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VOLUME 2

Transit Impacts on Jobs, People and Real Estate

Volume 2: Impact on Job Location Over Time with Respect to Transit Station Proximity Considering Economic Groups by Transit Mode and Place Typology with Implications for Transit and Land Use Planning

Arthur C. Nelson, Ph.D.
Robert Hibberd
Kristina Currans, Ph.D.
Nicole Iroz-Elardo, Ph.D.

THE UNIVERSITY OF ARIZONA

TRANSIT IMPACTS ON JOBS, PEOPLE AND REAL ESTATE

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by
Arthur C. Nelson
Robert Hibberd
Kristina Currans
with Nicole Iroz-Elardo

University of Arizona

for
National Institute for Transportation and Communities (NITC)
P.O. Box 751
Portland, OR 97207

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16. Abstract

Three sets of themes emerge from analysis reported in Volume 2.

First, although conventional wisdom would have it the High MA (mixed-use/accessible) Places would be more robust in attracting jobs over time than other Place Types, this is not true as our research shows, surprisingly. We find that transit systems vary substantially in their attractiveness to jobs with respect to Place Typology. CRT performs best in the Moderate MA (mixed-use/accessibility) Place Type than others. SCT does better among the Moderate and High Place Types. BRT performed best at the Moderate MA Place Type. LRT did best in the Moderate and Low Place Types.

Second, while one would assume that higher wage jobs might be attracted more so to transit stations than middle or lower wage jobs, this is not the case given considerable variation both by transit mode and Place Typology. Analysis reveals important contextual differences for each transit mode. CRT's performance at the lower levels (Low and Poor Place Types) of land use mix and accessibility shows its utility to the suburban commuter. LRT's highest performance in the middle ranges of the mix and accessibility continuum (Moderate and Low MA) may be due to the size and capacity of this mode. BRT did very well at all levels, showing exceptional adaptability to the land use context. BRT was the best-performing at the Poor MA Place Type. SCT clearly demonstrates its urban configuration, being the most successful at High MA places or urban core level.

Third, a new approach to measuring jobs-housing balance may be more informative for planning and policy than conventional measures—namely what we call the Employment-Worker Balance (EWB) metric. A more accessible workplace translates to a more productive and resilient workforce through potential improvements in work-life balance and overall cost of living, which in turn benefits the firm through higher output. Low EWB scores near transit stations reveal low-hanging fruit for planners who wish to increase economic and housing resiliency. The EWB metric is consistent with economic development theory whereby regions in which workers have greater TOD-driven access to firms also provide a more business-friendly environment with increased *situs* via a more accessible, active workforce. When appropriate housing is provided for workers of all sectors of the economy, greater economic diversification is possible. Targeted solutions are needed to increase EWB.

Transit planning and land use implications related to each of these three theme areas are offered.

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DISCLAIMER

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PREFACE

Transit Impacts on Jobs, People, and Real Estate is the fourth report in a series that started with funding from the National Institute of Transportation and Communities (NITC), a US DOT funded National University Transportation Center. While it completes the "quadrilogy" of work comprising a unique genre of transit and land use planning research it is by no means the last work—it is more likely the foundation for future work.

This document is Volume 2 of five volumes from the full report *Transit Impacts on Jobs, People, and Real Estate*:

- Volume 1: Orientation, Executive Summary, Context and Place Typologies
- **Volume 2: Impact on Job Location Over Time with Respect to Transit Station Proximity Considering Economic Groups by Transit Mode and Place Typology with Implications for Transit and Land Use Planning**
- Volume 3: Impact on Where People Live Over Time with Respect to Transit Station Proximity Considering Race/Ethnicity and Household Type and Household Budget by Transit Mode and Place Typology with Implications for Transit and Land Use Planning
- Volume 4: Impact on Real Estate Rents with Respect to Transit Station Proximity Considering Type of Real Estate by Transit Mode and Place with Implications for Transit and Land Use Planning
- Volume 5: Improving Transit Impacts by Reconsidering Design and Broadening Investment Resources

Each of these volumes, and the full report, can be found at https://nitc.trec.pdx.edu/research/project/1253

The genre of research within which four research projects call is grounded in trend that is common throughout all reports: That America is becoming increasingly focused on the need for transit to meet a growing number of social, economic and environmental objectives. But it is also rooted is simple market dynamics.

America will add at least 100 million new residents, 40 million new households, and 60 million new jobs by 2050. We know from demographic analysis and consumer preference surveys that at least a third of America's 150 million households (50+ million) in 2050 will want to live in locations providing them with transit options, in addition to mixed-use and mixed-housing options. We also know from research on firm location behavior that up to 100 million jobs will be attracted to locations with transit options. Indeed, some research has estimated that even if all new development to 2050 occurred within one-half mile of existing and planned transit stations—such as transit oriented development (TOD) planning areas—the market demand for such development would not be met.

Our prior research outlines the extent to which fixed route transit (FRT) systems can meet future demand. But each system has its own niche. Light rail transit (LRT) systems serve metropolitan wide markets, connecting multiple nodes to each other. Bus rapid transit (BRT) systems can accomplish many of the same objectives as LRT systems at lower cost per mile but also lower capacity—which is fine for the Eugene-Springfield metropolitan area though not necessarily the Portland metropolitan area which, being four times larger and more densely settled, relies on LRT. At the lowest scale of operations are street car transit (SCT) systems that serve mostly downtowns such as Seattle or connect employment centers near downtown to downtown such as Portland, Tucson and Dallas. At the other end of the spectrum are commuter rail transit

(CRT) systems that are intercity systems that connect cities within a metropolitan area to downtown such as San Diego's Coaster, or multiple metropolitan areas such as the Seattle-Tacoma Sounder or the Albuquerque-Santa Fe Rail Runner or the Utah Transit Authority's FrontRunner connecting three metropolitan areas.

Here we will summarize the purpose and key findings of each of the three prior reports and then frame the role of the fourth report.

Do TODs Make a Difference?
The first report in the Quadrilogy was *Do TODs Make a Difference?* (Nelson et al. 2015). NITC contracts 547 and 650 were used to build station area databases for 12 light rail transit (LRT) systems, nine bus rapid transit (BRT) systems, four streetcar transit (SCT), and five commuter rail transit (CRT) systems. In this report, we presented research that measures the outcomes of TOD areas in relation to their metropolitan area controls with respect to:

- Jobs by sector;
- Housing choice for household types based on key demographic characteristics;
- Housing affordability based on transportation costs; and
- Job-worker balance as a measure of accessibility.

Prior literature has not systematically evaluated TOD outcomes in these respects with respect to light rail transit (LRT), commuter rail transit (CRT), bus rapid transit (BRT), and streetcar transit (SCT) systems. Our analysis helps close some of these gaps. We applied our analysis to 23 fixed guideway transit systems operating in 17 metropolitan areas in the South and West that have one or more of those systems. We found:

- Most TOD areas gained jobs in the office, knowledge, education, health care and entertainment sectors, adding more than $100 billion in wages capitalized over time;
- In assessing economic resilience associated with LRT systems, jobs continued to shift away from TOD areas before the Great Recession, the pace slowed during the Recession, but reversed during recovery leading us to speculate that LRT TOD areas may have transformed metropolitan economies served by LRT systems;
- Rents for offices, retail stores and apartments were higher when closer to SCT systems, had mixed results with respect LRT systems, but were mostly lower with respect to CRT systems (our earlier BRT sample size was too small to evaluate);
- SCT systems performed best in terms of increasing their TOD area shares of metropolitan population, households and householders by age, housing units, and renters with BRT systems performing less well while LRT and CRT systems experienced a much smaller shift in the share of growth;
- Household transportation costs as a share of budgets increase with respect to distance from LRT transit stations to seven miles suggesting the proximity to LRT stations reduces total household transportation costs;
- Emerging trends that may favor higher-wage jobs locating in transit TOD areas over time than lower or middle wage jobs perhaps because TOD areas attract more investment which requires more productive, higher-paid labor to justify the investment; and
- The share of workers who commute 10 minutes or less to work increases nearly one-half of one percent for each half-mile their resident block group is to an LRT transit station, capping at a gain of 1.3 percent, which is not a trivial gain.

