LABOR MARKET EFFECTS OF LIGHT RAIL TRANSIT: A CASE STUDY OF PORTLAND'S ORANGE MAX LINE

by

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This thesis explores the relationship between transit development and job creation through a case study of the Orange MAX Line in Portland, OR. Opening on September 12, 2015, this transit investment introduced light rail transit to SE Portland and Milwaukie, OR. The City of Portland, the City of Milwaukie, and Metro sought to use the new MAX line as a means of initiating job growth in the surrounding neighborhoods. The City of Portland introduce this ideology as employment-transit-oriented development (E-TOD). This thesis examines whether the local authorities were successful in achieving their goal of job creation through a difference-in-difference econometric regressions and descriptive spatial analysis. The findings of this study were insignificant and inconclusive, as no clear effect of the transit investment on employment growth was identified. There appears to be limited evidence to suggest that there was substantial job creation in the surrounding areas of the new MAX stations compared to the control area. Using these results, this study highlights the discrepancy between the identified goals and the observed outcomes. These findings provide insight into the effectiveness of an E-TOD strategy and add to the existing literature on the relationship between labor markets and transit-oriented development.

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Introduction

Introduction

The City of Portland, the City of Milwaukie, and Metro, Portland's regional government authority, invested $1.49 billion to construct a new MAX light rail transit (LRT) line between downtown Portland and downtown Milwaukie. On September 12, 2015, Portland's TriMet unveiled the Orange MAX Line and the new Tilikum Crossing Bridge. The Portland-Milwaukie Transit Project connected SE Portland and Milwaukie, OR to the Portland State University, the Portland transit corridor, and Portland City Center. This investment in Portland's urban environment exemplifies transit-oriented development (TOD). TOD is a sustainable development strategy which aims to reduce car-dependency, reorient community structure around multi-modal transportation options, and increase mobility and access for citizens. TOD has become a popular urban planning tool which Metro, the City of Portland, and the City of Milwaukie have attempted to capitalize on to meet their development goals. The strategy is believed to have many benefits, including increased transit ridership, neighborhood revitalization, increased supplies of affordable housing, and economic returns to local landowners and businesses (Federal Transit Administration 2020).

The local authorities made explicit claims that this TOD investment would further the region's development and strengthen the local workforce. This thesis evaluates how effective Portland Metro was in meeting their stated development goals. Further, this thesis investigates how TOD impacts local labor markets. I use econometric regression and descriptive spatial analysis. Specifically, I examine changes in employment levels in Census blocks near the new transit stations before and after the line's opening, as well as differences in employment across demographics, job types, and income-levels using a difference-in-difference econometric model. Additionally, I use GIS to explore neighborhood land use change before and after the opening of the MAX line. My research analyzes whether this policy could be deemed successful and adds to our overall understanding of the comprehensive effects of TOD on local communities, particularly the impact on job creation.

Research Questions

- How did the opening of the Orange MAX Line impact the employment levels in SE Portland/Milwaukie?
- How was this impact distributed across income level, socioeconomic demographics, and job types?
- Did the surrounding areas experience TOD-inspired land-use change concurrently with the rail opening?

Literature Review

Transit-Oriented Development (TOD) and Measuring its Effect

Transit-oriented development (TOD) is an urban development strategy which concentrates a wide mix of development (residential, commercial, office, etc.) around a transit station (Federal Transit Administration 2019). TOD "builds spaces near transit where people can live, work and play" (TriMet 2021). The strategy typically results in vibrant, walkable neighborhoods with a variety of housing options and amenities. TOD typically results in a neighborhood with a range of transportation options, including pedestrian- and bicycle-friendly spaces. The main goals of TOD are to reduce vehicle miles traveled, increase public transit ridership, and promote livable neighborhoods. In theory, TOD should reduce the cost of transit, increase the accessibility to firms, and become a catalyst for economic activity. The existing literature on TOD primarily focus their analysis on the property value effects of rail transit investments.

In general, empirical studies of LRT investments in cities have found mixed results. Billings (2011) conducts a case study on Charlotte, North Carolina. The researchers utilize a difference-in-difference approach and construct a hedonic property value model to estimate the effect of new LRT lines. They find a 4% increase in single-family property prices and 11.3% increases in condominiums sold within one mile of the stations (Billings 2011). Ning (2020) supports this positive, significant conclusion in their case study of Portland, Oregon. Ning (2020) implements a similar approach to Billings (2011) and finds that TOD does have a significant and positive impact on single family residential properties located within 1 mile of a station.

However, not all the results on LRT and property values have been significant and positive. Wagner et al. (2017) examines the effect of light rail transit in Hampton Roads, Virginia. They implement a similar approach to Billings (2011) and Ning (2020), but their findings show significant, "negative consequences from the constructed light rail line" (Wagner et al. 2017, pg. 25). The researchers attribute these negative effects to the size of Hampton Roads. They state that "the connectivity of the rail transit lines in [larger metropolitan areas] provide arguably greater accessibility benefits to homeowners living near stations" (pg. 36). This study adds nuance to the discussion on LRT by examining the impact in smaller urban contexts.

Still, results exhibiting a positive increase in housing prices could indicate adverse effects in neighborhoods. Research shows that TOD could lead to or advance neighborhood change or gentrification processes among lower-income neighborhoods (Nilsson & Delmelle 2018). The impacts of transit policy on property values depends on the conditions of neighborhoods and the related economic development policies of the area.

Labor Market Examination of TOD

There is still substantial scholarship on the labor market effects of LRT investments in U.S. cities, despite property value being the primary target for TOD research. Employment levels and accessibility to jobs have been the main emphasis of this branch of research. Similar to property values, the findings on the effect of LRT on employment levels has been mixed. Canales et al. (2019) conducts a case study of Charlotte, North Carolina to examine employment opportunities in nearby neighborhoods (census blocks within ¼ of a mile of station) after the construction of a new transit corridor. The researchers implement a differences-in-differences approach and find that there were not increases in employment in the surrounding neighborhoods compared to those without LRT stations. Tyndall (2021) contrasts the findings from Canales et al. (2019) with his exploration of four U.S. metropolitan areas. The researcher examines Salt Lake City, Seattle, Minneapolis, and Portland using a general regression approach. Tyndall (2021) finds that there is significant improvement in the neighborhood level employment outcomes, but a negative impact on aggregate metropolitan employment. Kim et al. (2021) use propensity score matching across 12 metropolitan areas in the United States. The researchers find significant positive results that the introduction of an LRT station increases labor force participation.

Fan et al. (2012) provide compelling results on labor market accessibility and the introduction of LRT. The researchers conduct a case study of Minneapolis and St. Paul, Minnesota, and the implementation of the Hiawatha light-rail line. The researchers explore jobs of varying income levels (low-, medium-, and high-wage) and construct a weighted average accessibility index. Then, they conduct geospatial and regression analysis across each income level of jobs. Fan et al. (2012) find large, significant increases in accessibility to all workers, from low-, medium-, and high-wage jobs.

Santra (2022) explores a similar research question to my thesis project in their study. The author assesses the impact of Portland's Green MAX Line on employment growth in the short-term (5 years) and the long-term (10 years). Specifically, Santra (2022) examines job growth in retail, knowledge, and service sectors. They also refine their analysis to TOD centers (Clackamas Town Centers and Lents Town Center). The study finds that new LRT service line contributed to employment growth in the short-term near Clackamas Town Center. Santra (2022) offers compelling insight into Portland's LRT and the effectiveness of TOD.

The various studies on the labor market effects of LRT provide a mixed bag of results. There is not one overarching method that researchers implement to study these questions. There is not one clear answer that researchers receive through their analysis. Primarily, researchers employ a difference-in-difference approach. I follow this lead and implement a similar approach in this thesis.

Endogeneity Concerns

Endogeneity is one of the biggest limitations when studying the causal relationship of transit investments. All researchers, whether studying labor, property values, or land-use change, must address this concern in some capacity. Endogeneity refers to the situation where the independent variable is correlated with unobserved factors that affect both the treatment and the dependent variable. This interaction is a barrier to establishing a causal relationship because unobserved variables can bias our results. Since the implementation of LRT is a non-random occurrence, but instead is often specifically targeted to areas with high growth prospects even without light rail, the measured effect of LRT could be overestimated in our analysis. The location of LRT stations is possibly chosen for the neighborhood's high employment density (Canales et al. 2019) or for the neighborhood's desirability or appreciation rates (Billings 2011). The nature of station locations leads to biases in econometric research. Therefore, it is critical to compare the methods that existing research has done to address this issue and isolate the effect of LRT.

There are two common approaches to addressing endogeneity in transit policy research. The first includes the use of instrumental variables. Tyndall (2021) uses the airport corridor as an instrumental variable to address endogeneity in his study. They argue that "[census] tracts treated by LRT *by virtue* of their location relative to the airport can be assumed to have local economic trends that are orthogonal to the mechanism assigning treatment status" (Tyndall 2021, pg. 4). Fan et al. (2012) use three control variables in their regression analysis of job accessibility in Minneapolis. Their variables include pre-LRT job accessibility, distance to nearest transit stop, and hi-frequency bus lines.

The second most common approach is the use of a control group. In this approach, researchers examine the trends in labor market activity by the treatment group (where LRT was implemented) and a control group. Billings (2011) and Canales et al. (2019) implement this approach using neighborhoods along another LRT station and a proposed transit station in their TOD analysis. Santra (2022) constructs their control group from an exterior ring of their treatment area. For my study, I employ a methodology similar to the latter approach.

Portland Context

Portland's regional government authority, Metro, has a history of embracing sustainable development concepts as a part of its growth strategy. In the 1970s, the authority introduced the region's first urban growth boundary (UGB). In the 1980s, Metro opened the first LRT MAX line in the metropolitan area. In the 1990s, Portland's transit agency TriMet expanded the MAX Line out to Hillsboro, beginning a TOD project. The Orenco Station community was completed in 2003 and is widely regarded as one of the most successful TOD projects in the United States. Today, sustainable development strategies are identified as priorities in the Metro's 2040 comprehensive plan. Portland's local planning and development context provides insight into the goals of this investment, the potential for success, and adds nuance to our understanding of the plan.

Figure 1: Orenco Station in Hillsboro, OR

The Orange MAX Line is a continuation of Metro's TOD goals. The TriMet project was first introduced as the "Portland-Milwaukie Light Rail Transit Project" and began to pick up steam in 2011. The initial goals of the project were to connect SE Portland to the downtown transit corridor, Portland State University, and establish local transit hubs in Milwaukie and SE Portland. The region projected regional growth by 2035, with an increase in population of 400,000 (TriMet 2016). Since the UGB limits the distance of urban sprawl, Metro addressed the projected growth with land within the boundary. This project hoped to accommodate population and job growth by strengthening Portland's exterior city of Milwaukie and improving the network of transportation services in the regional area.

