determines where riders will have to walk to get to their stop, as well as the route they will take to get to their destination.

The built environment describes the amenities, structures, and services that we interact with (cite). The density, diversity, and design of amenities and services (e.g., parks, transit stations, cafes, sidewalks, etc.) are central to individuals trip behavior and travel mode decisions (Estupinan et al 2008, Aston et al 2020, Aston et al 2016, Chakour et al., 2016, Dill et al 2013). The built environment is important to riders, as it defines the structures, amenities, and services that they interact with throughout their trip and upon arrival to their destination(s). Estupinan et al. (2008) explains that a walkable built environment is critical to inducing transit ridership, as riders are pedestrians prior to boarding and after alighting the transit service. Estupinan et al. (2008) further notes that transit ridership is particularly high in areas where the built environment is uncondusive to driving (congested traffic, road tolls, high

licensing/registration fees, limited parking, etc.). The context in which your transit system operates is crucial in understanding the experience of the riders which use the system.

Berrebe explores socioeconomic factors to explain the overall decline of national transit ridership between 2012 and 2018. (Berrebe et al., 2020). An important first step is to address who is riding the bus. Although this is a much more macro scale than is applied to what our study will cover, it is important to understand all aspects which effect transit ridership as to not over or under-represent the effect that changes made by a transit agency have. In the United States, an auto dominated country, there is often an assumption that most of the people that ride the bus do so because they cannot afford a car. However, data shows this assumption to be untrue. While socio economic factors don't directly affect ridership, they provide clues at explaining the bigger aspects driving ridership such as job location and population density which are more difficult to measure. An important factor to consider is that this study focuses on major urban areas where as pullman is a rural college town context. In addition, a larger majority of riders are white in Pullman compared to the cities being looked at in this study.

Dill states that socio-demographic characteristics have a larger effect of large urban areas than smaller urban areas. Dill also emphasizes the importance of analyzing ridership at the stop level rather than the route level, because the route level assumes ridership is homogenous across routes. Dill defines "level of service" as assessed by transit frequency, transit density, and route density (how close together the stops are placed together). All these things are actually within the transit agency's control.

Finally, transit service quality plays an integral role in determining transit ridership and is also the only determinant of transit ridership that transit planners and managers have direct control over. Transit service quality is generally defined as how quickly, reliably, and safely transit can get you to where you need to go (Ashton et al 2020). There are many dimensions of transit service quality including: reliability, frequency, travel time, and cost. Each dimension of transit service quality, including their estimated effects on transit ridership, are discussed below.

Reliability

Arguably, the most important aspect of a bus system to the rider is reliability. If they are confident in their bus system and can trust when their bus will arrive, they can live more spontaneously when traveling, instead of having to fit their schedule around when the bus will arrive. There's a lot of trust that is necessary between riders and transit agency since, unlike automobiles, they are depending on an external force to get them where they need to go.

Boisjoly states that although most transit agencies track their performance, there is no universal definition on what reliability is. Chakrabarti et al 2015 defined two aspects of transit reliability: service punctuality (schedule adherence) and variation in schedule deviation. Schedule adherence can be measured using "on-time performance" (OTP). Low average OTP implies a transit line is unable to adhere to schedules. For a bus to be considered "on-time" it must be between 1 minute early and 5 minutes late with respect to the scheduled time. For an agency to collect this data, all busses in the system must have a GPS-based Automatic Vehicle Location (AVL) system installed. On-time performance is the most common metric in the US for measuring reliability because it is relatively simple to understand, although it can be difficult to distinguish how these OTP was derived. Therefore, it is imperative that this data be consistently collected to see how on-time performance changes over time

for a given transit system. Additionally, the more agencies adopt this data collection across the US, the more studies can be done to compare different agencies to one another.

Additionally, there are two other measures of reliability that Chakrabarti mentions: headway adherence and excess wait time. Headway adherence refers to how consistent a bus is at making a visit at any given stop. Notice that On-time performance and headway performance have the possibility of given conflicting data on whether a bus is reliable. For example, if a bus is 4 minutes late from its scheduled arrival time, it is considered on time, but that same bus could arrive at that stop at irregular intervals, giving it an unreliable rating in terms of headway performance.

In addition, the perception of how reliable a bus is not necessarily the same as how reliable the bus is. Walker et al 2012 argues that from the rider's perspective, a trip/service is reliable if it is predictable and repeatable. Studies like this that focus on the rider's perspective focus a lot more on the behavioral side of the problem, regarding how riders adapt and react to changes to reliability in their transit system. This can be more difficult data to collect since it is often collected through surveys. A caveat with this is that unreliability can also be predictable if a rider expects a bus to take longer to travel when there is a lot of traffic. They argue that riders will notice an unreliable bus system much more than a reliable one. In other words, a reliable transit system is what is expected by most riders in the United States even if that is not the country wide standard.

Walker argues that there's two types of ways that riders react to unreliability in a transit system: short term and long term. Short term refers to the ways in which a rider is first confronted with a problem and still need to make it to their destination. Long term refers to the decision making a rider goes through for future trips made. This long-term adaption does not necessarily mean a drop in ridership since many times these riders simply switch routes or busses because they still need to get to their destination. The problem is that this decision making is difficult to quantify in a way that is useful for transit agencies making decisions about how to increase ridership. Walker also noted that in the literature, there is generally a lot of turnover in ridership, meaning that many people will move on from riding the bus if it is not reliable enough to suit their needs.