This work identified a missing element of research relating to one of the fastest growing modes of fixed route transit systems: Bus rapid transit (BRT). That led to a second NITC-funded project.

National Study of BRT Development Outcomes

The second report was the nation's largest and most comprehensive assessment of the influence of bus rapid transit (BRT) systems on jobs, people and households, and real estate rents (Nelson and Ganning 2016).

Public transit systems are often promoted as offering a plethora of social, economic and environmental benefits to urban populations by transforming urban forms from auto-centric designs into more sustainable ones. The "next big thing" in public transit is bus rapid transit (BRT) systems. From virtually no systems a generation ago, there are now nearly 20 lines operating with at least seven under construction and more than 20 in the planning stages. Part of this recent popularity in BRT stems from its more affordable capital investment costs and its potential to be utilized by municipal planning organizations as an economic development tool. Yet, research into development outcomes associated with BRT station/stop proximity is small. This study found:

- For metropolitan counties with BRT systems, (0.50-mile) transit corridors increased their share of new office space by a third, from 11.4 percent to 15.2 percent and although new multifamily apartment construction was small, its share more than doubled since 2008;
- BRT station areas gained share of central county jobs at a faster pace or even at the expense of the rest of the central county and that more technologically advanced BRT systems may contribute to positive economic development outcomes;
- However, when disaggregating data to sectors, BRT is found to influence employment change in only one sector—manufacturing though that sector is broad and includes such activities as assembly, food processing (think beer making) and fashion design;
- Evidence of an office rent premium for location within a BRT corridor for most albeit not all of the metropolitan areas studied;
- Household transportation costs as a share of budgets increase with respect to CBD distance to about 19 miles and about eight miles with respect to BRT stations;
- Before the recession, the shift in jobs for all wage groups was about the same between BRT station areas and counterfactual locations but during recovery, BRT station areas saw larger shifts compared to counter-factual locations for lower-wage but upper-wage jobs had the largest change share in BRT station areas during recovery while the share of lower-wage jobs in BRT station areas fell; and
- There is little difference in BRT study area performance compared to their metropolitan areas in terms of influencing population and residential patterns though we did find indirect evidence that BRT systems choosing higher-quality design and technology options tended to enjoy better population and housing outcomes than those that chose lesser options.

We conclude that, on the whole, BRT systems are associated with positive development and job location outcomes, though not necessarily population or housing outcomes. By the time this study was completed more robust data had become available allowing for updates and expansions of prior work, which led to the third grant in this genre.

The Link between Transit Station Proximity and Real Estate Rents, Jobs, People and Housing with Transit and Land Use Planning Implications

This report updates and expands prior research in the genre of research that has used economic base analysis (especially shift-share) and CoStar commercial rent data to estimate the development outcomes to transit (Nelson and Hibberd 2019). The study period for prior economic base analysis was 2002-2011 and census data for 2000 and 2010, as well as CoStar data for 2013. This report expands the number of systems used in analysis to 17 LRT systems, 14 BRT systems, nine SCT systems and 12 CRT systems. It also expands the period of analysis to 2015 for jobs-related data, 2016 for census data, and 2018 for CoStar data. The expanded and updated databases allow for more comprehensive assessment of their outcomes. Key findings include:

- Market rents increase with respect to Fixed Guideway Transit (FGT) station proximity for nearly all commercial types and for all modes, except there no rent premium for BRT in the closet (0.125 mile) distance band and office responds positively only within the closets (0.125 mile) distance band from LRT stations, with rent premiums extend one to two miles away from FGT stations for many commercial types;
- On the whole, more mature Fixed Guideway Transit (FGT) system saw gains in regional share of jobs in closer in (0.25 mile and 0.50 mile) distance bands if not up to the 1.00 mile distance band from transit stations—BRT being an exception in gaining share only in the nearest (0.25 mile) distance band— while ones build during and since the Great Recession saw small or negative shifts in regional share;
- There are only modest gains in the regional share of population and housing before/during the Great Recession (2000-2009) bit somewhat more gains afterward (2010-2016) for all transit types except BRT with larger gains associated with households without children and early/middle aged households (35-49); and
- For the most part for all transit modes saw reductions in regional share of driving alone and carpooling, and increases in regional share of transit, biking, walking, and working at home with respect to FGT station proximity.

The report also featured illustrations of “good, bad and ugly” transit station/stop planning and design, suggesting that systems may be underperforming because of these limitations.

A missing element of prior work was the milieu or type of place within which transit stations are located. Addressing this is the key purpose of this report (Nelson, Hibberd and Currans 2021).

Transit Impacts on Jobs, People and Real Estate
This is the fourth report in the genre of research supported by NITC. This project entailed updating data and disaggregating it to assess outcomes based on station area types or what we call Place Typologies. This research is guided by two overarching questions and analytic contexts:

> ***How do Transit Development Outcomes Vary by Mode and Place Typology?*** This analysis includes each transit system for each metropolitan area studied during appropriate time periods for that system, as well as systems combined across metros. Trends that are assessed include: (1) Changes in the number and share of jobs by sector with respect to type of system and distance from stations, by type of station based on Place Typology; (2) Changes in the number and share of jobs by wage category with respect to transit mode and station proximity by Place Typology; and (3) Changes in number and share of population, households, householders by age, and housing by tenure with respect to transit mode, station proximity, and Place Typology.
>
> ***How does the real estate market for office, retail and apartment properties respond to proximity to transit stations by mode and Place Typology?*** Our prior work pioneered the use of CoStar commercial rental data for very broad assessments of real estate market responsiveness to transit by type but not really by location except for corridor distance bands. The new research conducts more refined relationships in those metropolitan areas based on mode and Place Typology where CoStar data are sufficient for analysis.

In addition, we updated our complete database with a codebook for anyone to access through NITC.

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SYNOPSIS FOR VOLUME 2

Three sets of themes emerge from analysis reported in Volume 2. First, although conventional wisdom would have it the High MA (mixed-use/accessible) Places would be more robust in attracting jobs over time than other Place Types, this is not true as our research shows, surprisingly. Second, while one would assume that higher wage jobs might be attracted more so to transit stations than middle or lower wage jobs, this is not the case given considerable variation both by transit mode and Place Typology. Third, a new approach to measuring jobs-housing balance may be more informative for planning and policy than conventional measures—namely what we call the Employment-Worker Balance (EWB) metric.

Variation in Transit Station Proximity Job Attractiveness by Mode and Place Typology Over Time (Chapter 2)

Transit systems vary substantially in their attractiveness to jobs with respect to Place Typology. CRT performs best in the Moderate MA (mixed-use/accessibility) Place Type than others. SCT does better among the Moderate and High Place Types. BRT performed best at the Moderate MA Place Type. LRT did best in the Moderate and Low Place Types. Notably, for each transit mode:

- BRT proved to be quite flexible to the variations of each place type, showing robust growth across three four place types, shining in the two mid-range classes (Moderate and Low MA Places Types), while losing share slightly in the lowest-mix (Poor MA) areas. BRT stations may need to adapt to the context of the outlying areas to better attract firms to them. This may be undermined by the challenges of low-density dispersed land uses, however.

- CRT showed mostly modest gains in job share for the Low MA place type stations. Perhaps firms are opting for locations farther from stations because of externality affects such as noise and air pollution. Newer systems such as that in Salt Lake City, Utah use quieter, less polluting train technology for these commuter-oriented stations. An update may be necessary in other metropolitan areas to attract further job share gain near these stations.

- LRT saw modest growth at the Poor MA station areas but saw great share gains in the Low MA and Mod MA place type areas, with acceptable gains in the High MA areas. This seems reasonable given the scale of the trains, the competition from SCT systems for the most urban land, and the low response to transit proximity in all of the transit mode stations.

- SCT did best in the context for which it was designed, the High MA and Moderate MA Places. It saw a slight loss of job share in the Poor MA place type areas, for reasons that are likely to be similar to the other transit modes. SCT, like LRT, may benefit from efforts at greater integration of BRT and other transport mode to increase the utility of the system for all place types.