In 2010, the City of Portland, through the Bureau of Planning and Sustainability, applied to Metro for a grant worth $485,000. The grant was applied for through the Construction Excise Tax program under the project name "Portland-Milwaukee LRT Project: E-TOD Plan." The proposal details the general goals of the project and describes how the grant money will be allocated towards the development of zoning and development strategies for the LRT plan. Moreover, the grant proposal presents a new "Employment Transit Oriented Development Strategy" for the project. The City of Portland reference the Portland Development Commission's Economic Development Strategy Five-Year Plan, which intends on employment growth in the city by 10,000 jobs. Employment transit-oriented development (E-TOD) is introduced as a new concept to meet this economic development goals and signals that the City of Portland prioritized job creation as an outcome of the LRT project.

The City of Portland argues in their grant proposal that LRT can be a method to meet the region's employment density goals. The E-TOD plan in this proposal seeks to support the local Economic Development Strategy by creating station area employment growth and establishing an employment base typology. The City of Portland describes the industrial core and the quantity of underutilized and vacant land surrounding proposed Orange Line stations as key reasons for this grant and this development plan. The grant proposal argues that the Orange Line provides a “unique opportunity to reinvigorate the neighborhoods within the grant request area” (City of Portland 2010, pg. 7). Typically, TOD projects focus station area planning on building mixed use residential communities. However, this E-TOD plan creates a new typology – one that focuses high employment development around the new transit stations. The City of Portland explains that the E-TOD plan will “optimize the positive impacts of LRT on these neighborhoods by identifying the regulatory and physical improvements needed to increase employment opportunities, reduce multi-modal transportation conflicts and improve public infrastructure within station neighborhoods” (City of Portland 2010, pg. 7).

Figure 2: Station Area Land Use Map (City of Portland 2010)

The land use map presented above displays the SE Portland station areas before the LRT investment was made. In 2010, the primary land use type surrounding the proposed stations was industrial. Residential neighborhoods were concentrated mainly between a quarter mile to half-mile of the station area. There were barely any multifamily residential and residential/commercial land uses within the half-mile zone.

Most commercial land use types in the area were "converted commercial," indicating a potential for transitioning land uses into commercial spaces. The grant proposal presents their intentions to "create vibrant station communities that complement industrial areas" (City of Portland 2010, pg. 6). The City explicitly states that they were going to alter zoning and regulatory standards to maximize the employment opportunity in the station areas and promote alternative forms of transportation as the preferred travel mode for the commuting workforce. The employment and land use goals of this LRT project are identified clearly in the grant proposal.

In 2013, the City of Milwaukie released a final Tacoma Station Area Plan to examine opportunities for redevelopment and investment surrounding the future Orange Line station (City of Milwaukie 2013). The plan presents the condition of the local area prior to the new MAX line and describes how the City of Milwaukie perceived the potential of this project. Since the document was prepared by the City of Milwaukie, the plan focuses on areas within their city borders.

The document describes the strengths and weaknesses of the surrounding area of the Tacoma Station and offers land use recommendations for achieving E-TOD. The strengths include their proximity to adjacent neighborhoods, like Selwood Moreland and downtown Milwaukie, for promoting retail shopping, access to amenities and opportunities, and the proximity to rail facilities (Union Pacific Railroad) as an asset for business. The weaknesses described were physical barriers to access the station area, like the rail line and McLoughlin Boulevard, competition from Downtown Milwaukie for attracting non-industrial businesses, and the level of noise disturbance from promoting residential development. Overall, the city identifies the surrounding station area as a potential hub for TOD and provides opportunities sites for development (and redevelopment) near the transit station.

The Tacoma Station Area Plan offers four sub-areas and two opportunity sites to focus land use change and redevelopment. These areas are located south of the station, within the Milwaukie city borders. The first opportunity zone is located on the Pendleton Woolen Mills property between the station and the Springwater Corridor trail. The second opportunity zone is owned by Oregon Department of Transportation between Stubb and Beta streets (see Figure 3 below). In 2013, the entire surrounding station area in Milwaukie was zoned for manufacturing, which allows “any combination of manufacturing, office and commercial uses as long as 25 percent of the total project involves an industrial use” (City of Milwaukie 2013, pg. 4). The plan suggests amendments to the M zone would improve the potential for this plan to achieve their employment density goals. Overall, Milwaukie sought to use the incoming LRT station as an employment base.

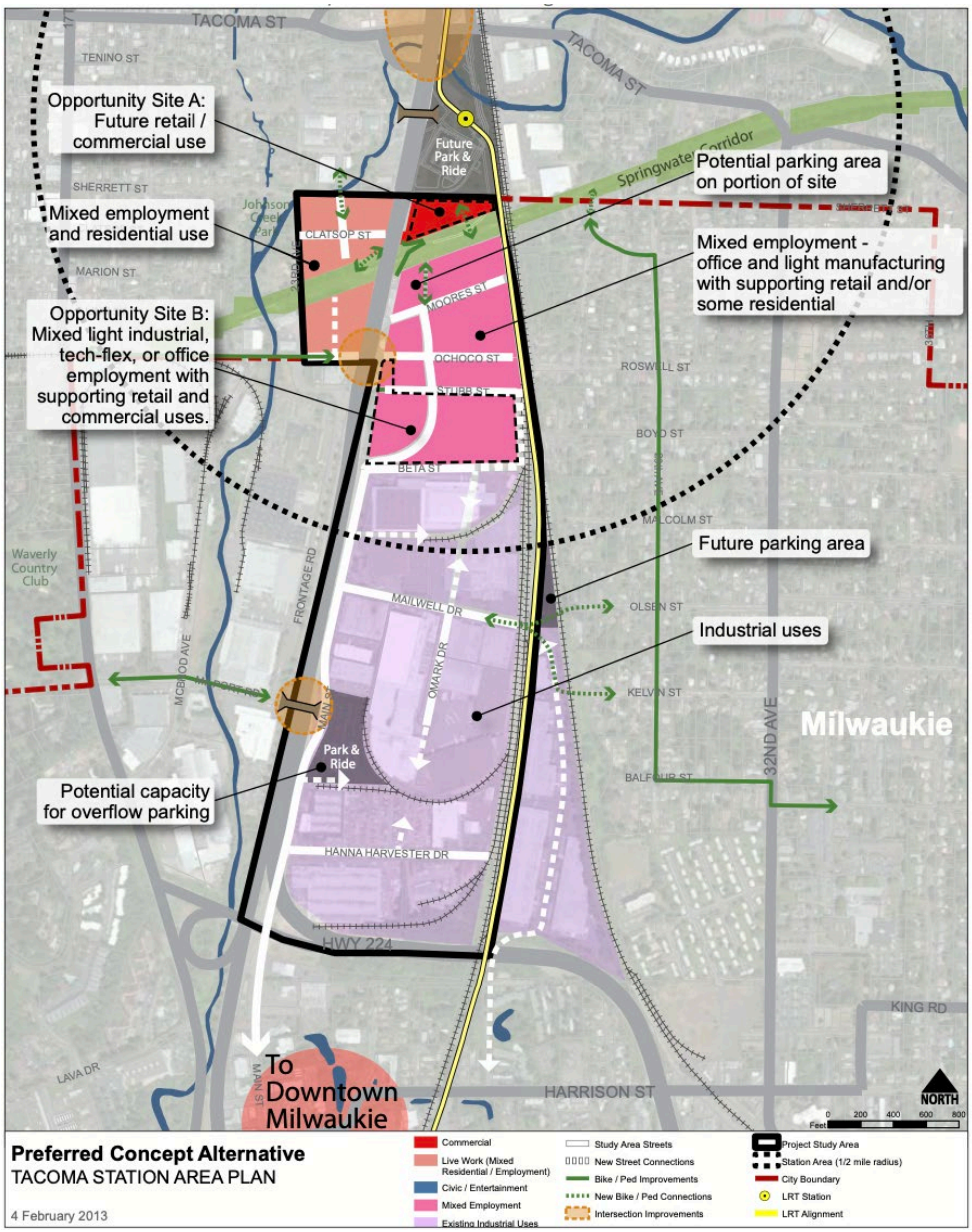

Figure 3: Tacoma Station Opportunity Zones (City of Milwaukie 2013)

More specifically, the plan promotes the E-TOD concept by including provisions for potential employment densities of 45 employees per acre within primary redevelopment station area. Subarea 3 and Opportunity Site B was envisioned for a mix of employment and higher employment densities than the existing land uses (see Figure 4 below). The preferred outcome for the station area included a mixture of redevelopment and new development to create a robust, complete employment zone. The area would include a public plaza space and bicycle/pedestrian path to establish a sense of place. The proposed scenario made sure to note that it would not change the existing alignment of the street structure, but rather create dense employment development and transit-supportive infrastructure.

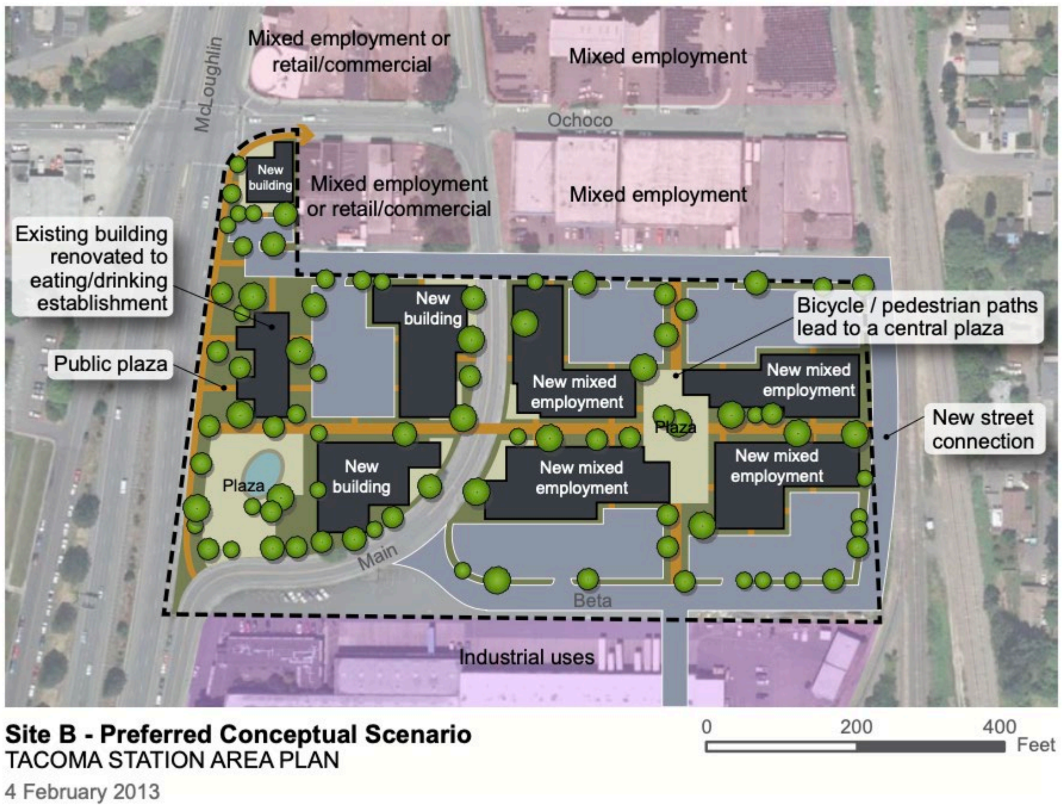

Figure 4: Tacoma Station Preferred Scenario Plan (City of Milwaukie 2013)