Technology over the past couple decades has also influenced how people choose to get where they want to go (Tang et al 2012). Many transit agencies allow riders to directly track where their bus is instead of having to rely on a schedule that may not be adhered to.

Frequency

Frequency is important to the rider because a passenger's perception of level of service can persuade them to use it more often. Iarra-Rojas defines state that a transit agency should allocate the most frequent service to when there is most transit demand (such as during peak hours of the morning for commuters). This allows shorter wait times for riders and shorter overall trip times for when it is needed most, while also only increasing cost of operation for the transit agency when it is most necessary.

Frequency as a subcategory of level of service is defined many ways, ranging from a more general definition of how long on average a rider must wait for the bus, to a more specific definitions to fit the objectives of the paper. Iarra-Rojas et al. 2014 defines frequency as busses per hour for each line. This is most useful for the transit agency because it deals specifically with the cost of operation. However, this definition does not consider any characteristics of the transit lines such as length or the built

environment around the bus lines. This frequency analysis deals with the route level and allows you to look at the average travel times to determine how frequent the busses arrive at any given stop.

Perhaps what's more useful when considering frequency's effect on ridership is headway time. This is defined as the average time in between any two given busses on a route. However, this does not consider the number of busses in operation at once. Headway time is identified as the inverse of frequency. Meaning, that if a bus is more frequent, it will take less time to make a complete loop. This is important to know because headway time is much easier to measure than frequency.

Chackour et al 2016 defines frequency to be the inverse of headway time, which is the time between busses on a given loop. Therefore, longer the headway time is, the lower the frequency would be. With this definition, frequency can be increased by increasing the number of busses on a route, decreasing the amount of time any given stop sees a stop, or also by decreasing the distance that a route covers, meaning that the same number of vehicles will have to cover less distance. This definition is more difficult to measure than busses per hour, however it is more useful when considering which specific lines and stops have the most demand for traffic.

In the United States, the industry standard of high frequency transit service is a headway time of less than 10 minutes (Chakrabarti et al 2015), with higher frequency (shorter headway times) being found to increase ridership (Chakour et al., 2016). This 10-minute mark is consistent with Walker et al 2012 found in response to a survey where riders were asked what they considered frequent service. Frequency is important because it makes riding the bus much less of a burden for the rider when they can get to a bus stop and not have to wait very long for a bus to arrive.

Travel time

Brown analyzes the effect of travel time on ridership, however, uses a combination of rail transit and bus transit in conjunction to determine these effects.

Bus rapid transit (generally decreases travel times, but also increases service; disentangling the two has proven challenging... Presumably, at least some of the increases in ridership caused by BRT can be attributed to reduced travel times...) papers (indirectly

Studies analyzing bus rapid transit are important to us because they are very similar to the shock to the system that our experiment performed. A route increased its frequency without increasing more cost.

Another section of studies views travel time in the context of which commute mode a rider will use. This is important because riders will pick the mode or modes of travel that will take the least amount of time for them to get to their destination.

Cost

From the rider's perspective, the cost of ridership is one of the main things influencing whether they take the bus over another form of transportation. And since fare is directly controlled by the transit agency, it is important to get right. One of the aspects that Tang et al. 2012 discusses when looking at the Chicago Transit ridership is how fare affects ridership.

Gas prices have been found to have a positive effect on transit ridership, but not nearly as much as fare cost, since the price of gasoline is one of many costs of owning and operating a motor vehicle. Taylor

found that increasing cost of parking is much more effective way to increase transit ridership. I presume this is because, in most of the United States, parking is free. Whereas gas is a mandatory fee every car owner must pay. When they suddenly must pay for parking, they are more incentivized to find alternative modes of transport.

Chen found that ridership is affected more by a rise in gas price but not as much as a reduction in price. (Chen et al. 2011).

Each dimension of service quality: travel time, reliability, and quality, affects individuals’ trip behaviors and travel mode choices. In fact, each travel mode: walking, biking, driving, and transit, have analogous qualities that individuals evaluate and make tradeoffs between in deciding if and how they will commute from point A to point B. There is a lot of literature on this trip behavior and mode choice decision (see cite for review), including recent work evaluating these decisions in our study location (cite). The purpose of this project, however, is focused solely on transit ridership and evaluating the effects of transit service qualities on ridership demand, to help transit managers solve their public transit planning problem.