Variation in Transit Station Proximity Job Attractiveness based on Economic Group and Wage Group by Mode and Place Typology Over Time (Chapter 3)

Each mode has different levels of attractiveness to jobs by economic and wage group, at different distances from transit stations and also depending on the Place Typology. Perhaps this should not be surprising intuitively but our research confirms that adage that "one size does not fit all." For instance, the Poor MA place type struggled with low job numbers, but all transit modes but SCT gained respectable shares of jobs. At the Low MA place type areas, with the exception of CRT, all job groups were repelled from the station. For their part, High MA Places mostly suffered from competition, with most wage and economic groups competing to be near the stations. These are job destinations for those riding CRT and LRT; they are place destinations for SCT riders, while BRT attracts everyone.

Overall, CRT and BRT did the best in the "Poor MA" neighborhoods. Still growth was miniscule for all transit modes in Poor MA. SCT actually declined at the "Poor MA" level. BRT and LRT had significant growth in job share at the "Low MA" neighborhoods. All modes grew, moreover; SCT and CRT showed modest growth, which was nevertheless disproportionate to the land area of the stations, compared to their share of regional urbanized area. BRT and LRT had significant growth at transit typology level 3, "Mod MA." SCT had strong growth. CRT showed very modest growth, almost remaining flat. At the most urban neighborhood type, SCT had robust growth, and BRT grew at a tremendous rate. LRT showed respectable rates of growth, while CRT was again flat in growth.

Trends for individual modes are as follows.

- Bus Rapid Transit performed well across all station types. The Poor MA type performed at the lowest rate of all types, with the land nearest the station declining in share and land in the next distance bands doing well. BRT systems did the best of all modes in the Poor MA category, implying that it may well be the best option for connecting outlying suburbs to more urban locales and rail transit. The implication for the low response of the market to the BRT station at the Poor MA station type is that the relative lack of walkability, as well as the auto-centric nature of transport leads to a poor response nearest the station, but a more robust response further away from the station. The lack of enthusiasm for the area nearest the station reflects the design conflicts that lead to negative spillovers. Examples include poor street connectivity to the station area and low-density development that does not respond to transit proximity as well as higher density areas.

- CRT also did better than LRT and SCT in the Poor MA station type. It reflected the same negative response at the station, with the neighborhoods beyond the station responding very positively to station proximity. CRT's low response to the high and moderate station types but robust response at the Low MA level reflects that its best applicability at present is in lower-density neighborhoods, with riders being most likely commuters for the light industry and other sectors.

- LRT systems as a whole performed best at the middle of the access and land use mix scale. This is likely due to the large size of these systems, which are usually above ground and not as well-connected to the built environment as the heavy rail systems of cities like New York or Washington, D.C. Further, the streetcar systems of many cities likely pull away some of the returns for LRT in High MA Places, as they are smaller and more amenable in design than lower-level places.

- Streetcar Transit performed well in High MA places. This is due largely to the focus of streetcar systems on the urban core. The scale of the built environment is well-matched to the scale of the SCT system. However, in all but the Office and Education sector groups, the SCT LQ declined at the station, while improving just beyond.

Improving Jobs-Housing Balance Metrics through the Employment-Worker Balance Metric (Chapter 4)
A more accessible workplace translates to a more productive and resilient workforce through potential improvements in work-life balance and overall cost of living, which in turn benefits the firm through higher output. Low EWB scores near transit stations reveal low-hanging fruit for planners who wish to increase economic and housing resiliency. Targeted solutions are needed to increase EWB. The EWB metric is consistent with economic development theory whereby regions in which workers have greater TOD-driven access to firms also provide a more business-friendly environment with increased *situs* via a more accessible, active workforce. When appropriate housing is provided for workers of all sectors of the economy, greater economic diversification is possible.

The policy implications of increasing employment-worker balance depend upon the nature of Place Typology imbalance that needs correction. In neighborhoods that are job-rich and housing poor for a lower- to moderate-income worker, challenges may include potential for local opposition from businesses that benefit from larger numbers of workers than residents, businesses seeking to protect their market share from newcomer firms, or from residents who fear negative externalities of lower or moderate-income housing development in their neighborhoods. Neighborhoods with upper-income jobs that seek to improve EWB may face gentrification pressures. Bedroom communities for blue-collar workers needing more jobs may face challenges from industrial externalities.

CHAPTER 2: The Link between Transit Station Proximity and Typology and Change in Jobs Over Time

OVERVIEW

The research reported in this chapter expands upon previous work by assessing the extent to which jobs by sector are attracted to transit stations over time and across a range of station area intensities. Analysis is given of the land area encompassed by transit systems by mode and station type. Using economic base theory and relying upon shift-share and location quotient analyses, the economic development outcomes of station areas are assessed by transit mode, such as light rail, and by station typology. Transit modes include light rail transit, commuter rail transit, streetcar transit, and bus rapid transit systems. The station area types are characterized as lying somewhere along a continuum of land use mix, intensity, and accessibility. These types are based upon the relative intensity of a combination of characteristics of jobs, households, and the built environment. The analysis will advance the understanding of how transit stations by type effect the economy in a multimodal transportation system context. Case studies comprise metropolitan areas across the United States, in the Urbanized Area of the counties served by the transit systems under study. Each station area is analyzed by distance from the station in eighth-mile distance bands.

Introduction

Several of our previous studies (Arthur C Nelson 2017b; A. Nelson et al. 2015; Arthur C Nelson and Ganning 2015; A.C. Nelson et al. 2015; A. Nelson et al. 2013; Petheram et al. 2013; Arthur C Nelson 2017a; Arthur C. Nelson and Hibberd 2019; Arthur C Nelson and Hibberd 2019) focused on the economic outcomes of transit station proximity. These studies especially focused on economic base theory, and particularly shift-share analysis. They analyzed economic development, demographic and housing outcomes associated with those transit systems. Many focused on the period before the Great Recession (2000 through 2009) and during recession into and beyond the years of recovery (2010 through 2016).

The present work builds upon those previous studies, extending them to include segmentation of previous variables by transit station typology. The typology is based upon clustering of values in a series of characteristics indicative of the intensity and density of population, jobs, and housing. It also includes density and connectivity of street intersections. Each class (cluster) of station area represents a combination of characteristics that is unique from the other classes. Our methodology focuses on making associations and correlations, rather than causal relationships.

Our study includes transit systems of several different modes in metropolitan areas across the United States. Those modes include Bus Rapid Transit (BRT), Commuter Rail Transit (CRT), Light Rail Transit (LRT), and Streetcar Transit (SCT). These modes present different technologies and intensities of transport. Each mode, as the study will demonstrate, functions differently across the spectrum of land use mix, intensity, and accessibility.

Table 2.1
Fixed Route Transit (FRT) Systems Studied

Light Rail Transit	Year	Bus Rapid Transit	Year	Streetcar Transit	Year	Commuter Rail Transit	Year
Buffalo	1984	Cleveland	2008	Atlanta	2014	Albuquerque-Santa Fe	2006
Charlotte	2007	Eugene-Springfield	2007	Cincinnati	2016	Austin	2010
Cleveland	1980	Kansas City	2005	Dallas	2015	Dallas-Ft. Worth	1996
Dallas	1996	Nashville	2009	Kansas City	2016	Miami Tri-Rail	1989
Denver	1994	Pittsburgh	1977	Little Rock	2004	Minneapolis	1997
Houston	2004	Reno	2010	New Orleans	2016	Nashville	2006
Minneapolis-St. Paul	2004	Salt Lake City	2008	Portland	2001	Orlando	2014
Norfolk	2011	San Antonio	2012	Salt Lake City	2013	Portland	2009
Phoenix	2008	San Diego	2014	Seattle	2007	Salt Lake City	2008
Pittsburgh	1984	Seattle	2010	Tacoma	2003	San Diego	1995
Portland	1986	Stockton	2007	Tampa	2002	San Jose-Stockton	1998
Sacramento	1987			Tucson	2014	Seattle-Tacoma	2000
Salt Lake City	1999			Washington, D.C.	2016		
San Diego	1981						
San Jose	1987						
Seattle	2003						
St. Louis	1993						

Of the transit modes studied, light rail transit systems have the longest heritage. Several cities opened LRT operation in the early 1980s. Commuter Rail systems began opening in the 1990s. With the exception of Pittsburgh's long-standing BRT system of the late 1970s, SCT and BRT systems began opening only after the turn of the century. The more recent transit systems are BRT and SCT.