The City of Portland, the City of Milwaukie, and Metro all identified a desire for the Orange MAX Line to stimulate employment development. Moreover, the City of Portland created a new typology to describe benefits of transit development on local employment. The various plans, grant proposals, and the establishment of E-TOD highlight the focus of this project on creating positive labor market outcomes. The City made explicit claims that they would alter the zoning to promote the expansion of the workforce in the surrounding areas. In total, Metro invested nearly $1.8 billion into this project. Nearly half a million dollars in construction excise tax revenue was funneled into the planning and development strategy for increasing employment and meeting regional goals. Did Metro meet their E-TOD goals? This thesis attempts to evaluate how successful they were at achieving their plan. My research questions ask whether there was noticeable job growth or land use change in the surrounding areas of the new MAX stations. The answers to these questions will guide me to a greater conclusion about the success of Metro's E-TOD strategy.

Methodology

The methodology of this study is composed of two parts. First, I conduct an econometric regression analysis. Then, I conduct descriptive spatial analysis using ArcGIS. For my econometric regression methods, I use data from the Census Bureau and the Longitudinal Employer-Household Dynamics (LEHD). More specifically, I will be utilizing LEHD Origin-Destination Employment Statistics (LODES) Workforce Area Characteristics (WAC) data to compare the labor market in Portland before (2010-2015) and after (2016-2019) the opening of the Orange MAX Line in Portland, OR. My analysis will be conducted at the census block level, but some of my control variables could only be found at the census block group level. My descriptive spatial analysis uses City of Portland tax lot data from 2014 and 2019 and Metro's Regional Land Information System (RLIS) catalog of spatial data.

Statistical Methodology

My analysis uses a difference-in-difference approach, similar to that used in Canales et al (2019) and Santra (2022). I create a treatment area of census tracts that are ½ of a mile from the light rail line. To address the issue of endogeneity, I will use a buffer from ½ to 1 mile outside of the Orange MAX Line station as my control area. The multiple ring buffer analysis is common in existing transportation literature, including Santra (2022). Additionally, I restrict my analysis to Portland's eastside, where the introduction of light rail stations was new to the area. I remove Orange MAX stations which were preexisting with the other MAX lines.

Difference-in-differences (DiD) is a statistical method used to estimate the causal effect of a treatment or intervention. It is commonly used in social sciences and economics to evaluate policy interventions or changes in regulations. DiD compares changes over time in an outcome variable between a treatment group and a control group *before* and *after* the intervention. By comparing the difference in changes over time between the treatment and control groups, the DiD model can estimate the causal effect of the intervention, while accounting for other factors that might also influence the outcome.

The parallel trends assumption is a key feature of DiD approach. This assumes that in the absence of the intervention, the trend in the outcome would have been similar between the treatment and control groups. Endogeneity, as addressed in the literature review, is the most relevant limitation of this quasi-experimental methodology. Endogeneity refers to situation where the variable of interest (total jobs) is correlated with unobserved factors that affect both the area around the transit station and the outcome of job development. The presence of endogeneity makes it more difficult for researchers to make causal arguments about their study. Endogeneity is typically addressed by the use of control and treatment groups, and an inspection of the parallel trends assumption. By checking that the treatment and control group follow similar trends before the treatment, the parallel trends assumption helps to control for unobserved factors that may influence the outcome variable. Additionally, the use of control variables is another tactic to address potential endogeneity. If potential confounding variables are added to the DiD regression, the DiD effect can be isolated and a causal claim is more valid. In this study, I inspect the parallel trends assumption and add control variables to ensure that endogeneity is not present.

My DiD model to explore the effect of the Orange MAX Line on local employment is constructed as such:

$$\textbf{TotalJobs}_i = \beta_0 + \beta_1(\textbf{Treatment}_i) + \beta_2(\textbf{BeforeAfter}_i) + \beta_3(\textbf{Treatment}_i * \textbf{BeforeAfter}_i) + \beta_4 \textbf{X}_i + \epsilon_i$$

where:

- **Treatment**$_i$ represents the dummy variable indicator for being within the half-mile area buffer.
- **BeforeAfter**$_i$ represents the dummy variable indicator for years before or after the intervention (2010-2015 is before/2016-2019 is after)
- **Treatment**$_i$***BeforeAfter**$_i$ represents the average treatment effect.
- **X**$_i$ represents a vector of control variables, such as median age and ethnicity indicators by block as well as median income and education indicators by block group.

I conduct additional DiD regressions with specific sub-groups of the worker population. I explore the changes in the number of workers by three age brackets (under 30 years-old, between 30 and 55 years-old, and over 55 years-old); three income level brackets (under $1250/month, between $1250-$3333/month, over $3333/month); three job type indicators (Retail Jobs, Service Jobs, and Industrial Jobs); and race and ethnicity (Hispanic and Non-White Jobs). I identify retail jobs as jobs with the NAICS sector 44-45 code (retail trade). I identify service jobs as jobs with the NAICS sector code 72 (accommodation and food services) and code 81 (other services [except public administration]). I identify industrial jobs as jobs with NAICS sector code 31-33 (manufacturing), 42 (wholesale trade), and 48-49 (transportation and warehousing). I receive all job data from the Census LODES WAC dataset. I obtain my control variables from the 2010 Decennial Census and the 2013 American Community Survey 5-Year Estimates. In order to allow for a logarithmic regression, I add 1 job to every Census block for each subgroup. This is a common econometric practice which allows economists to estimate using logarithms when datasets have values of 0. Overall, the various regressions offer insight into the nuance of the relationship between transit presence and job growth.

Incorporating GIS

GIS is an important tool for constructing the study areas of my analysis. First, I upload the Census data onto ArcMap. Then, I select Census tracts within the buffer area of my treatment and control groups. I filter and extract this data from ArcMap to use for my regression analysis in R. The map below shows the treatment and control groups with the half-mile and mile buffer around the new Eastside MAX stations.

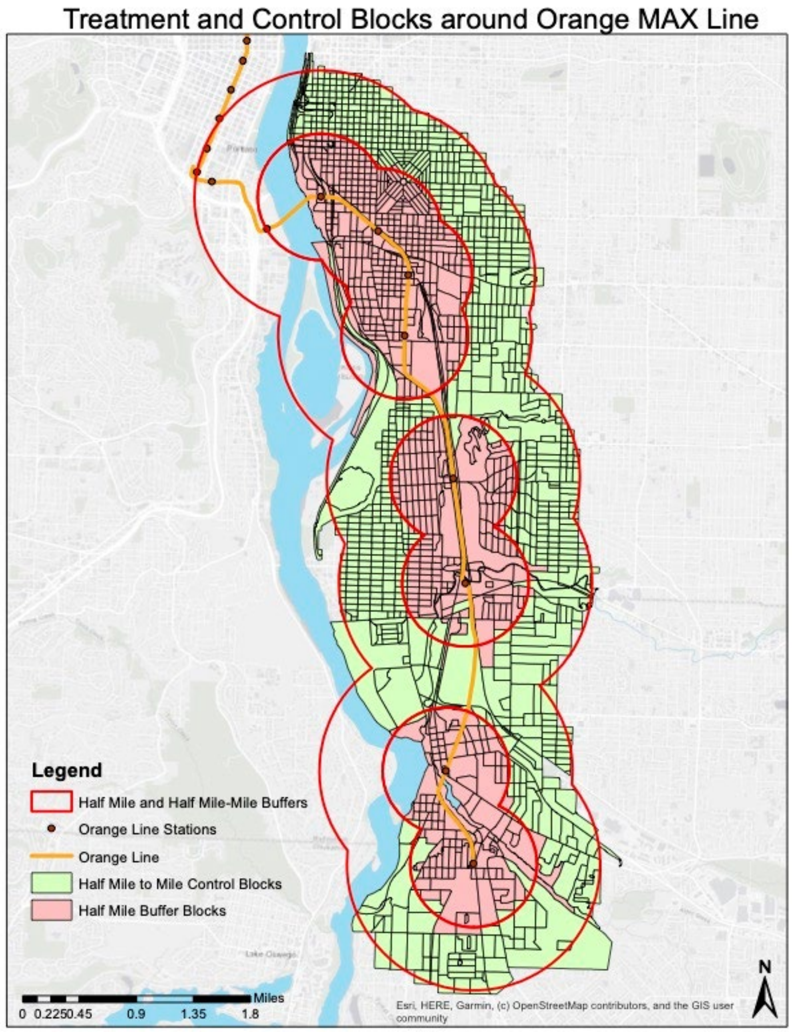

Figure 5: Map of Treatment and Control Blocks

I utilize Portland Metro Regional Land Information System (RLIS) tax lot datasets from 2010-2019 to explore changes in land use and development. I inspect the ½ buffer areas around the Orange Line stations to detect land use change and evaluate the effects of the project on development and redevelopment efforts. The goal of this spatial analysis is to detect whether the transit station promoted higher density, mixed-use development – a common indicator of TOD. Specifically, I examine the land use typology surrounding the Tacoma Street Station, SE Clinton St Station, SE Holgate St Station, and the Milwaukie Town Center Station from 2014 to 2019.

This spatial analysis is a visual assessment of the Orange Line's impact on land use composition and evaluates the success of the local authorities' plans.