Table 1 Literature Review

Authors (year)	Objective	Solutions Method	findings
Chakrabarti et al. 2015	Determine the effects of service reliability on transit demand in LA bus system	Cross sectional Analysis	More reliable bus lines are more successful in attracting peak performance ridership.
El-Geneidy et al., 2011	Analysis transit service reliability in western suburbs of Minneapolis using Automatic Vehicular Locator (AVL) systems	Series of analytical models for predicting run time, schedule adherence, and reliability at the time point segment and route level	Their data recommends stop consolidation as a tool to decrease variability in a transit system and thus increase reliability.
Strathman et al., 2002	Automatic Vehicle Location (AVL) and Automatic Passenger Counter (APC) are used to evaluate bus running time variation for Tri Met (Portland Transit system)	Analysis of trip level data	If recovery times or operator-related variation can be reduced, schedule efficiency will be more cost effective.
Ji et al., 2014	Determine how bus driver’s schedule adherence effects transit reliability	Automatic Vehicle Location (AVL) data and bus driver’s responses to real time schedule adherence	Late and early busses with respect to their scheduled times can be controlled through dwell time and other

			factors within the bus driver's control.
Parker et al., 2021	Determine how United States Transit riders' mobility has been affected by the pandemic compared to non-transit riders	Survey and passive behavioral analysis	Transit riders reduced their travel by about 50% more than non-riders.
McHugh et al., 2017	Determine if electronic fare surveys are more effective than paper surveys	Sampling and Data Analysis were used	Riders prefer them and they cost 32% less to implement.
Diab et al., 2020	What are the determinants of bus ridership at the route level from 2012 to 2017 in Montreal	Panel data at the local level	Increasing weekday trips by 10% will increase annual ridership by 8.60%.
Berrebi et al., 2020	Give clues as to why ridership has declined from 2012 to 2018 in four US cities?	Panel data at the stop level	Socio-demographic groups associated with least bus ridership are responsible for the most ridership decline over time.
Brakewood et al., 2015	To what extent does real time information impact bus ridership in New York City?	Panel Regression (Route Level)	Median Increase of 1.7% of weekday route-level ridership (2012-2015).
Kerkman et al., 2015	Determine what factors influence ridership in the Arnhem-Nijmegen region in the Netherlands the most from March 2012 to March 2013.	Panel data at the stop level	Land use and sociodemographic information along with level of transit supply at the specific bus stop affect ridership the most.
Frei et al., 2013	Estimate disaggregate ridership elasticity for Chicago Transit network	Panel data at the stop level	Aggregate analyses overestimate the effect of service frequency on demand. Walking quality results in increased ridership.
Tang et al., 2012	To what extent does bus information system effect ridership for the	Panel data from the route level	Real time bus information does help increase bus

	Chicago Transit Authority (CTA)		ridership, although results are modest.
Aston et al., 2020	What effect does the Built Environment (BE) of surrounding train, tram, and bus use in Melbourne, have on ridership?	Cross sectional data	Specifically for busses, job housing balance and presence of Activity Centers, commercial density are predictors of ridership.
Mucci et al., 2018	Can Transit Direct Ridership Models (DRM's) forecast medium-term ridership changes?	Cross sectional data of Bus and rail system in San Francisco from 2009 to 2016.	Rail model correctly predicated the direction of change but was a third of the magnitude. And the bus model predicted the wrong direction of change and was about 15% off from true magnitude.
Ma et al., 2018	How effective is a Geographically and Temporally weighted Regression model (GTWR) of exploring the effect of the built environment of transit ridership	Cross section data since built environment doesn't change that much over a month time span	GTWR's are much more successful than traditional GWR's because they give a time component to the model.
Aston et al., 2016	Is there significant observable variation between transit modes of transit orientation of the built environment?	Cross Sectional Data (Doesn't deal with ridership, may not be very helpful to us)	When planning Transit-Oriented Development, it is important to consider what mode of transit is being implemented.
Chakour et al., 2016	What effect does the built environment and stop level infrastructure have on bus ridership in Montreal?	Stop level cross sectional data	Transit Facilities and parks have a positive effect on ridership, while the presence of highways has a negative effect. Most effective way to increase ridership is to increase service and accessibility,

			whereas changes in land use produce small changes in ridership (pg. 216, P5).
Hu et al., 2016	To what extent does land use affect public transportation ridership	Cross sectional data	More specific <i>amenity structures</i> are better predictors in ridership than more general land use type.
Chakrabarti et al., 2015	How much does service reliability increase transit patronage?	Cross sectional data	Reliability investments should be the top priority for transit agencies because it effects ridership the most.
Wu et al., 2019	What effect does public transportation have on sustainability in the context of growing cities?	Cross sectional data from 48 metropolitan areas	Locations with high transit accessibility consistently have more riders and higher residential density. This study recommends investing in existing transit infrastructure instead of starting a brand-new system.
Dill et al., 2013	How does transit service characteristics and urban form affect Transit ridership	Cross sectional data at the stop level using three metropolitan areas in Oregon	Transit level of service is the most important factor in determining ridership at the stop level, but built environment around a stop is also important.
Pulugurtha et al., 2012	How effective are spatial modeling methods at estimating Bus ridership?	Cross sectional data	0.25-mile proximity to a bus stop does a much better job at modeling ridership than longer walking distances from a stop.
Gutiérrez et al., 2011	How effective is distance-decay weighted regression at	Station level cross sectional data	This model does not replace a traditional four-step model