The land area encompassed by transit stations varies by transit mode and station type. We measure station area to a distance of one mile (referred to below as a one-mile distance band). Transit stations' square miles within the Urbanized Area are broken down by distance bands. These bands are one-eighth mile bands to half a mile from the stations, then by quarter-mile distances to one mile. Table X sums all stations by mode and type for all metropolitan areas under study.

For all transit system modes, the land area within a mile of the stations increases with land use intensity, with exception of the commuter rail (CRT), which has much more land in the lower half of the land use mix and accessibility scale. CRT has the most land area in the Poor MA and Low MA types, while LRT has the most land area in the Mod MA and High MA station areas. SCT has the smallest spatial footprint, with a maximum of 79 square miles total in the High MA station type for all studied regions.

The Urbanized Area totals for each mode speak to their function within the regional transportation systems of each region. Overall sums for square miles within Urbanized Areas are as follows: SCT and BRT at approximately 14,000 square miles each; LRT at 30,000 and CRT at roughly 42,000 square miles. The limited area encompassed by the first two modes relative to the last two hint at the difference in scope for these modes. Highlighting the individual metropolitan regions' area figures reveals that the variation in scope for each transit mode is significant between each region. BRT ranges from a low 111 square miles in Eugene, OR to 2,700 square miles in the Washington, D.C. region. Only four of the metropolitan regions studied had more a thousand square miles devoted to BRT, while the rest average roughly 500 square miles. Likewise, large-scale regional SCT systems, those of approximately 2,000 square miles each, were limited to four regions, with the remaining regions' systems being much smaller in area, at an average of roughly 600 square miles. CRT and LRT systems for each region averaged a much larger area per region. The largest CRT system, for Washington, D.C., is nearly 17,000 square miles, and the largest LRT system, for Dallas, is nearly 8,000 square miles. Only two of the CRT systems are under 1,000, while LRT systems vary much more in area. A closer look at the number of stations versus the length of the routes would provide further insight on these figures.

Table 2.2
Square Miles in Urbanized Area by Station Typology for all transit systems to 1 Mile from Station – Incremental (Increm.) and Cumulative (Cum.) Square Miles

		SCT		*LRT*		*CRT*		*BRT*	
Station Types	*Distance Bands*	*Increm. Square Miles*	*Cum. Square Miles*	*Increm. Square Miles*	*Cum. Square Miles*	*Increm. Square Miles*	*Cum. Square Miles*	*Increm. Square Miles*	*Cum. Squar e Miles*
Poor MA	0.125	2	2	3	3	10	10	15	15
	0.25	6	8	19	22	30	40	20	35
	0.375	10	18	20	42	51	91	22	57
	0.5	4	22	5	46	71	162	24	81
	0.75	4	25	8	55	205	367	53	134
	1	10	35	48	103	277	644	57	191
Low MA	0.125	11	11	45	45	17	17	27	27
	0.25	4	15	9	55	51	68	44	71
	0.375	5	19	14	68	81	149	49	120
	0.5	11	30	69	137	105	254	51	171
	0.75	10	40	56	193	261	515	102	273
	1	3	44	10	203	307	822	98	371
Mod MA	0.125	5	5	18	18	9	9	23	23
	0.25	12	16	80	98	25	33	38	61
	0.375	10	26	61	159	38	71	39	100
	0.5	3	29	10	169	47	118	36	136
	0.75	9	38	46	215	110	229	61	196
	1	25	62	172	386	124	352	50	246
High MA	0.125	19	19	124	124	1	1	4	4
	0.25	4	23	19	143	3	3	7	11
	0.375	10	33	56	199	4	7	6	17
	0.5	24	58	173	372	5	12	5	22
	0.75	18	75	116	488	12	24	8	30
	1	3	79	17	504	14	38	6	36

Table 2.3
BRT Square Miles of Urbanized Area by Region

Metropolitan Areas with Bus Rapid Transit	*Urbanized Area Sq. Miles for Transit-Served Counties*
Albuquerque, NM	254.0
Cleveland, OH	778.4
Eugene, OR	111.1
Kansas City, MO-KS	730.2
Minneapolis-St. Paul, MN	2,225.5
Nashville, TN	579.6
Pittsburgh, PA	1,938.0
Reno, NV	180.1
Salt Lake City, UT	278.1
San Antonio, TX	608.3
San Diego, CA	780.6
San Jose, CA	617.6
Seattle-Tacoma, WA	2,263.7
Stockton, CA	158.1
Washington, DC	2,697.7
Grand Total	*14,201*

Table 2.4
CRT Square Miles of Urbanized Area by Region

Metropolitan Areas with Light Rail	*Urbanized Area Sq. Miles for Transit-Served Counties*
Albuquerque-Santa Fe, NM	651.1
Austin, TX	1,081.7
Dallas-Fort Worth, TX	3,932.8
Denver, CO	1,362.6
Miami, FL	3,960.4
Minneapolis-St. Paul, MN	3,376.3
Nashville, TN	1,188.2
Orlando-Deltona, FL	1,795.8
Portland, OR	1,094.6
Salt Lake City-Ogden-Provo, UT	1,450.3
San Diego, CA	780.6
San Jose-Stockton, CA	1,061.8
Seattle-Tacoma, WA	3,342.6
Washington, DC	16,624.4
Grand Total	*41,703.2*

Table 2.5
LRT Square Miles of Urbanized Area by Region

Metropolitan Areas with Light Rail	*Urbanized Area Sq. Miles for Transit-Served Counties*
Buffalo, NY	403.55
Charlotte, NC	957.73
Cleveland, OH	778.40
Dallas, TX	7,810.96
Denver, CO	3,422.63
Houston, TX	1,694.23
Los Angeles, CA	2,111.32
Minneapolis-St. Paul, MN	2,225.55
Phoenix, AZ	1,261.74
Pittsburgh, PA	967.62
Portland, OR	1,645.59
Sacramento, CA	488.04
Salt Lake City, UT	278.08
San Diego, CA	780.58
San Jose, CA	331.53
Seattle-Tacoma, WA	1,089.45
St. Louis, MO	2,832.58
Virginia Beach-Norfolk, VA	589.08
Grand Total	*29,668.66*

Table 2.6
SCT Square Miles of Urbanized Area by Region

Metropolitan Areas with Light Rail	*Urbanized Area Sq. Miles for Transit-Served Counties*
Atlanta, GA	2,681.4
Cincinnati, OH	806.3
Dallas, TX	1,963.5
Kansas City, MO-KS	730.2
Little Rock, AR	262.0
New Orleans, LA	539.3
Portland, OR	551.0
Salt Lake City, UT	278.1
Seattle-Tacoma WA	2,168.4
Tampa, FL	1,038.5
Tucson, AZ	402.1
Washington, DC	1,348.9
Grand Total	*12,770*

Table 2.7
Sums of Square Miles for 1-Mile Distance Bands for All MSA's

	SCT		*LRT*		*CRT*		*BRT*	
1-Mile DB Area	*Increm. Square Miles*	*Cum. Square Miles*	*Increm. Square Miles*	*Cum. Square Miles*	*Increm. Square Miles*	*Cum. Square Miles*	*Increm. Square Miles*	*Cum. Square Miles*
Poor MA	10	35	48	103	277	644	57	191
Low MA	3	44	10	203	307	822	98	371
Mod MA	25	62	172	386	124	352	50	246
High MA	3	79	17	504	14	38	6	36
Sums	41	220	247	1,196	722	1,856	211	844

The sums for square miles at a one-mile distance band for each station type gives a clearer picture of the extent of the systems across the country by mode. CRT systems had the highest figures in both incremental and cumulative area for each station type (see Table X). SCT had significantly less area than the other modes for all station types. The incremental area by station typology gives a sense for what typology is most prominent for each transit mode. SCT has the most area in the Mod MA type; LRT also has the most area in the Mod MA type. CRT has the most in the Low MA and Poor MA types. BRT is concentrated mainly in the Mod MA station type. Three transit modes have the most area in the Mod MA, while CRT is concentrated more in the Low MA type.