Results

Descriptive Statistics

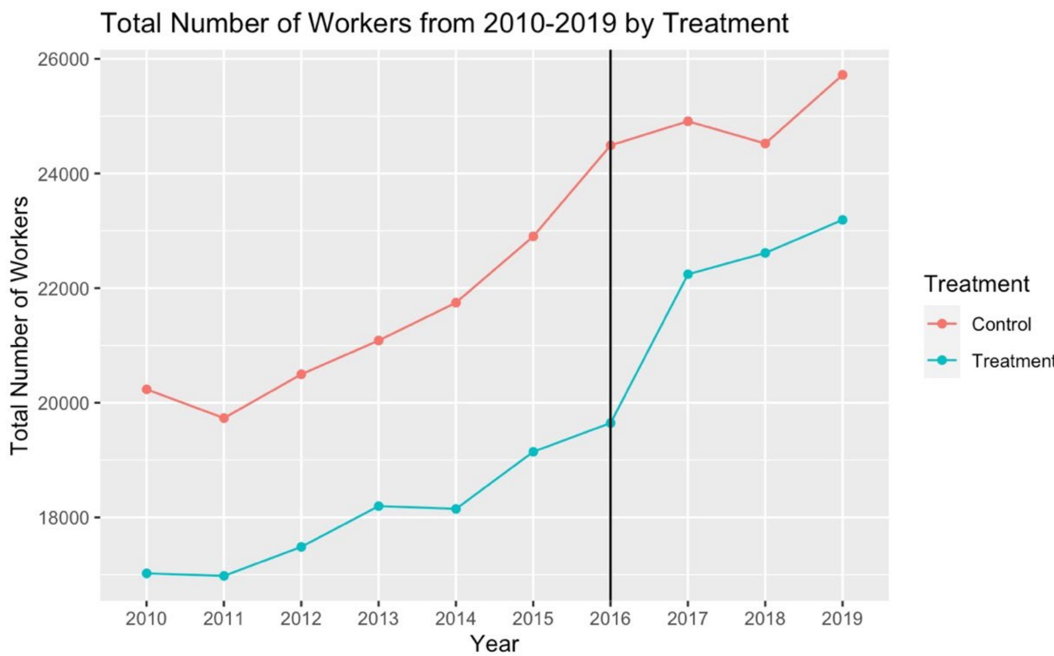

Figure 6: Total Jobs by Treatment

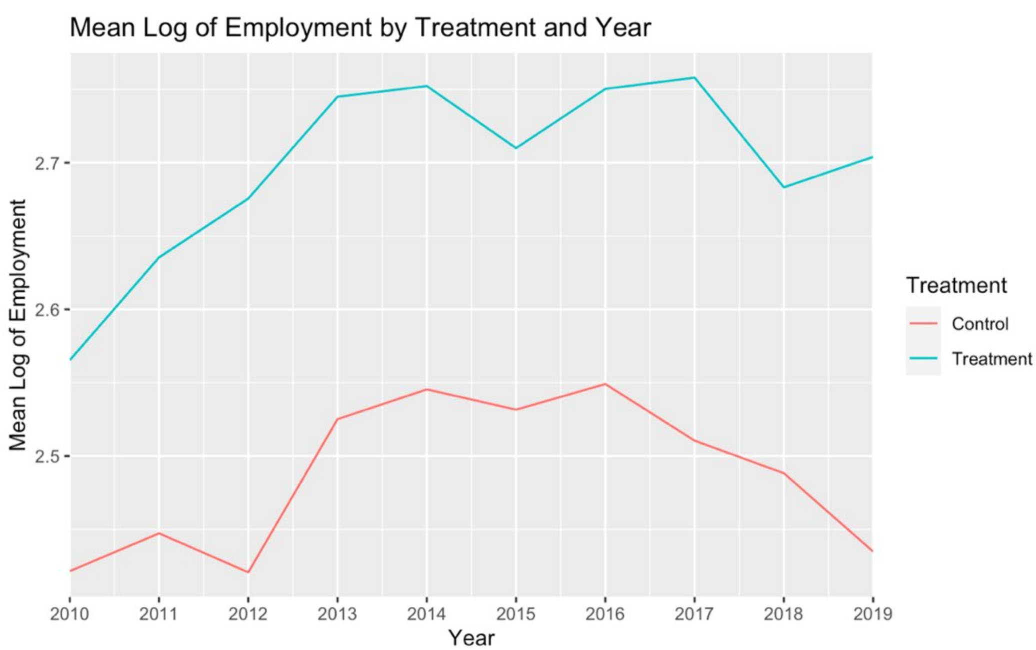

Figure 7: Mean Log of Jobs by Treatment

In general, there were less jobs within a half-mile radius of the new Orange MAX line stations compared to the control area buffer. It can be observed that each treatment group saw steady increases in the number of jobs leading up to the intervention year. The treatment area buffer has a higher mean log of employment overall compared to the control group. However, the mean log of jobs appears to have similar rise and falls across both treatment groups. These graphs are visual evidence that the parallel trends assumption is met and a DiD approach is fair. The two groups follow similar trends leading up to the intervention in both absolute and relative terms.

Year	Number of Blocks	Minimum Jobs	Median Jobs	Mean Jobs	Max Total	Sum of Total Jobs
2010	446	1	14	38.1704	697	17024
2011	403	1	14	42.134	690	16980
2012	414	1	14	42.23671	677	17486
2013	403	1	14	45.15385	988	18197
2014	403	1	15	45.03226	928	18148
2015	419	1	16	45.69212	854	19145
2016	420	1	15	46.77857	862	19647
2017	434	1	15	51.24654	1370	22241
2018	445	1	15	50.81798	1267	22614
2019	445	1	14	52.11236	1269	23190

Table 1: Treatment Area Descriptive Statistics by Year

The table above shows a variety of descriptive statistics of the treatment group by year. The overall count of total blocks in the treatment area ranged from 403 to 445 between 2010-2019. The variation is caused by lack of data reporting from the Census Bureau. The mean number of jobs per block in treatment groups increased from roughly 38 in 2010 to 52 in 2019. The median number of jobs per block in the treatment area remained between 14-16 jobs across all years. The minimum number of jobs in a block across all years was 1 worker while the maximum reached as high as 1269 workers in 2019. Thus, the range of workers per block was widely varied and indicates that this dataset is skewed positively.

Year	Number of Blocks	Minimum Jobs	Median Jobs	Mean Jobs	Max Total	Sum of Total Jobs
2010	521	1	12	38.83685	941	20234
2011	474	1	12	41.62869	1347	19732
2012	501	1	11	40.91218	1527	20497
2013	481	1	13	43.83784	1505	21086
2014	491	1	13	44.28921	1477	21746
2015	500	1	13	45.804	1618	22902
2016	530	1	12	46.20943	1634	24491
2017	549	1	12	45.37523	1637	24911
2018	546	1	12	44.91392	1566	24523
2019	565	1	11	45.52212	1610	25720

Table 2: Control Area Descriptive Statistics by Year

The table above describes the descriptive statistics of total jobs in the control area by year. Overall, there were more Census blocks in the control area than in the treatment area. The difference in number of Census blocks should not impact our results because each group has a large number of blocks and the DiD regressions are evaluated in logarithmic terms. The mean number of workers per block increases from roughly 38 to 45 jobs from 2010 to 2019, but the median job remains mostly constant around 11-12 jobs. The minimum number of jobs reported in a block was 1 worker and the maximum was as high as 1610 workers. Both datasets are skewed positively with incredibly high ranges.

Regression Analysis

	Dependent variable:
	log(C000)
TreatmentTreatment	0.197***
	(0.043)
Before_After	0.013
	(0.045)
DiD	0.031
	(0.067)
Constant	2.481***
	(0.029)
Observations	9,390
R2	0.004
Adjusted R2	0.004
Residual Std. Error	1.583 (df = 9386)
F Statistic	13.936*** (df = 3; 9386)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 3: Basic Difference-in-Difference Regression

The table above presents the results of basic regression of all jobs in the treatment and control blocks. The positive and statistically significant finding in the treatment variable indicates that being in the treatment blocks is associated with higher job growth. The DiD indicator reveals a small, positive increase for job growth (about 3 percent) attributed to the Orange MAX Line. However, the effect of the MAX line on employment levels was not statistically significant. Further, the large standard error for the DiD variable (.067) indicates that the effect of the intervention on job growth may not be substantial.

	Dependent variable:		
	log(Young)	log(Middle)	log(Old)
	(1)	(2)	(3)
TreatmentTreatment	0.065*	0.170***	0.128***
	(0.035)	(0.037)	(0.033)
Before_After	0.023	0.037	0.001
	(0.036)	(0.039)	(0.034)
DiD	0.047	0.007	0.060
	(0.054)	(0.058)	(0.050)
Constant	1.377***	2.151***	1.348***
	(0.024)	(0.025)	(0.022)
Observations	9,390	9,390	9,390
R2	0.001	0.004	0.004
Adjusted R2	0.001	0.004	0.004
Residual Std. Error (df = 9386)	1.285	1.377	1.197
F Statistic (df = 3; 9386)	4.472***	12.797***	13.545***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 4: Age Group Jobs Regression

The table above presents three DiD regressions for the various age group levels. The findings indicate that the treatment area had a strong, positive association with jobs among the older two age groups (30-55 and 55+ years old). There appears to be no association for any of the three age groups in regard to the years after the MAX line opened. Similar to prior regression, the intervention of MAX stations appears to have a small, positive effect across all three age groups. Still, there is no statistically significant effect on the DiD variable across all three sub-groups, thus the effect of the LRT intervention does not appear to be substantial.

	Dependent variable:		
	log(lowincome)	log(midincome)	log(highincome)
	(1)	(2)	(3)
TreatmentTreatment	0.002	0.094**	0.224***
	(0.034)	(0.037)	(0.038)
Before_After	-0.097***	-0.079**	0.251***
	(0.035)	(0.039)	(0.039)
DiD	0.032	0.058	-0.018
	(0.052)	(0.058)	(0.058)
Constant	1.506***	1.851***	1.523***
	(0.023)	(0.025)	(0.025)
Observations	9,390	9,390	9,390
R2	0.001	0.002	0.013
Adjusted R2	0.001	0.002	0.013
Residual Std. Error (df = 9386)	1.248	1.377	1.385
F Statistic (df = 3; 9386)	3.577**	7.216***	41.750***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 5: Income Group Jobs Regression

The table above presents three DiD regressions for the various income level groups. It can be observed that the treatment area had a positive association with jobs of the middle- and higher-income brackets ($1250/month+). Additionally, the time after the line opened had a negative association with the prevalence of low- and middle-income bracket jobs, but a positive association with higher income jobs. This finding could indicate that there may be a citywide trend towards higher paying jobs. The DiD variable indicates that there were small, positive increases in the rate of low- (3.2 percent) and middle-income jobs (5.8 percent) attributed to the MAX line and a small, negative effect in the rate of high-income jobs (-1.8 percent). Still, there were no statistically significant results, and the magnitude of the standard errors indicate that there may not be substantial evidence of any effect of the intervention on job growth across these specific subgroups.