	forecasting ridership at the station level?		however, it is useful for agencies with limited time or budgets with which to work with.
Ryan et al., 2009	How does the quality of the pedestrian environment around the bus stop effect ridership	Cross Sectional Data	Walkability index is a good tool for predicting transit ridership.
Estupinan et al., 2008	What is the relationship between urban form and transit demand?	Cross Sectional Data	Built Environment is most successful in increasing transit ridership when it supports walking and disincentivizes car use.
Sun et al., 2016	How to estimate transit ridership from spatial analysis and precise land use data	Cross Sectional data	Traditional four-step demand model is expensive and not very accurate at predicting ridership. Activity-based model is better, but Direct Ridership Models (DRM's) are the best.
Kimpel et al., 2007	How to use GIS to measure the effect of overlapping service areas on transit demand. (Overlapping service areas are those where two stops are less than 0.25-miles away from each other and are thus competing for each other's service.)	Cross sectional data at the stop level	A distance decay function was used to compute an accessibility to account for overlapping bus stop service areas.
Peng et al.,1997	How to estimate ridership based on supply, demand, and inter-route relationship	Route level cross sectional data	Service improvements will increase boarding rides but also may reduce boarding rides on competing routes, so the net increase in ridership

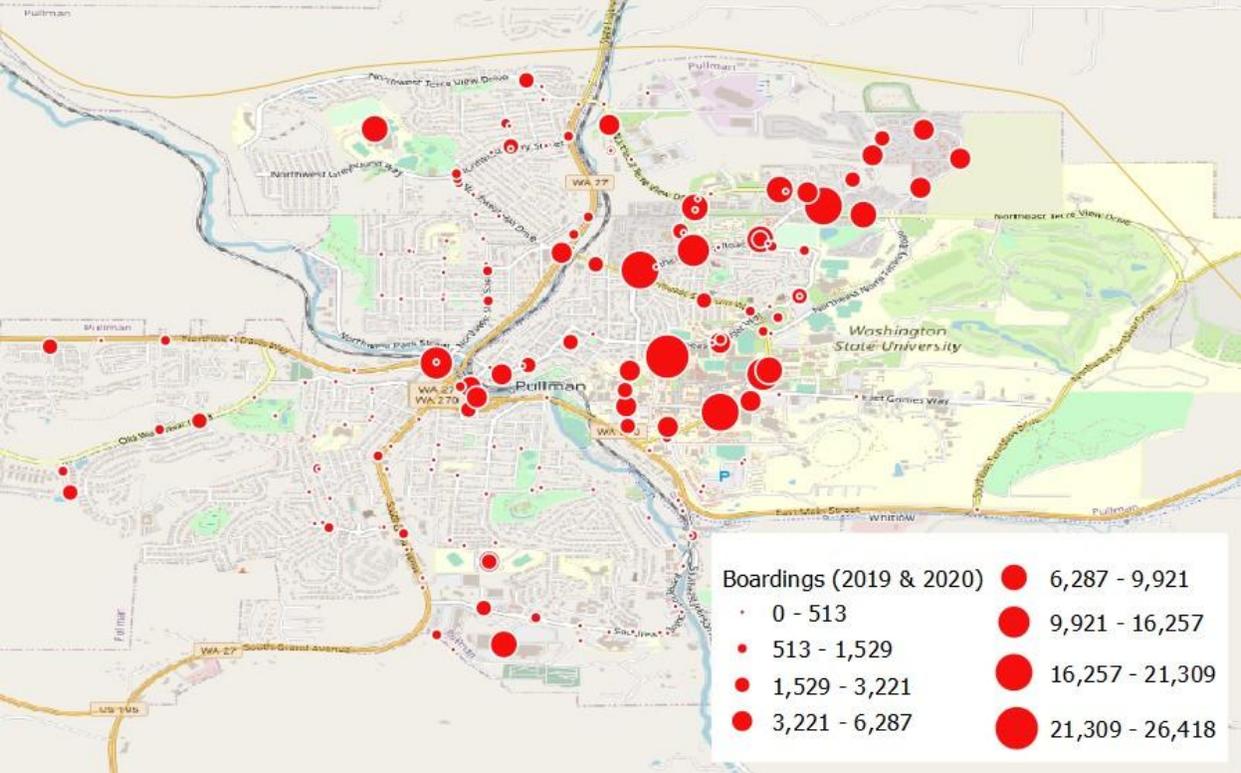
			may be smaller than anticipated.
Lee et al., 2019	How bus revenue vehicle-kilometers effect bus ridership	System wide panel data	Bus revenue service vehicle-kilometers denotes the supply of the transit system.
Woo et al., 2020	How does price affect ridership across the entire system in Hong Kong?	System wide panel data	-0.24 elasticity for the bus.
Ko et al., 2019	What determines Bus rapid transit ridership at the system level?	System wide panel data	For BRT, real-time information systems can boost ridership by 47%.
Ederer et al., 2019	How to compare transit data between transit agencies using cluster analysis	System wide panel data	Categorizing transit agencies into groups and comparing agencies within the same group is more effective than comparing a single agency to the national average.
Graehler et al., 2019	Why is ridership falling over the past ten years?		While VRM is an important determinant of transit ridership, it is insufficient to explain the sharp decline from 2015 to 2018.
Hall et al., 2018	Is Uber a substitute for public transit?		Uber and other rider sharing services act like small transit agencies in big cities. It is more financially exclusive, so it draws away wealthier riders from the bus. This research suggests that Uber helps small transit systems and hurts larger ones

Driscoll et al., 2018	The effect of demographic changes on transit ridership trends		The population is aging, so tailor service to meet their needs
Boisjoly et al., 2018	Why is ridership down in North America?		Invest in bus service to mitigate decline in public transit ridership. Reduction in VRK is likely the main reason ridership is down in the US.