Literature Review and Research Questions

Studies on outcomes to station proximity that have disaggregated by station mode and typology are non-existent. Also needed is research that provides a way to predict transit station development outcomes based on transit station planning and design. However, what we do know is that ineffective station design and linkage to surrounding neighborhoods significantly impacts, even hinders, station access. The market responds in kind. Were it not for present barriers in design and planning, a substantial portion of urban growth since 2010 could have been absorbed within the first half-mile distance from stations; there yet remains a great deal of room for development within those neighborhoods, much of which are comprised of vacant or dated retail astride vast seas of empty parking lots (Arthur C. Nelson and Hibberd 2019), (Arthur C. Nelson 2013).

Our study focuses on transit-served regions (i.e., counties or multiple counties directly served by transit via the presence of a transit station; hereafter referred to as “Transit Regions”).The *Nelson-Stoker-Hibberd Resilience Hypothesis* (Arthur C. Nelson, Stoker, and Hibberd 2019) posited that the Great Recession’s economic shocks upon Transit Regions lead firms, especially in key economic sectors, to seek to reduce vulnerability to possible subsequent shocks by relocating their firms nearer to transit stations. Our 2019 study on transit systems at a systemwide scale confirmed this hypothesis. For our present study, we will further disaggregate transit systems into a hierarchy of station area types, from low-density suburban to high-intensity urban core. More accurately, we will segment land use by relative level and intensity of accessibility and land use mix. We expect that this disaggregation will reveal results that stand counter to our earlier results, which is a common occurrence in studies employing methodological refinements. We will study a range of transit systems (see Table X.1).
We are concerned with changes in the number and share of jobs by sector with respect to type of transit system and distance from stations, by type of station. Specifically, we want to know:

> ***Is there a link between transit station proximity and change in workers by economic sector across a hierarchy of station area land use mix and accessibility types from 2010 to 2016?***

Our hypothesis is that station proximity will result in a wide variety of outcomes, depending upon the regional economy, the land use intensity of the station area, and the local job sector and income mix. We hypothesize that each transit mode will serve different areas of the region and different sectors of the economy and the worker population. SCT will depend highly upon more urban areas, while CRT and BRT will serve outlying areas. LRT will serve primarily areas in the middle of the urban range. This means further that each mode will serve a particular range of job sectors.

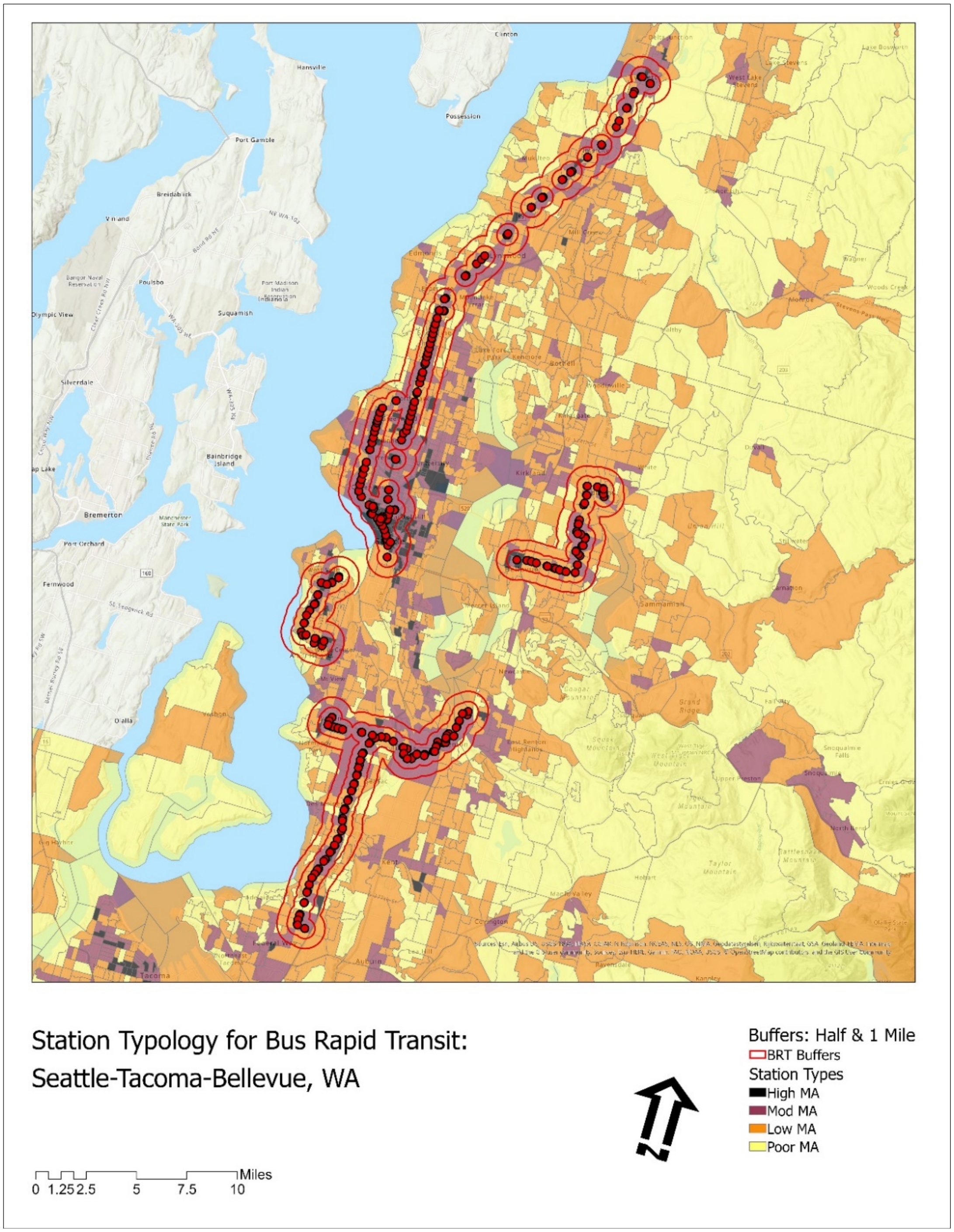

Figure 2.1
Bus Rapid Transit Station Area Typology, with buffers at half-mile and 1-mile distances from the station

Distance bands are based upon Euclidean distance from the edge of the census block group to the transit station centroid. Block groups classified to each distance band may have area that extends into other distance bands. Station Typology is classified by relative scores along continuum from poor to high land use mix / accessibility (seen on map legend as "Poor MA," etc.). Seattle's BRT systems is one of the most extensive in the USA. The typology map shows specific stations that may provide ready opportunities for targeted development.

Research Design and Plan

Our research design and plan include using GIS data and analyses to join transit stations and buffers, representing eighth-mile distance bands around each station, to a layer of land use intensity. These data allow the segmentation of the station areas, their environs, and their regions into relative land use mix and intensity. We call these place types. US census data provide job figures over time by sector, income and other categorizations. Economic base analysis is used to analyze the shift in share and relative local concentration of jobs near the station viz-a-vis the transit-served region surrounding the study transit systems.

Data Resources

The employment data come from the US Census Bureau's Longitudinal Employer-Household Dynamics data (LEHD) for 2010 and 2016. Transit system data come from the General Transit Feed Specification (GTFS).[1] Census blocks were downloaded from IPUMS HGIS website (##). Station typology data are outlined below.

Transit Station Typology – Place Types

To evaluate by place types, we aggregate the following built environment variables to the census block group, and then apply a data clustering method:

Longitudinal Employer-Household Dynamics (LEHD, 2017)

- Total jobs per acre
- Proportion of jobs that are retail or entertainment

American Community Survey (ACS, 2017, 5-year)

- Total residential population per acre
- Total households per acre
- Proportion of households with no kids (representing smaller dwelling units)
- Proportion of households that are owner occupied

Smart Location Database[2]

- Intersection density (an indication of connectivity)
- Proportion of intersections that are three-way to those that are four-way (an indication of connectivity)

We apply Jenks natural breaks to each variable to segment the spectrum of variables. Each "break" is ranked in terms of the urban intensity of the categories. The lowest density category has a score of 1, while the highest has a 5. The sum of these rankings, summing all variables together, provides an indication of the level of urban intensity and concentration for each block group. The sum of rankings is then divided into the number of categories of interest. For this study, we aggregated the place types into four categories labeled from 1 = most suburban to 4 = highly urban. An iterative verification process rotated between testing variables and ground-truthing them through spatial mapping and observations using Google Streetview. Figure 2 shows a map of LRT stations in the St. Louis metropolitan area. It demonstrates that many stations consist of multiple land use types, indicating that different land use intensities and mixtures occur in different sectors of the station area, even within a 1-mile DB of the station. We calculate each station type separately in our analysis of economic change.