	Dependent variable:		
	log(RetailJobs)	log(ServiceJobs)	log(IndustrialJobs)
	(1)	(2)	(3)
TreatmentTreatment	-0.107***	-0.133***	0.265***
	(0.028)	(0.035)	(0.036)
Before_After	-0.031	0.093**	-0.031
	(0.029)	(0.036)	(0.038)
DiD	0.045	-0.034	-0.028
	(0.044)	(0.054)	(0.056)
Constant	0.533***	0.926***	0.742***
	(0.019)	(0.024)	(0.024)
Observations	9,390	9,390	9,390
R2	0.002	0.004	0.009
Adjusted R2	0.002	0.004	0.009
Residual Std. Error (df = 9386)	1.042	1.294	1.334
F Statistic (df = 3; 9386)	5.950***	13.097***	28.953***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 6: Service, Retail, and Industrial Jobs Regression

The analysis of three job types is presented in the table above. It can be observed that there was a negative association within the treatment area for retail and service industries. Industrial jobs had a strong positive association with the treatment area. These findings are expected based upon the known characteristics of the area (see Portland Context section). There appears to be a positive association among the rate of service jobs in the time after the MAX Line opened. The DiD variable suggests that there was small growth among retail jobs (4.5 percent) and small decline among service and industrial jobs (3.4 percent and 2.8 percent, respectively) attributed to the MAX stations. Similar to all the prior regressions, the results present no substantial findings of an effect of the intervention on job growth.

	Dependent variable:	
	log(Hispanic)	log(NonWhite)
	(1)	(2)
TreatmentTreatment	0.076***	0.078***
	(0.026)	(0.030)
Before_After	0.144***	0.122***
	(0.027)	(0.031)
DiD	0.060	0.038
	(0.041)	(0.046)
Constant	0.722***	0.889***
	(0.018)	(0.020)
Observations	9,390	9,390
R2	0.010	0.006
Adjusted R2	0.010	0.005
Residual Std. Error (df = 9386)	0.972	1.093
F Statistic (df = 3; 9386)	32.216***	18.093***
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 7: Race and Ethnicity Worker Characteristics Regression

Lastly, race and ethnicity regressions appear in the table above. It can be observed that there is a significant positive association among non-white and Hispanic jobs being located within the treatment area. There is also a significant positive association between non-white and Hispanic jobs after the MAX was opened. These findings signal insight into the demographics of nearby area of the new transit, indicating a higher prevalence of diverse jobs compared to the control group. The DiD variable finds a moderate, positive increase in the rate of Hispanic (6 percent) and non-white job (3.8 percent) due to the new MAX line. Yet, I still do not find statistically significant evidence to conclude that the growth can be attributed to the introduction of the MAX Line.

Adding Control Variables to Analysis

Control variables are important to include to the DiD regression to address potential confounds and strengthens the ability to evaluate the effectiveness of an intervention. Controls account for important aspects of a labor market, like age, income, education, and ethnicity. The inclusion of these variables at the block and block group level helps me isolate the labor market effect of the MAX line. The vector of control variables included in my regression include median age, Hispanic population, median income, and the population of individuals with bachelor's degrees.

	Dependent variable:
	log(C000)
TreatmentTreatment	0.149***
	(0.040)
Before_After	0.057
	(0.041)
DiD	0.039
	(0.061)
Median_Age	-0.019***
	(0.001)
TotalHispanic	0.013***
	(0.003)
MedianIncome	-0.00001***
	(0.00000)
Bachelors	-0.0005***
	(0.0002)
Constant	3.850***
	(0.050)
Observations	9,390
R2	0.158
Adjusted R2	0.157
Residual Std. Error	1.457 (df = 9382)
F Statistic	250.658*** (df = 7; 9382)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 8: Basic Regression with Control Variables

The table above presents the basic regression of total jobs with the addition of the four control variables. There appears to be a significant association among the control variables and the rate of total jobs. Although, the magnitude of the relationship between total jobs and the controls for education and income appears to be close to zero. The median age seems to have a slightly negative relationship with job growth, indicating that older blocks experienced less growth than younger blocks. There appears to be a positive relationship between job growth and the Hispanic community, as blocks with more Hispanic population experienced greater job growth. In general, my variables from the basic regression do not change with the inclusion of controls. The association between the treatment area and the rate of total jobs remains significant and positive with the addition of control variables. Again, there is a positive but insignificant finding that the new LRT stations impacted job growth in the surrounding areas.

	Dependent variable:		
	log(Young) (1)	log(Middle) (2)	log(Old) (3)
TreatmentTreatment	0.033	0.127***	0.096***
	(0.028)	(0.028)	(0.025)
Before_After	0.023	0.037	-0.004
	(0.029)	(0.029)	(0.025)
DiD	0.031	-0.011	0.043
	(0.043)	(0.043)	(0.038)
Median_Age	-0.008***	-0.010***	-0.008***
	(0.001)	(0.001)	(0.001)
TotalHispanic	0.003	0.002	0.009***
	(0.002)	(0.002)	(0.002)
MedianIncome	-0.00001***	-0.00001***	-0.00001***
	(0.00000)	(0.00000)	(0.00000)
Bachelors	0.024***	0.028***	0.025***
	(0.0004)	(0.0004)	(0.0003)
Constant	1.847***	2.697***	1.658***
	(0.031)	(0.031)	(0.027)
Observations	9,390	9,390	9,390
R2	0.361	0.445	0.437
Adjusted R2	0.360	0.444	0.437
Residual Std. Error (df = 9382)	1.028	1.028	0.900
F Statistic (df = 7; 9382)	755.623***	1,073.888***	1,042.390***
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 9: Age Group Jobs Regression with Control Variables

The addition of control variables did not lead to any significant results for this DiD regression among the various age groups. The positive association between treatment group and middle age and older age group jobs remains the same across the basic and control variable regressions. The control variables all appear to have similar relationships across the three age-group regressions. Again, there were no significant results that indicate whether the introductions of MAX stations increased employment across the age groups. However, it is interesting to note how the coefficients surrounding the DiD variable changed with the addition of controls. The youngest age group's coefficient fell from 4.7 percent to 3.1 percent, the middle age group's coefficient became negative, and the oldest age groups fell from 6 percent to 4.3 percent.

	Dependent variable:		
	log(lowincome)	log(midincome)	log(highincome)
	(1)	(2)	(3)
TreatmentTreatment	0.002	0.052*	0.168***
	(0.029)	(0.030)	(0.028)
Before_After	-0.104***	-0.075**	0.249***
	(0.030)	(0.031)	(0.029)
DiD	0.013	0.043	-0.036
	(0.045)	(0.046)	(0.043)
Median_Age	-0.003***	-0.011***	-0.012***
	(0.001)	(0.001)	(0.001)
TotalHispanic	0.009***	0.005**	0.003*
	(0.002)	(0.002)	(0.002)
MedianIncome	-0.00001***	-0.00001***	-0.00001***
	(0.00000)	(0.00000)	(0.00000)
Bachelors	0.021***	0.025***	0.030***
	(0.0004)	(0.0004)	(0.0004)
Constant	1.754***	2.474***	1.981***
	(0.032)	(0.033)	(0.031)
Observations	9,390	9,390	9,390
R2	0.280	0.375	0.464
Adjusted R2	0.280	0.374	0.464
Residual Std. Error (df = 9382)	1.059	1.091	1.021
F Statistic (df = 7; 9382)	522.476***	802.851***	1,160.892***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 10: Income Group Jobs Regressions with Control Variables

Similar to the prior regressions, the effect of the LRT intervention on total jobs across all three income groups was not significant with the addition of control variables. The magnitude of the relationship between the LRT intervention and total jobs by income groups appears to have changed with the introduction of the additional variables. Jobs in the lowest income group attributed to the LRT stations fell from 3.2 percent to 1.3 percent. Jobs in the middle-income group fell from 5.8 percent to 4.3 percent. Lastly, jobs in the highest income group became more negative. The effect of the LRT stations on high income job growth changed from -1.8 percent to -3.6 percent. The control variables have a similar relationship as the previous regression, as the median age has a negative effect on job growth while the Hispanic and education indicators had a positive effect.

	Dependent variable:		
	log(RetailJobs)	log(ServiceJobs)	log(IndustrialJobs)
	(1)	(2)	(3)
TreatmentTreatment	-0.136***	-0.117***	0.161***
	(0.028)	(0.035)	(0.033)
Before_After	-0.023	0.092**	-0.009
	(0.029)	(0.036)	(0.034)
DiD	0.045	-0.042	-0.023
	(0.043)	(0.053)	(0.051)
Median_Age	-0.006***	0.001	-0.019***
	(0.001)	(0.001)	(0.001)
TotalHispanic	-0.002	0.002	-0.012***
	(0.002)	(0.002)	(0.002)
MedianIncome	-0.00000***	-0.00001***	-0.00000***
	(0.00000)	(0.00000)	(0.00000)
Bachelors	0.005***	0.007***	0.010***
	(0.0004)	(0.0005)	(0.0005)
Constant	0.858***	1.122***	1.458***
	(0.030)	(0.038)	(0.036)
Observations	9,390	9,390	9,390
R2	0.059	0.040	0.180
Adjusted R2	0.058	0.039	0.179
Residual Std. Error (df = 9382)	1.012	1.271	1.214
F Statistic (df = 7; 9382)	83.509***	55.260***	294.328***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 11: Job Type Regression with Control Variables

The table above showcases the three job types with the addition of control variables. These regressions follow a similar trend of the prior regressions with control variables. There is no statistically significant effect from the intervention of LRT across jobs of these sectors. The magnitude of the effect of the LRT stations on the job growth of these industries did not change with the addition of control variables. The control variables seem to have a smaller effect on these regressions compared to the subgroups earlier, but the trends remain the same. Median age has a negative effect, income has no identifiable effect, and education has a small positive effect on job growth across the three industry types.