CHAPTER 3. DATA

Pullman, Washington is a city most known for Washington State University, with approximately 30,000 students enrolled. In addition, there is also Schweitzer Engineering Laboratories based in Pullman that provides many manufacturing jobs. Pullman Transit is the leading rural transit system Washington providing approximately 1.4 million rides annually. Approximately 80% of all transit riders are students, faculty, or staff. The city of Pullman works with WSU transportation services to provide efficient and safe transit service to get people to where they need to go year-round.

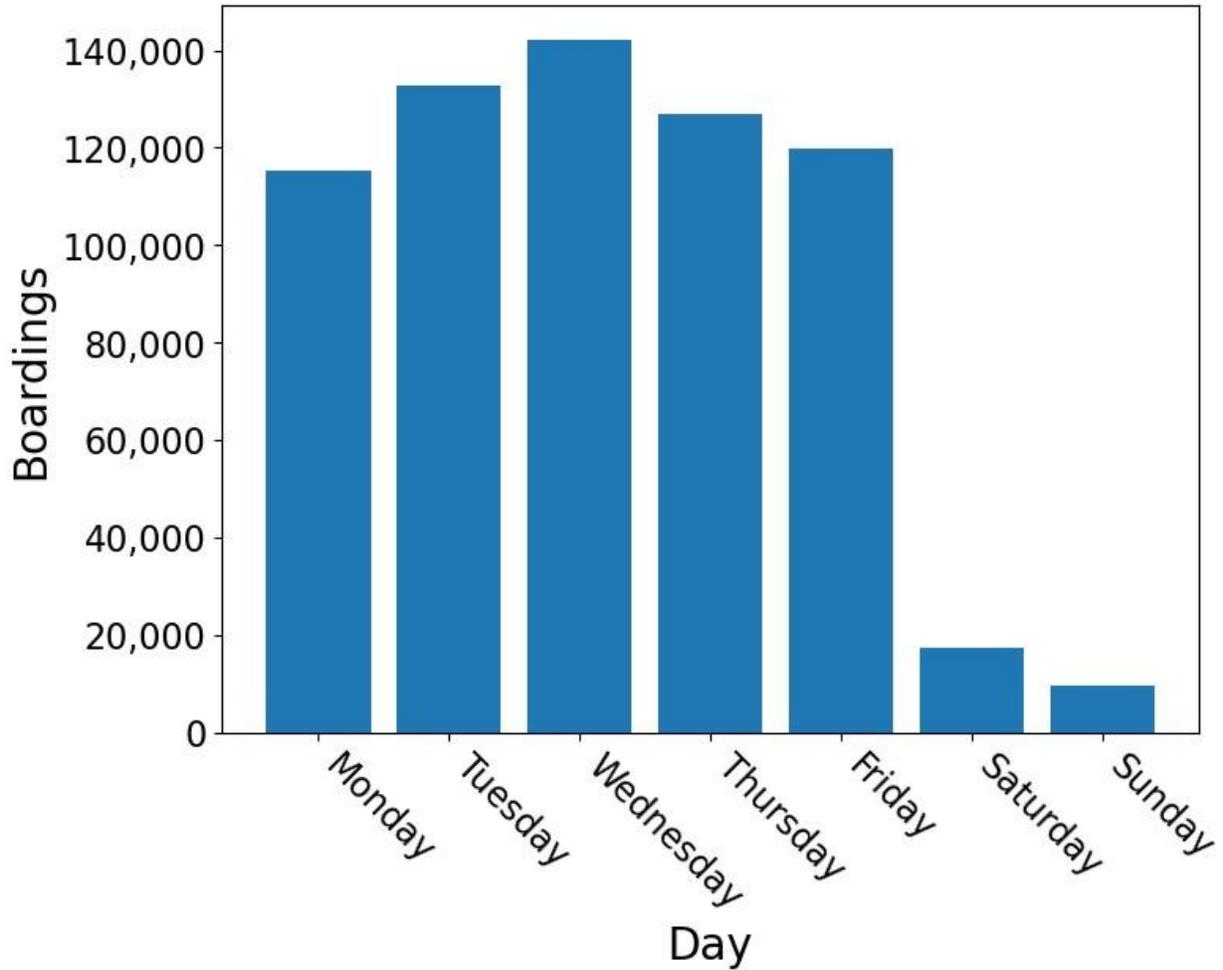
Figure 3.1 Pullman Transit Boardings (2019 & 2020)



Because most of the people living in Pullman have school or work in session during a typical work week (Monday – Friday), that’s when there is most demand for public transit (Figure 3.1). There are currently

8 normal routes and 2 express routes that serve the city of Pullman Monday through Friday, with Lentil and Wheat Bus routes offering limited service on the weekends. Throughout the year, Pullman transit adjusts to the demand for busses by adding limited routes and hours of service to save on cost when there is less demand (when school is not in session or during holidays).