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[1] See TransitFeeds.com for downloadable tables, which get regular updates.

[2] See https://www.epa.gov/smartgrowth/smart-location-mapping. Accessed 11-25-2020. Note that while this data is older, intersection density is not something that widely changes from decade to decade in most of the areas that are already developed enough to have FRT.

Shift-Share Method

Economic development is often analyzed using economic base theory and measures spatial concentrations of jobs by sector or other segmentations, as well as their spatial and temporal dynamics. Shift-share analysis compares change of employment concentrations at the "regional" level, which is defined by the analyst at a chosen scale (e.g., national, state, or county), with changes in concentrations at the "local" level, which can also be defined at various scales by the analyst. The study assigns "transit-served" counties as regions (those counties with access to a transit system) and assigns transit neighborhoods as the "local" scale. The transit neighborhoods are further segmented into distance bands away from the station, in increments of one-eighth or one-quarter mile, up to a distance of 1 mile from the transit station centroid. The analytic method isolates the various sources of job change into 3 categories: 1) the **Transit Region Share**, which references overall economic dynamics at the regional scale 2) the **Industry or Job Sector Mix**, which accounts for job dynamics as a result of change in a specific industry, and 3) **FRT Station Shift**, also called the "competitive effect," which measures the degree of change at the local spatial scale of the transit station neighborhood. It measures the station's lagging and leading job sectors by isolating station area economic trends from those at the regional scale. The shift-share formula is as follows (Carnegie Mellon n.d.):

$$SS_i = TR_i + SM_i + FRT_i$$

Where

SS_i = Shift-Share

TR_i = Transit Region share

SM_i = Sector Mix

FRT_i = FRT Station Shift

Each component is calculated with the following equations:

$TR = ({}_i\text{FRT Station Area}^{t-1} \times TR^{t} / TR^{t-1})$ (5-2)

$SM = [({}_i\text{FRT Station Area}^{t-1} \times {}_iTR^{t} / {}_iTR^{t-1}) – TR]$ (5-3)

$FRT = [{}_i\text{FRT Station Area}^{t-1} \times ({}_i\text{FRT Station Area}^{t} / {}_i\text{FRT Station Area}^{t-1} – {}_iTR^{t} / {}_iTR^{t-1})]$ (5-4)

Where:

${}_i$FRT Station Area = number of jobs in the FRT Station Area sector (i) at the beginning of the analysis period (t-1)

${}_i$FRT Station Area^{t} = number of jobs in the FRT Station Area in sector (i) at the end of the analysis period (t)

TR^{t-1} = total number of jobs in the Transit Region at the beginning of the analysis period(t-1)

${}_iTR^{t}$ = total number of jobs in the Transit Region at the end of the analysis period (t)

iTR = number of jobs in the Transit Region in sector (i) at the beginning of the analysis period (t-1)

${}_iTR^{t}$ = number of jobs in the Transit Region in sector (i) at the end of the analysis period (t)

Location Quotients

Location Quotients (LQ) provide a spatial concentration measure that compares local concentrations of phenomena with a regional or global concentration of the same phenomena. For this study, transit station areas by eighth-mile distance bands provide the local context, while “transit-served counties,” or counties and groups of counties that are served by transit systems, provide the regional context. LQ metrics, along with shift-share analyses, are a proven methodological staple of economic development studies. The effectiveness of these methodologies at providing evidence of economic development highlight the spatial nature of the economy. Transit systems serve to provide network connectivity across local economies, connecting the geographies highlighted by these methodologies.

Results and Discussion

In our 2019 report, we discussed an emerging theme, which follows *the Nelson-Hibberd-Stoker Resilience Hypothesis*—that neighborhoods proximate to transit stations will attract and absorb many times more workers than the urbanized area of the same Transit Region. This study supports that hypothesis. However, results greatly vary by transit mode (e.g., SCT or LRT) and station type on the continuum from poor to high access and land use mix. BRT is proving to be the most versatile to changes in land use intensity. CRT and LRT are more successful in middle urban intensities, while SCT shines the brightest at the highest level of urban intensity.

The most significant growth in job share within half a mile of the station of all systems and station types occurred in BRT systems at the moderate level of station area accessibility and land use mix. The next-most successful near the station, within a half-mile distance, was LRT at the more moderate levels of station intensity. These also performed best of all the categories at the eighth-mile distance band. SCT outperformed the other modes in the High MA station areas both at the eighth mile and the half-mile distances from the stations. It brought significant gains in share in areas that were already highly developed, suggesting a shift in share of jobs that is not completely dependent upon development.

Station Type 1: Poor Land Use Mix & Accessibility (Poor MA)

We shall review total employment growth trends across each transit mode, considering modes in order of highest to lowest growth trends for the study period. In Poor MA BRT station areas across the study regions, the trend of total workers declined for the first half-mile from the station. For CRT and LRT at the distance band just beyond the station, from one-eighth of a mile to one-quarter, the growth was small but positive. The other modes experienced no growth or loss of job share growth at the first DB. These neighborhoods may represent regionally outlying areas, but they often represent neighborhoods just beyond more intensely developed land, with which they are competing for land use intensity.

- CRT: The Poor MA station types for the CRT systems, saw the highest overall growth of the four transit modes, with most one-eighth mile distance bands (DBs) growing by several thousand jobs between 2010 and 2016. While these stations account for half a percent of the regional total Urbanized Area (UA), job growth was slightly higher, at 0.58%. So, CRT remained in positive growth even in outlying areas with very low levels of land use mix and accessibility.
- LRT: The response to LRT station proximity in Poor MA locations was modest but positive overall. These station areas, to the half-mile DB, comprised 0.2% of their regions' Urbanized Area and gained 0.25% of the regional growth in total jobs.
- SCT systems in Poor MA station areas comprised a very small percentage of the urbanized land use in their regions. They stayed relatively flat in growth, with a loss of about one-tenth of one percent, which was a loss of 577 jobs in the first half-mile DB.
- BRT: The Poor MA neighborhoods near BRT stations, at a half-mile distance from the stations, accounted for less than 1 percent of the regional Urbanized Area, at 102 square miles. In these neighborhoods, BRT saw a modest loss of regional share of employment growth from 2010 to 2016.