	Dependent variable:	
	log(NonWhite)	log(Hispanic)
	(1)	(2)
TreatmentTreatment	0.054**	0.061***
	(0.023)	(0.021)
Before_After	0.114***	0.135***
	(0.023)	(0.021)
DiD	0.020	0.045
	(0.035)	(0.032)
Median_Age	-0.005***	-0.004***
	(0.001)	(0.0005)
TotalHispanic	0.0002	0.001
	(0.002)	(0.001)
MedianIncome	-0.00001***	-0.00001***
	(0.00000)	(0.00000)
Bachelors	0.024***	0.021***
	(0.0003)	(0.0003)
Constant	1.105***	0.881***
	(0.025)	(0.023)
Observations	9,390	9,390
R2	0.435	0.405
Adjusted R2	0.435	0.405
Residual Std. Error (df = 9382)	0.824	0.753
F Statistic (df = 7; 9382)	1,031.742***	913.868***
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 12: Race and Ethnicity Regression with Control Variables

Finally, the table above provides the regressions of nonwhite and Hispanic jobs with the addition of control variables. The trend of insignificant results of the DiD variable follows through to these results as well. Interestingly, the magnitude of the nonwhite variable falls notably. In the regression without control variables, there was a 6 percent increase in nonwhite jobs attributed to the new LRT line. The addition of control variables decreases the results to 2 percent. Additionally, the positive and significant association of nonwhite and Hispanic jobs from 2016 onwards remains constant with the addition of control variables. Again, this could indicate a citywide trend of increased diversity.

Overall, my five regressions without control variables and my five regressions with control lead to the same result. There is inconclusive evidence to state whether the introduction of the Orange MAX Line had a significant effect on job growth in the surrounding areas. I examine this relationship across multiple sub-groups, and I find the same inconclusive response. The results highlight some overall trends. For example, there appears to have been some decline in industrial job types, while there was a rise in retail job types. There appears to have been an increase in non-white and Hispanic jobs as well. However, as my results indicate, I cannot point to the new MAX line as the reason for these changes.

Measuring Land Use Change Using GIS

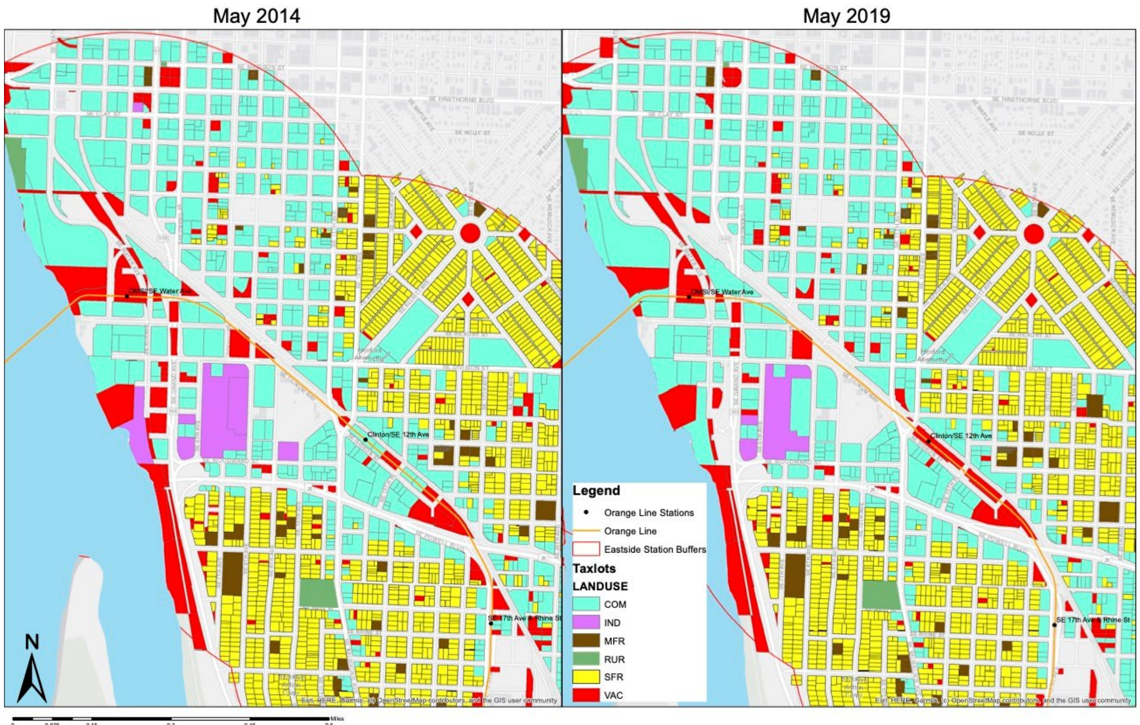

Figure 8: Land Use Map of OMSI and Clinton St. Station

The maps above represent land use surrounding the OMSI and Clinton St stations of the Orange MAX Line from 2014 and 2019. These two stations are close to the Portland city core and are within the "Southern Triangle" (City of Portland, 2010). The City identified these areas as places with high potential for success with the new LRT station (City of Portland, 2010). Before the MAX line was introduced, the area north of the station was primarily commercial. The high concentration of commercial land use remained constant after the line opened. The area south of both stations had a mix of commercial, industrial, and vacant land in 2014. The industrial tax lots decreased over time after the MAX stations opened and transitioned into commercial land. The amount of vacant land appears to remain constant from 2014 to 2019. In general, there is a moderate transition away from industrial land use, but the general neighborhood characteristics of the station areas remained the same.

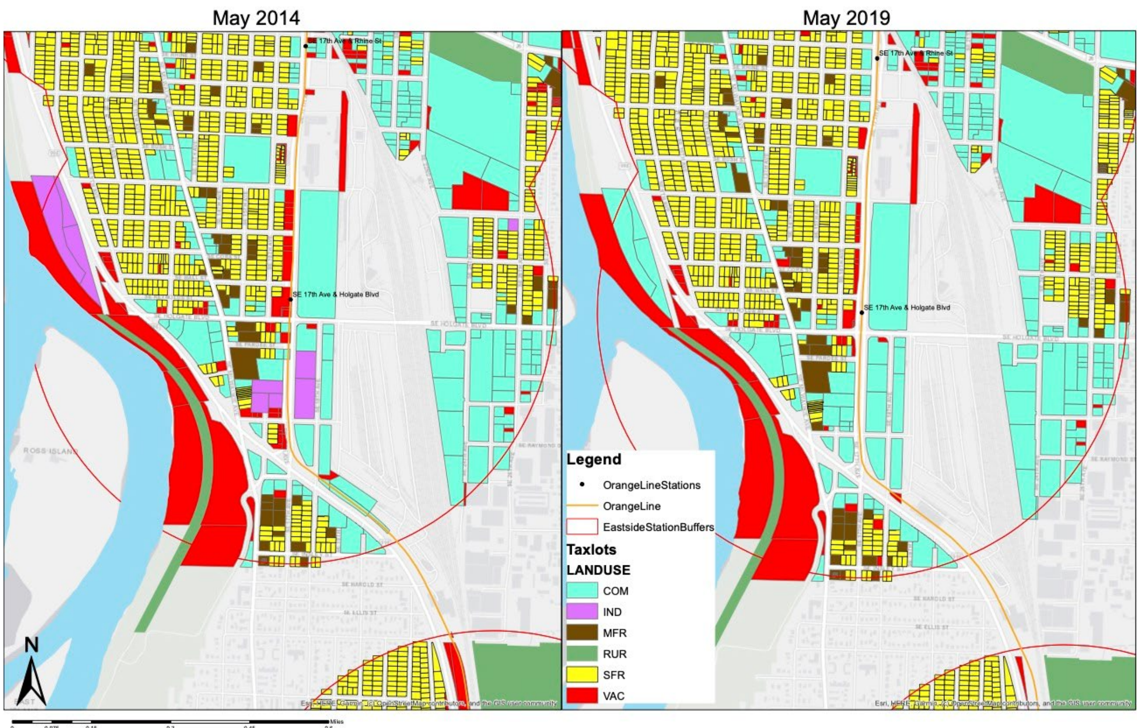

Figure 9: Land Use Map of Holgate Blvd Station

The Holgate Blvd station from 2014 and 2019 is showcased above. This station is located just west of the Union Pacific railroad. The western side of the station area has a diverse mix of land use types. There is the highest proportion of multi-family residential housing surrounding this station compared to the other Orange Line stations. In May 2014, the station area had a handful of industrial land use taxlots. In May 2019, all industrial land use was transitioned to commercial. The amount of vacant land surrounding this station appeared to remain the same from 2014 to 2019.

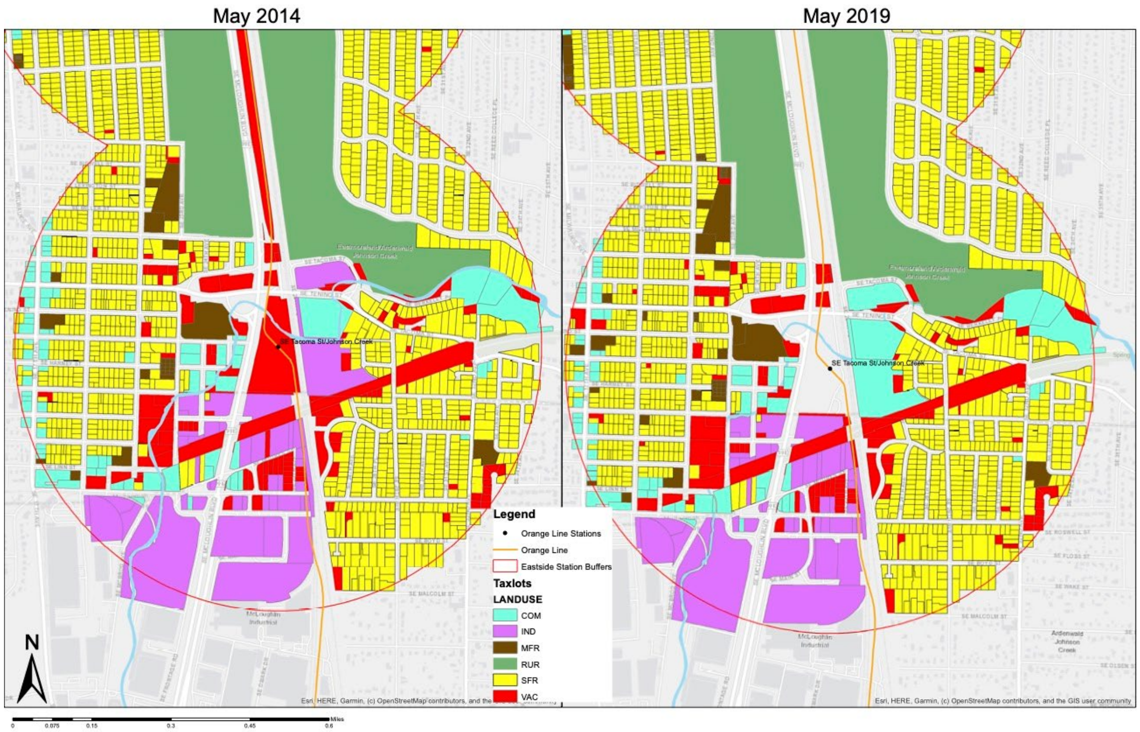

Figure 10: Land Use Map of Tacoma St Station

The figure above highlights land use surrounding the Tacoma Street station before the MAX Line opened (May 2014) and after (May 2019). Prior to the intervention, the area directly surrounding the Tacoma St station was primarily industrial and vacant. There was a small amount of multi-family residential land use type, but single-family residential was the primary housing typology. The station area experienced a noticeable amount of change from 2014 to 2019. Industrial land use declined moderately as commercial land uses took over on the eastside of the station street. Additionally, there was a slight increase in multi-family residential housing, as expected by TOD-style changes.