Figure 3.2 Daily Boardings



The two express routes (Crimson Express and Gray Express) have the primary task of getting commuters to and from campus during the morning and afternoon hours when transit demand is greatest. These routes serve many residential areas on the north side of Pullman where it is inconvenient to walk to campus.

Figure 3.3 Hourly Boardings

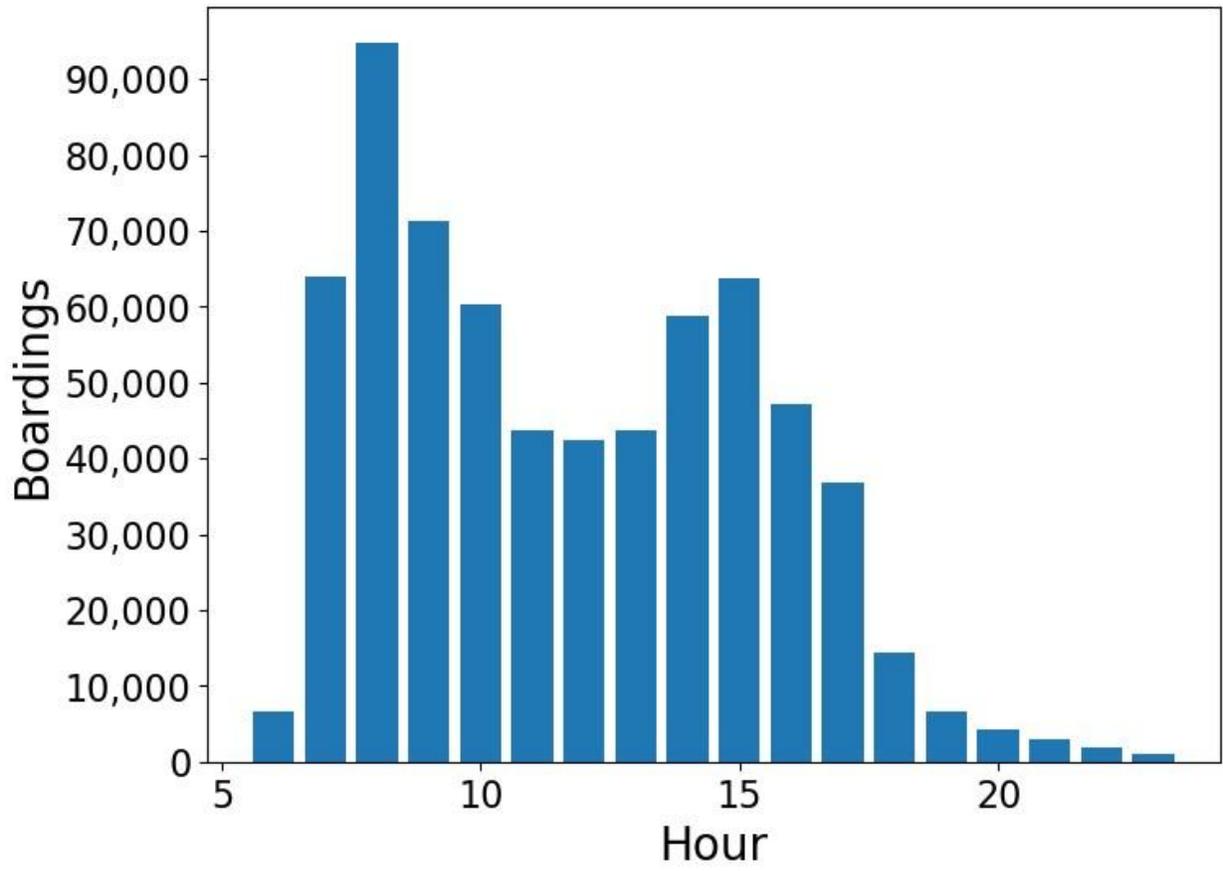
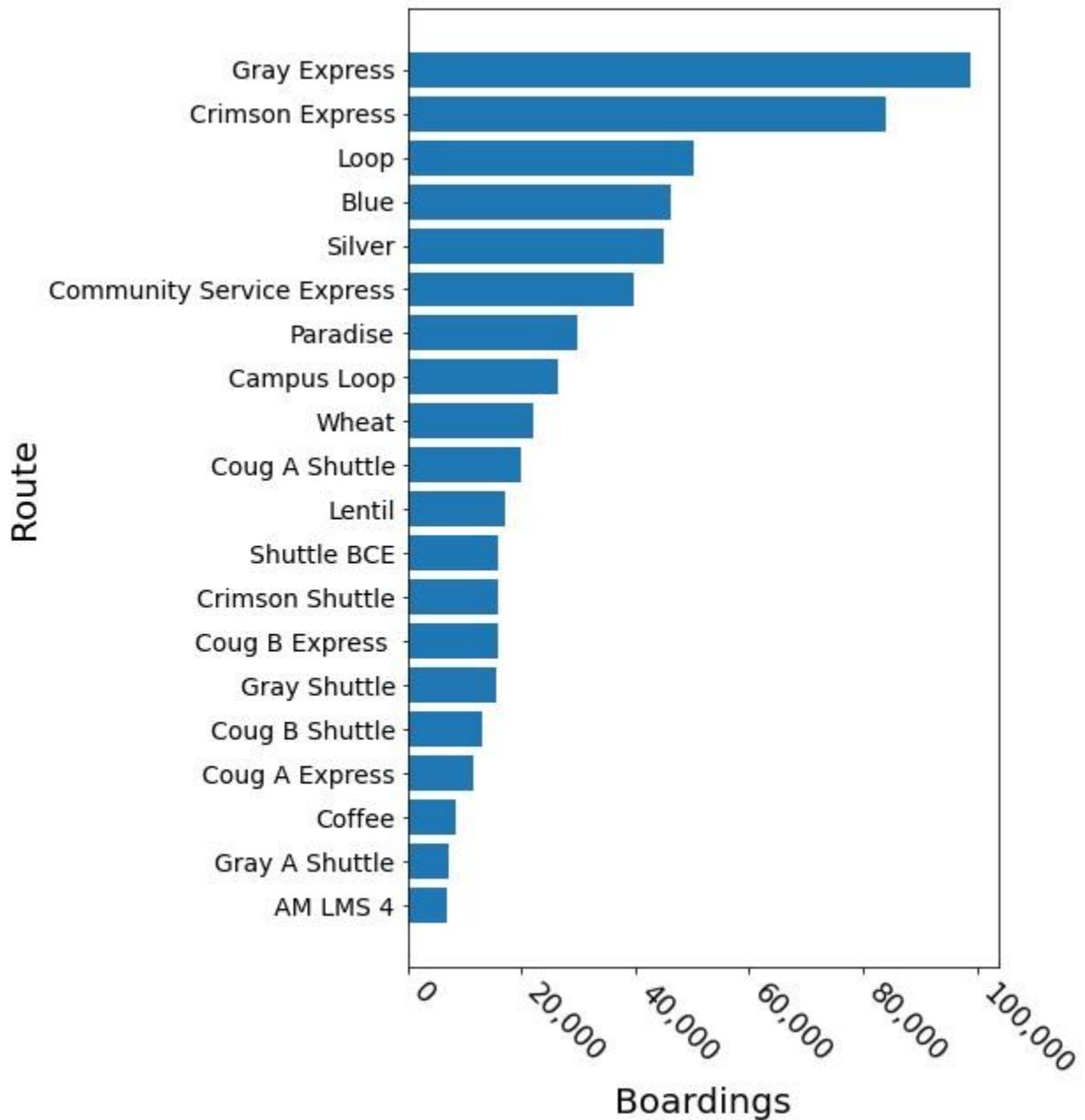