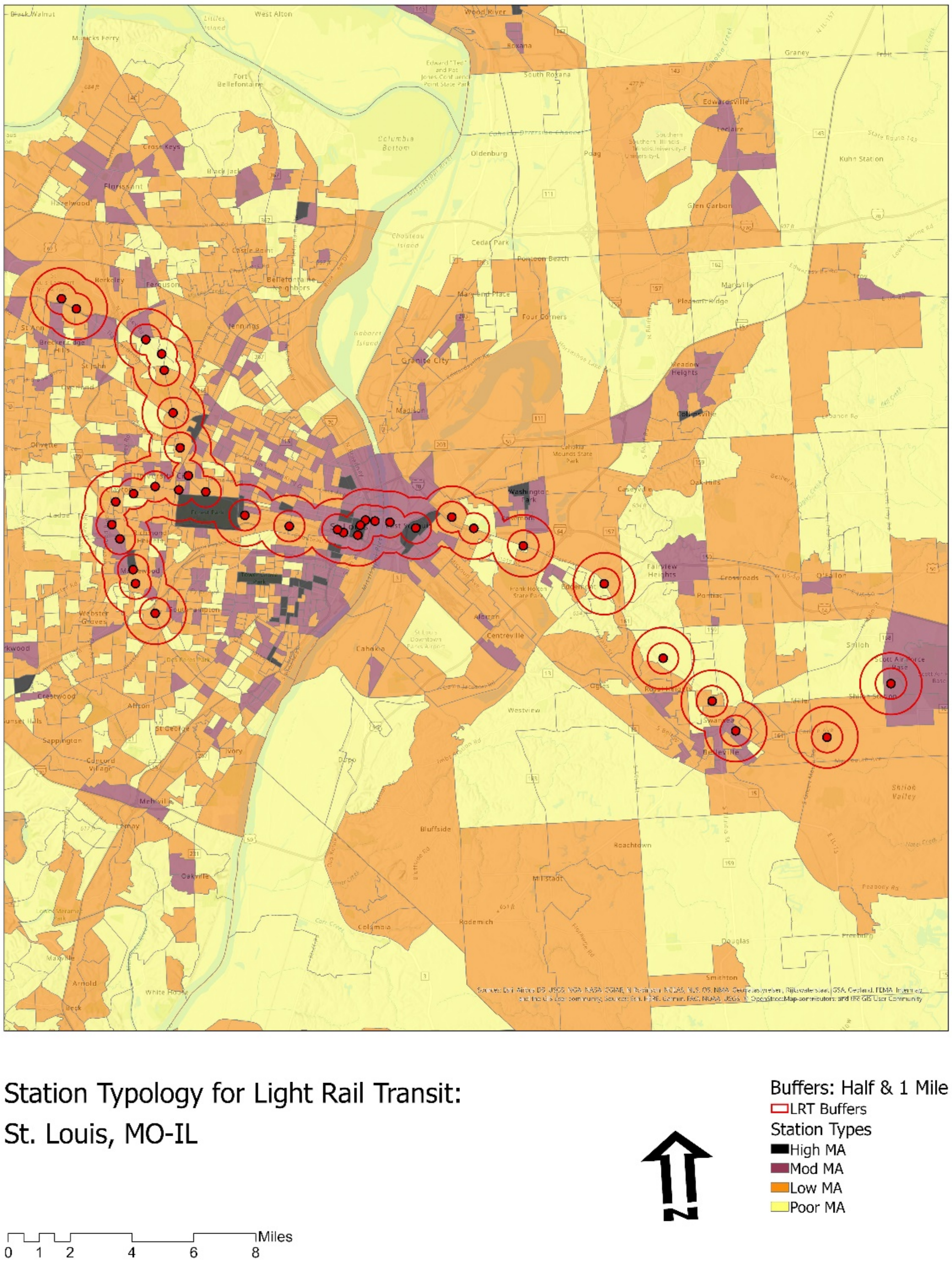

Figure 1.1
St. Louis LRT stations contain all of the four station types.
Many stations have multiple types. In outlying areas, for example, there are stations that range from Mod MA to Poor MA within the 1-mile distance band around a station.

The firms in these areas responded to the kind of transit mode at hand. CRT and LRT each picked up thousands of jobs with a half-mile DB of the stations, while BRT and SCT saw mild losses. These results speak partly to the design of the transit modes, but mainly they indicate the challenge that transit has in general of attracting use in dispersed-intensity areas of the region. It also indicates some major opportunities in these neighborhoods to attract further growth very near the transit station (Renne et al. 2016). This kind of growth will increase the economic resilience of more outlying areas. The challenge then becomes to increase these areas' land use mix and accessibility sufficiently to attract viable transit options while maintaining the local populations' desired sense of place. Main Street projects have been occurring around the country in an attempt to retrofit these areas in appropriate ways (Dunham-Jones and Williamson 2011).

Station Type 2: Low Land Use Mix & Accessibility (Low MA)
Growth was much more robust in Low MA station type areas than in Poor MA areas. All four transit modes achieved growth. Those most suited to a lower-intensity land use environment again saw the highest gains in regional job share.

- BRT, at 1.5% of the regions' UA, achieved 11% of the regional share of job growth. This is the highest rate of growth for the transit modes in Low MA neighborhoods. It indicates that BRT is capturing far more share of regional job growth than could be indicated by the land area it utilizes.
- LRT, with 0.5% of the regions' UA, captured the next highest level of growth, which was 6.15% of regional share of job growth. LRT thrives best, according to the numbers, in mid-level land use intensities. This may be due to the typical size of LRT systems. They are of higher capacity than BRT and SCT, and therefore provide economies of scale in appropriately scaled neighborhoods. They attract less growth in areas that are too dispersed or too concentrated.
- CRT, at 0.7% of the regions' UA, achieved 2.25% of regional job growth share, which is near 50,000 total jobs just within the first half-mile DB from these stations, and a rate considerably higher than the station area proportion of the regions.
- SCT only encompassed 0.3% of UA for its regions but captured 1.6% of job growth share. The streetcar suburbs of New Orleans provide a great example of areas of relatively modest land use intensity and mix that can still benefit from proximity to SCT stations. Like LRT, SCT does less well in Poor MA than in Low MA neighborhoods.

Even at this relatively low level of land use intensity, all four transit modes absorbed disproportionate numbers of jobs relative to their respective regions. BRT and LRT saw significantly robust growth, while CRT and SCT growth rates were more modest. These percentages represent considerable numbers of jobs. For the first half-mile DB, the figures, were approximately as follows: 73,000 for BRT, 48,700 for CRT, 95,000 for LRT, and 8,400 for SCT. These figures provide a picture of which systems are most suited to a Low MA neighborhood context. SCT grew the least, while LRT and BRT saw notable growth and CRT fared well.

Table 2.8
Change in Total Workers 2010-2016 for all FRT Modes, Poor MA Station Type

Distance Band	Transit Region UA (sq.mi.)	Type 1 Station Distance Band UA (sq.mi.)	Type 1 Station DB Share of Transit Region UA	Type 1 Station Area Worker Change 2010-2016	Station Share of Regional Worker Change 2010-2016
Change in Total Workers by Time Period for BRT					
0.00-0.125	14,201	15	0.1%	(7,425)	-1.09%
0.125-0.25	14,201	20	0.1%	4,395	0.64%
0.00-0.25	14,201	35	0.2%	(3,030)	-0.44%
0.25-0.50	14,201	67	0.5%	(1,496)	-0.22%
0.00-0.50	14,201	102	0.7%	(4,526)	-0.66%
Transit Region				682,029	
Change in Total Workers by Time Period for CRT					
0.00-0.125	41,703	10	0.02%	8,373	0.39%
0.125-0.25	41,703	30	0.1%	(1,213)	-0.06%
0.00-0.25	41,703	40	0.1%	7,160	0.33%
0.25-0.50	41,703	152	0.4%	5,417	0.25%
0.00-0.50	41,703	192	0.5%	12,577	0.58%
Transit Region				2,164,974	
Change in Total Workers by Time Period for LRT					
0.00-0.125	29,669	3	0.0%	4,200	0.27%
0.125-0.25	29,669	19	0.1%	804	0.05%
0.00-0.25	29,669	22	0.1%	5,004	0.32%
0.25-0.50	29,669	44	0.1%	(1,104)	-0.07%
0.00-0.50	29,669	66	0.2%	3,900	0.25%
Transit Region				1,540,751	
Change in Total Workers by Time Period for SCT					
0.00-0.125	12,770	2	0.02%	0	0.0%
0.125-0.25	12,770	6	0.05%	78	0.01%
0.00-0.25	12,770	8	0.1%	78	0.01%
0.25-0.50	12,770	20	0.2%	(655)	-0.12%
0.00-0.50	12,770	28	0.22%	(577)	-0.11%
Transit Region				540,545	

Table 2.9
Change in Total Workers 2010-2016 for all FRT Modes, Low MA Station Type

Distance Band	Transit Region UA (sq.mi.)	Type 2 Station Distance Band UA (sq.mi.)	Type 2 Station DB Share of Transit Region UA	Type 2 Station Area Worker Change 2010-2016	Station Share of Regional Worker Change 2010-2016
Change in Total Workers by Time Period for BRT					
0.00-0.125	14,201	27	0.2%	33,253	4.88%
0.125-0.25	14,201	44	0.3%	14,011	2.05%
0.00-0.25	14,201	71	0.5%	47,264	6.93%
0.25-0.50	14,201	144	1.0%	25,654	3.76%
0.00-0.50	14,201	215	1.5%	72,918	10.69%
Transit Region				682,029	
Change in Total Workers by Time Period for CRT					
0.00-0.125	41,703	17	0.04%	30,363	1.40%
0.125-0.25	41,703	51	0.1%	6,006	0.28%
0.00-0.25	41,703	68	0.2%	36,369	1.68%
0.25-0.50	41,703	237	0.6%	12,295	0.57%
0.00-0.50	41,703	305	0.7%	48,664	2.25%
Transit Region				2,164,974	
Change in Total Workers by Time Period for LRT					
0.00-0.125	29,669	45	0.2%	55,649	3.61%
0.125-0.25	29,669	9	0.03%	15,048	0.98%
0.00-0.25	29,669	54	0.2%	70,697	4.59%
0.25-0.50	29,669	92	0.3%	23,985	1.56%
0.00-0.50	29,669	146	0.5%	94,682	6.15%
Transit Region				1,540,757	
Change in Total Workers by Time Period for SCT					
0.00-0.125	12,770	11	0.1%	5,561	1.03%
0.125-0.25	12,770	4	0.03%	2,033	0.38%
0.00-0.25	12,770	15	0.1%	7,594	1.40%
0.25-0.50	12,770	20	0.2%	841	0.16%
0.00-0.50	12,770	35	0.3%	8,435	1.56%
Transit Region				540,545	