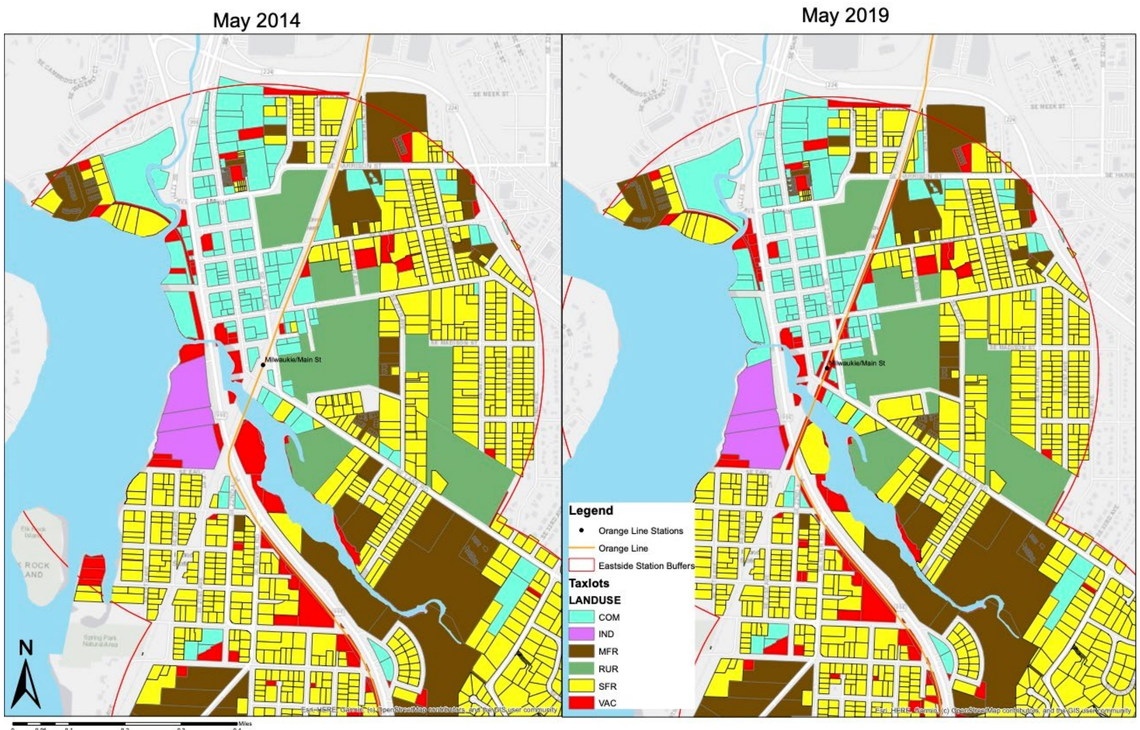

Figure 11: Land Use Map of Milwaukie Main St Station

Lastly, land use surrounding the Milwaukie Main Street is shown from before and after the Orange MAX Line opened. This station is located in the downtown core of the City of Milwaukie. The opening of the Orange Line was the first time that LRT had been introduced to the city. It does not appear that there was any significant change in land use type surrounding this station. The industrial land use type remained consistent from 2014 to 2019. The amount of vacant land also appeared to remain the same. There does not appear to visual evidence that the new LRT station stimulated new development types in the Milwaukie town center area.

Discussion of Robustness/Sensitivity Analysis

When I conducted initial descriptive statistics, there was a sharp and sudden decline of jobs in the treatment buffer area in the year 2016. The jobs rebounded in the following years, but the extreme decrease of thousands of total reported jobs interfered with the results of this study. First, I identified the individual Census block causing the steep decline in my dataset. Then, I used ArcMap and Google Maps to locate what the cause of this outlier. I found that the Census block was located at the Fred Meyers Headquarters. The company has been stationed at that location for many years, dating back to the 1980s and the company headquarters are still located there in 2023. I was unable to identify any reports that Fred Meyers had a major decline in employment in the year 2016. Thus, this outlier led me to believe that Fred Meyers changed the way they reported their employment. The workforce area characteristics dataset identifies the number of jobs given by the businesses that exist within that block. A large business with numerous branches like Fred Meyer may have used their headquarter locations as the "workforce area" where their employees were hired. The company may have moved people from locations or reported their "workforce area" differently in the years after 2016. The Census block had over 1000s jobs from the years 2010-2015, but under 100 jobs from the year 2016 onwards. I believe that the company must have changed their job reporting behavior which caused this outlier.

I address the issue of this outlier by removing it from my treatment block area. The resulting descriptive statistics better represent the distribution of jobs in the treatment area (see Figure 5). The figures below indicate the dramatic difference that this block made on my study. The treatment area jobs were notably impacted by this outlier. Further, the regression results with the block included reduces the DiD indicator from 3.1 percent to 2.4 percent. The removal of this treatment block from my analysis adds a limitation to my study. There is a chance that my findings are positively skewed.

However, the removal of this Census block felt necessary for isolating the effect of the LRT line on employment of the surrounding areas.

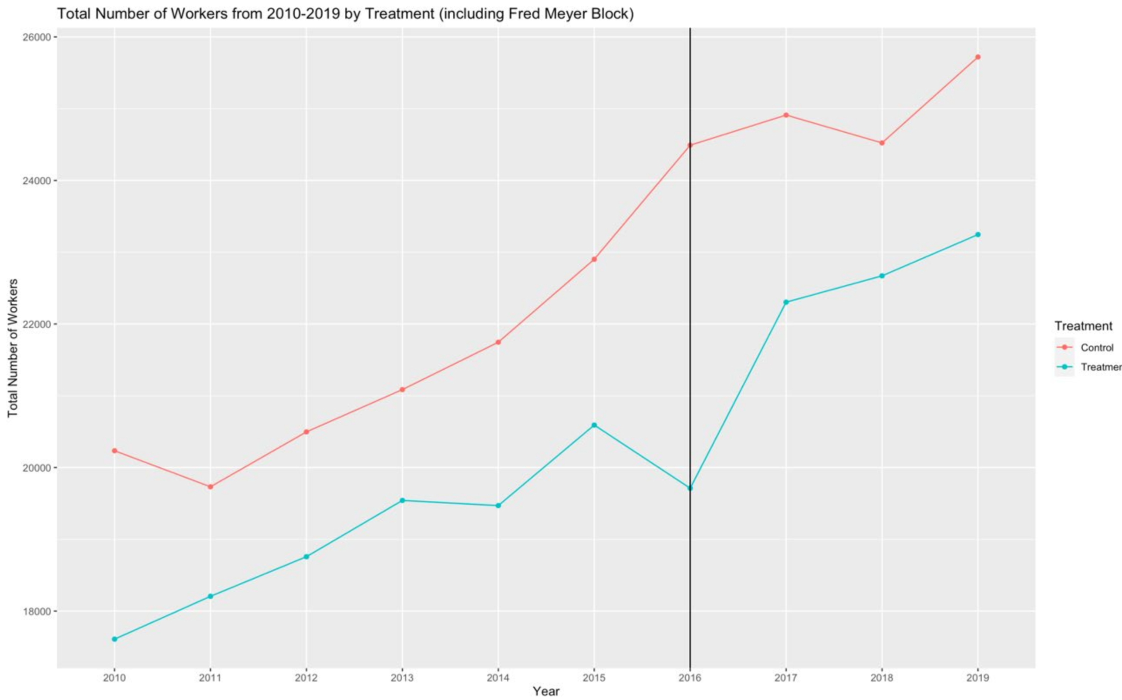

Figure 12: Total Jobs by Treatment (Including Fred Meyer Block)

	Dependent variable:
	log(C000)
TreatmentTreatment	0.208***
	(0.043)
Before_After	0.013
	(0.045)
DiD	0.024
	(0.067)
Constant	2.481***
	(0.029)
Observations	9,400
R2	0.005
Adjusted R2	0.004
Residual Std. Error	1.587 (df = 9396)
F Statistic	14.800*** (df = 3; 9396)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 13: Basic Difference-in-Difference Regression (Including Fred Meyers Block)

Discussion

The promise of job creation was a prominent feature of the plan to bring LRT to SE Portland and Milwaukie. The City of Portland was awarded nearly $500,000 under the Construction Excise Tax grant for developing a plan to stimulate job creation with this project. The City created a new transit-oriented development classification, E-TOD, to define employment-based growth around transit stations. It is clear that local authorities prioritized job growth. However, the results of this study struggle to find significant evidence that this promise was met. I explored the changes in jobs in the half-mile area surrounding each new eastside Orange MAX station. I examined these changes specifically across subsets of the worker population including race, ethnicity, income-level, and job type. I cannot conclude that there was any significant impact of the Orange MAX Line on employment.

The basic regression exploring the change in total jobs finds a moderate 4 percent increase in workers within a half-mile radius of the east side Orange MAX Lines. However, this increase was similar to that of the half-mile-to-one-mile radius. So, while my findings indicate that there may be a positive employment effect of the MAX Line in the surrounding area, I cannot conclude anything certainly due to a lack of statistically significant results. When I refined my analysis towards specific subgroups of the labor market, my findings remained insignificant. Nevertheless, it is interesting to compare the 4 percent increase of total jobs to these other subgroups. Workers earning less than $1250 per month experience only a 3.2 percent increase attributed to LRT intervention whereas workers earning between $1250 to $3333 per month saw a 5.8 percent increase. Moreover, workers in the highest income bracket

($3333+ per month) saw a decrease of 1.8 percent attributed to the MAX Line. It appears that there was a stronger relationship for this middle-income bracket compared to the basic regression, while there was roughly the same effect for the lowest income group. Interestingly, the rate of low- and middle-income bracket jobs had a negative association with the years after the Orange Line opens. This indicates that there may have been a metropolitan-wide trend towards higher paying jobs. However, within my half-mile treatment area, these variables experienced moderate yet insignificant positive growth in jobs.