Figure 3.4 Total Boardings by Route (2019-2022)

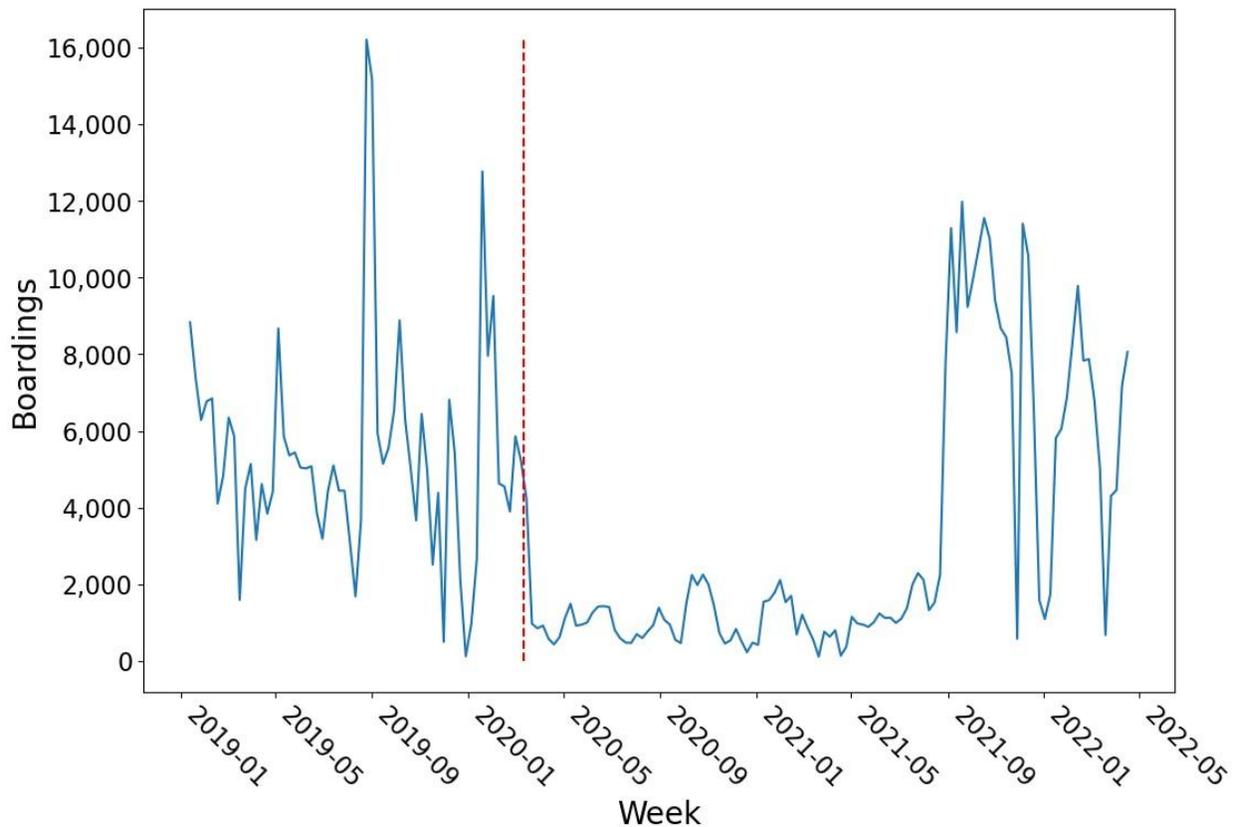


Historically, these routes have been overwhelmed by the number of riders during these peak hours and have had to skip patrons waiting at stops because the express busses on these routes were already at capacity. Due to cost constraints, Pullman transit cannot simply add more busses to fulfill this demand, so a re-route of the two express routes was implemented starting August 19th, 2021. These re-routes cut much of the express busses distance with the goal of increasing frequency for riders. Prior to the re-route, the express busses ran through campus, but now after the re-route, they only briefly stop at the north side of campus (near Beasley Coliseum) and head back north towards the residential areas. The

goal is that commuters get to campus quicker, and then they can simply walk the rest of their journey once they get to campus.

The objective of this research is to evaluate the efficacy of the rerouting in alleviating/meeting demand during peak hours. Evaluation will include an analysis of Pullman Transit ridership data to determine if ridership increases after the rerouting of the express busses. One complication to this analysis is that the rerouting coincided with the Covid-19 pandemic. To control for the impacts of the pandemic on ridership, other non-express route stops will be used for comparison.

Figure 3.5 Weekly Boardings



CHAPTER 4. ANALYSIS AND RESULTS

A regression model is used to estimate the re-routing of express routes on ridership. To estimate the impacts of re-routing on ridership, other impacts, such as the Covid-19 pandemic must be addressed. To account for other impacts, a difference-in-difference model is used. This difference-in-difference model compares the change in ridership on express routes compared to the change in ridership on non-express routes, after re-routing. Under this model, time-variant impacts, such as Covid-19 are controlled for, so long as these time-variant impacts do not also vary across routes. This difference-in-difference model is given by the following linear regression equation:

$$Y_{srt} = B_0 + B_1 \text{Express}_r + B_2 \text{Treatment}_r + B_3 \text{Express}_r \text{Treatment}_t + e_{srt}$$

where Y_{srt} represents the number of boardings at stop s on route r in time period t , $Express_r$ is an indicator that equals 1 if the route is an express route and zero otherwise, $Treatment_t$ is an indicator that equals 1 if the time period is after re-routing (August 19th, 2021) and zero otherwise, and e_{srt} is a normally distributed error term.

Under this regression B_1 will measure the difference in boardings on express routes, compared to all non-express routes, and B_2 will measure the difference in boardings in the treatment period, compared to the pre-treatment period. Our coefficient of interest in this regression is B_3 , which will measure the difference in boardings on express routes before and after treatment (re-routing), compared to the difference in boarding on non-express routes before and after treatment. This is the causal impact of re-routing express routes on boardings on express routes.

The level of observation for analysis is hourly boardings at the stop, route, date level. Results show that on average hourly boardings are 0.58 (75%) higher on Express routes compared to non-express routes, and increased in the treatment period by 0.22 (29%). The impact of re-routing on express routes is estimated to 1.24, representing an 161% increase in express route ridership. Importantly, this increase in boarding does not seem to be a substitution away from non-express routes, as boardings increased (29%) for non-express routes after re-routing as well.

Table 2 Results

Model:		OLS		Adj. R-squared:		0.018	
Dependent Variable:		Boardings		AIC:	4,454,148		
No. Observations:		862,282		BIC:	4,454,195		
Df Model:		3		Log-Likelihood:	-2.23E+06		
Df Residuals:		862,278		F-statistic:	5214		
R-squared:		0.018		Prob (F-statistic):	0		
	Coef.	Std.Err.	t	P> t 	[0.025	0.975]	
Intercept	0.583	0.004	136.712	0.000	0.575	0.592	
Express	0.578	0.013	45.761	0.000	0.553	0.603	
Treatment	0.224	0.009	26.298	0.000	0.207	0.240	
Express*Treatment	1.242	0.022	56.298	0.000	1.199	1.286	

CHAPTER 5. CONCLUSIONS

The re-routing of express routes appears to be successful in increasing Pullman Transit ridership on express routes, without sacrificing ridership on alternative routes. Further investigation is needed to identify the determinants of this increase in ridership, but the increased frequency and decreased transit time are likely to be primary drivers. Further investigation is also needed to evaluate if this increased ridership is persistent.

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