The addition of control variables did not have a substantial impact on my results. I found the same inconclusive results throughout my five regressions with the addition of controls for age, income, education, and ethnicity. These variables had some significant relationships with various subgroups of jobs. For example, median age primarily had a negative relationship with my job variable which indicates that older blocks experienced less job growth. The number of bachelor's degrees appears to have had a positive relationship with job growth, which is to be expected. There were also some changes in the magnitude of the relationship between the MAX line and jobs. Interestingly, the control variables reduced the effect of the MAX line on non-white jobs from 6 percent to 2 percent. Other regressions experienced some change too, but the most noticeable difference came from the non-white regression.

Overall, the entire Portland metropolitan region and the area surrounding the new transit stations experienced regional job growth. The total number of jobs was on the rise from 2010 to 2019. There were some small, positive change in the half-mile treatment area for Hispanic workers, non-White workers, and low- and middle-income workers. This growth cannot be attributed to the Orange Line, but the neighborhoods have appeared to experience growth. Further, the positive associations surrounding the race and ethnicity subgroups of the worker population indicates potential growth in the diversity of the area. The general increase in total jobs indicates that there was validity in Portland Metro's assumption of regional growth. There was observable growth descriptively, however, these employment increases cannot be attributed towards the new transit stations.

The transition in business type in SE Portland supports the goals addressed in the plans of the project. There appears to be a decline of industrial jobs and the increase in service/retail jobs. Specifically, the station area surrounding Tacoma Street experienced a decline in industrial and a transition towards commercial (see Figure 7). The City of Milwaukie's Tacoma Street Plan addresses this land use change. Industrial land use types do not generally improve the aspirations of TOD. Industrial buildings often require their own typologies because they can have externalities, like air and noise pollution. Industrial land is separated from residential land to address these potential harms for residents. Service and retail land usage can be mixed with housing. Dense, livable communities are created through the merging of service, retail, and residential land use. Service and retail job development is style of business creation that would be desired for the goals of TOD. The transition towards these jobs and towards these zoning types are inducive of potentially positive TOD change in the area.

The City of Portland's E-TOD plan does not appear to have had as much success. The E-TOD plan was intended to alter the structure of the local area such that there could be an observable increase in employment density. The City aspired to bolster the industrial area in inner SE Portland by maintaining the rate of industrial land use and increasing commercial spaces. The regression results and the land use maps of 2014 and 2019 surrounding the OMSI and Clinton Street stations indicate that there was not an observable change in the manner they hoped. The land use maps show a decline in industrial land use, as it has been overtaken by commercial, and a constant rate of vacant land. Further, the regression results offer no support towards their goal of having strong increases in employment surrounding the station areas.

Lastly, the Orange MAX Line was the first LRT to be introduced to the suburban city of Milwaukie. Portland Metro described the need for this connectivity because the region was going to experience growth. They hoped to bring the city into Portland's connected transit corridor. The implementation of the MAX Line did connect the City of Milwaukie. However, I cannot draw any conclusions that the local area experienced significant change in the aftermath of this intervention. Visually, the land use map of Milwaukie in May 2014 and May 2019 does not appear to have many noticeable changes. There was a slight decrease in the amount of vacant land in the station area which primarily went towards more commercial land usage. Still, the neighborhood composition of land use did not appear to change significantly after the introduction of the MAX Line.

Did this transit project provide the benefits of job creation as described in its plans? My findings on this question are inconclusive. I cannot conclude the City of Portland was successful in initiating job growth by the transit investment. However, I do not have enough evidence to say that there was no change experienced.

Future Research

My research failed to find conclusive and significant evidence that there was any effect of the Orange MAX Line on employment levels in the surrounding neighborhoods. My approach replicated the approach of other urban economists interested in similar topics. My regression analysis and descriptive spatial assessment of land use do not provide a complete picture of the economic and neighborhood changes experienced in the nearby area of the Orange MAX Line. Further research is necessary to make true conclusions on the effect of LRT on SE Portland's employment base. Namely, stronger block level control variable data and the availability of ridership data would be beneficial for future analysis of this research question.

I struggled to find meaningful and applicable control variable data at the geographical level of analysis that I had hoped. Block level data is the most refined geographic level that the Census offers. Blocks are located within block groups which are located within census tracts. The LODES data is conducted by blocks. Meaningful income or education data is primarily conducted at the block group level through the ACS 5-Year Estimates. More complete and robust block level data would strengthen my ability to reduce surrounding noise in the data and isolate the effect of the intervention on the number of jobs.

Moreover, Portland's transit agency TriMet did not publish their ridership data from before and after the Orange MAX Line opened. I emailed TriMet numerous times, but I was unable to obtain their ridership data within the timeframe of this study. I believe that ridership data is the most important piece of this topic that is missing from my study. If I were able to evaluate who rode the MAX line after it opened, I would have a much clearer picture of the effect of this investment. In their grant proposal, the City of Portland identified that they hoped the new MAX line would motivate the workforce to use “alternative modes of transportation.” My study would benefit from an analysis of ridership after the MAX Line opened. Did commuters begin to use it? Are riders still using the line today? I could better identify the immediate and lasting effects of this transit investment if I was able to use robust ridership data.

Conclusion

My findings on the labor market effects of the Orange MAX Line in Portland were insignificant and inconclusive. I could not find a clear effect of this transit investment on employment in the surrounding areas. I refined my analysis to jobs from specific industries, jobs with varying paygrades, and jobs across various demographics. No regression found statistically significant results from the effect of the LRT intervention.

The City of Portland identified E-TOD as a new typology of economic development that can be achieved through sustainable development strategy of TOD. The idea of E-TOD is compelling because of how it takes the idea of a proven sustainable development tool a step further. E-TOD is an unproven ideology. The existing literature on the relationship between LRT and job creation was mixed and inconclusive. Primarily, the most positive effects were identified through job accessibility (Fan et al. 2012). However, job creation in the surrounding areas, an idea that the City of Portland tried to run with, was not always positive.

The City of Portland explicitly labeled E-TOD as their strategy for approaching the predicted growth of the metropolitan area. Further, they received substantial amount of public funding to create a plan for these goals. My thesis does not find evidence that supports their goals. These inconclusive results have implications on how we evaluate the merits of city plans and development plans.

It appears that the E-TOD plan did not achieve its goals. My basic regression, my refined regressions, and the addition of control variables did not lead me to any significant evidence of increased job growth in the surrounding areas of the new LRT stations.

Further, my visual descriptive analysis using ArcGIS identifies another gap in the E-TOD plan. The City of Portland labeled the industrial core of SE Portland as a critical aspect of the city's fabric. The City prioritized balancing the needs of industrial work with further development. They did not want to eliminate the importance of industrial jobs. Rather, they wanted to bolster the neighborhoods with a mix of industries. My study finds that there was some noticeable decline in the prevalence of industrial land use types in the areas surrounding the new MAX stations. The rates of vacant land use types did not change as substantially as the industrial land. This is intriguing because it is the opposite of the goals addressed by the City in their grant proposal.

Lastly, my thesis was limited in its ability to truly uncover the effect of the Orange MAX line on the labor market and the neighborhood characteristics of the surrounding areas. There were some gaps in my data, and I was unable to obtain robust ridership data. I believe that the true key to identifying the success of these investments is through ridership. If a transit project is introduced and no one uses it, what is the real purpose of that investment? If it increases economic growth but commuters are not using the LRT, did it achieve the sustainable development goals it set out for? Ridership is the best method to address the real changes that occur from a transit investment. I believe that this would be the most important next step if I were to explore this relationship further.

I cannot conclude that the City of Portland achieved its goals. I do not find convincing evidence that the Orange MAX Line increased local employment as hoped for. Moreover, I do not have significant evidence that this investment affected specific subgroups of the labor force differently, whether it be income, race/ethnicity, or industry type. There is not compelling evidence that this investment had the effects that it hoped to have, leaving lasting policy and city planning implications to consider for the future of TOD.

Bibliography

Billings, S. B. (2011). Estimating the value of a new transit option. *Regional Science and Urban Economics, 41(6),* 525–536. https://doi.org/10.1016/j.regsciurbeco.2011.03.013

Canales, K. L., Nilsson, I., & Delmelle, E. (2019). Do light rail transit investments increase employment opportunities? the case of Charlotte, North Carolina. *Regional Science Policy & Practice*, *11(1)*, 189–202. https://doi.org/10.1111/rsp3.12184

City of Milwaukie (2013). *Tacoma Station Area Plan*. https://www.milwaukieoregon.gov/sites/default/files/fileattachments/planning/page/37951/copy_of_tsap_revsedplan_042513_compressed2_planonly.pdf

City of Portland (2010). *Portland-Milwaukie LRT Project: E-TOD Plan*. https://media.oregonlive.com/portland_impact/other/Portland-Milwaukie%20LRT%20Project%20E-TOD%20Plan.pdf

Knowles, R., & Ferbrache, F. (2016). Evaluation of wider economic impacts of light rail investment on cities. *Journal of Transport Geography*, *54*, 430–439. https://doi.org/10.1016/j.jtrangeo.2015.09.002

Fan, Y., Guthrie, A. E., & Levinson, D. M. (2012). Impact of light rail implementation on labor market accessibility: A transportation equity perspective. *Journal of Transport and Land Use, 5(3)*. https://doi.org/10.5198/jtlu.v5i3.240

Federal Transit Administration (2019). *Transit-Oriented Development*. https://www.transit.dot.gov/TOD.

Kim, K., Park, K., & Nelson, A. C. (2021). Impacts of light rail transit on labor participation and housing affordability in the U.S.: Longitudinal analysis using propensity score matching. *Transportation Research Record: Journal of the Transportation Research Board*, *2675(12),* 419–431. https://doi.org/10.1177/03611981211029650

Sanchez, T. W. (1999). The connection between public transit and employment*. Journal of the American Planning Association, 65(3),* 284–296. https://doi.org/10.1080/01944369908976058

Santra, L. (2022). The Impact of New Light Rail Service on Employment Growth in Portland, Oregon. *Dissertations and Theses.* Paper 5890. https://doi.org/10.15760/etd.7761

Tornabene, S., & Nilsson, I. (2021). Rail Transit Investments and economic development: Challenges for small businesses. *Journal of Transport Geography*, *94*, 103087. https://doi.org/10.1016/j.jtrangeo.2021.103087

TriMet (2016). *MAX Orange Line Fact Sheet.* https://trimet.org/history/pdf/max-orangeline.pdf

TriMet (2021). *What is Transit-Oriented Development?* https://blog.trimet.org/2021/07/13/what-is-transit-oriented-development/

Tyndall, J. (2021). The local labour market effects of Light Rail Transit. *Journal of Urban Economics*, *124*, 103350. https://doi.org/10.1016/j.jue.2021.103350