Station Type 3: Moderate Land Use Mix & Accessibility (Mod MA)
Firms in Mod MA neighborhoods saw growth; some transit systems had considerable growth, while others were more modest. Neighborhoods near BRT stations saw great gains in total workers, considerably above the percentage of regional UA. The CRT systems in these station areas faired most modestly but saw some growth overall. These results may indicate that the market is drawn towards systems of greater flexibility (LRT and BRT) across the land use continuum. CRT and SCT both may be limited by their size to certain areas of the region, especially as competition from BRT systems grows.

- BRT-proximate neighborhoods saw the highest employment growth, at a very strong 17.6% of total regional growth share with a half-mile of the station. These station areas accounted for only 1.2% of total regional urbanized land area. The number of jobs added was 120,117.
- LRT station areas within a half-mile DB from the station saw the next-highest growth rate, at 8.3%, also a very strong rate of employment growth. Accounting for less than 1% of the total urbanized land area of their respective regions, these stations attracted jobs at a disproportionate rate compared to the rest of the region.
- SCT: The next-highest rate of growth occurred in the SCT-proximate neighborhoods of their respective regions. At a slightly negative rate of growth, the SCT station areas repelled less than a proportional share of regional employment growth. They comprised 0.2% of the urbanized area of the regions.
- CRT had flat growth in the moderate-intensity neighborhoods. At 0.6% growth CRT grew slightly faster than the rest of the region, of which it comprised 0.3% of the urbanized land area of the respective regions. These results may be indicative of multiple challenges. First, each station usually consists of more than station typology, and the land with the most effective station type (or, in other words, land use type) may be outcompeting the other types.

Table 2.10
Change in Total Workers 2010-2016 for all FRT Modes, Mod MA Station Type

Change in Total Workers by Time Period for BRT

Distance Band	Transit Region UA (sq.mi.)	Type 3 Station Distance Band UA (sq.mi.)	Type 3 Station DB Share of Transit Region UA	Type 3 Station Area Worker Change 2010-2016	Station Share of Regional Worker Change 2010-2016
0.00-0.125	14,201	23	0.2%	75,322	11.04%
0.125-0.25	14,201	38	0.3%	12,950	1.90%
0.00-0.25	14,201	61	0.4%	88,272	12.94%
0.25-0.50	14,201	113	0.8%	31,845	4.67%
0.00-0.50	14,201	174	1.2%	120,117	17.6%
Transit Region				682,029	
Change in Total Workers by Time Period for CRT					
0.00-0.125	41,703	9	0.02%	3,492	0.16%
0.125-0.25	41,703	25	0.1%	890	0.04%
0.00-0.25	41,703	34	0.1%	4,382	0.20%
0.25-0.50	41,703	110	0.3%	8,004	0.37%
0.00-0.50	41,703	144	0.3%	12,386	0.57%
Transit Region				2,164,974	
Change in Total Workers by Time Period for LRT					
0.00-0.125	29,669	18	0.1%	64,225	4.17%
0.125-0.25	29,669	80	0.3%	21,360	1.39%
0.00-0.25	29,669	98	0.3%	85,585	5.55%
0.25-0.50	29,669	151	0.5%	41,995	2.73%
0.00-0.50	29,669	249	0.8%	127,580	8.28%
Transit Region				1,540,757	
Change in Total Workers by Time Period for SCT					
0.00-0.125	12,770	5	0.04%	16,194	3.00%
0.125-0.25	12,770	12	0.1%	6,786	1.26%
0.00-0.25	12,770	17	0.1%	22,980	4.25%
0.25-0.50	12,770	25	0.2%	5,144	0.95%
0.00-0.50	12,770	42	0.3%	28,124	5.20%
Transit Region				540,545	

Station Type 4: High Land Use Mix & Accessibility (High MA)
At the highest level of land use mix, intensity and accessibility, growth tapered off while continuing at a good clip for most modes. The land use intensity and the related constraints can be seen in the results: BRT and SCT grew the most, while LRT grew modestly, and CRT remained flat. Still, growth in the High MA neighborhoods near transit stations was at a much larger scale than in the Poor MA in outlying or underdeveloped neighborhoods. While some cities such as Denver and Salt Lake City bring LRT directly into the CBD, others have opted to build SCT systems in the High MA neighborhoods, which provide the kind of land use from which SCT systems most greatly benefit. CRT faces challenges from the scale of the trains and therefore the stations, as well as noise and air pollution disamenities. BRT has begun competing well with SCT but has to contend for space on congested streets in the urban core.

- BRT also grew significantly at a rate of 6.1% at the half-mile DB from the station. It captured more regional share of growth than its land area, 0.2%, would indicate. It more modest growth relative to SCT may indicate some competition between the two for routes in the CBD.
- LRT: Light rail stations in high mix and accessibility areas comprised 1.3 percent of the urbanized land area in metropolitan areas served by LRT systems. At the same time, the employment growth in those areas represented 1.8 percent of the total regional employment growth. Most of that growth occurred within a quarter mile of those transit stations, 1.24 percent, while the land area only consisted of 0.5% of the regional land area.
- CRT saw flat growth in the highest intensity land use neighborhoods of the CRT-served regions. At the same time, CRT has long been oriented toward taking commuters from outlying areas and delivering them to jobs at the CBD in the urban core of the region. While the highest intensity areas saw flat growth, this may be due to the fact that the CBD is much more built out than the areas from which commuters usually travel to work.
- SCT: Cumulatively at the half-mile distance band, SCT type 4 accounted for 0.5% of the Urbanized Area of the streetcar-served counties in metropolitan areas of the study. While these transit regions increased total workers by 540,545 the half-mile DB obtained 27,251 jobs, or 5 percent of the job growth in these regions.

Table 2.11
Change in Total Workers 2010-2016 for all FRT Modes, High MA Station Type

Change in Total Workers by Time Period for BRT

Distance Band	Transit Region UA (sq.mi.)	Type 4 Station Distance Band UA (sq.mi.)	Type 4 Station DB Share of Transit Region UA	Type 4 Station Area Worker Change 2010-2016	Station Share of Regional Worker Change 2010-2016
0.00-0.125	14,201	4	0.03%	24,773	3.63%
0.125-0.25	14,201	7	0.05%	7,966	1.17%
0.00-0.25	14,201	11	0.1%	32,739	4.80%
0.25-0.50	14,201	18	0.1%	8,846	1.30%
0.00-0.50	14,201	29	0.2%	41,585	6.10%
Transit Region				682,029	

Change in Total Workers by Time Period for CRT					
0.00-0.125	41,703	1	0.002%	3,962	0.19%
0.125-0.25	41,703	3	0.01%	166	0.01%
0.00-0.25	41,703	4	0.01%	4,128	0.20%
0.25-0.50	41,703	12	0.03%	6,394	0.30%
0.00-0.50	41,703	16	0.04%	10,522	0.50%
Transit Region				2,114,955	
Change in Total Workers by Time Period for LRT					
0.00-0.125	29,669	124	0.4%	20,582	1.04%
0.125-0.25	29,669	19	0.1%	3,970	0.20%
0.00-0.25	29,669	143	0.5%	24,552	1.24%
0.25-0.50	29,669	248	0.8%	11,022	0.56%
0.00-0.50	29,669	391	1.3%	35,574	1.79%
Transit Region				1,985,309	
Change in Total Workers by Time Period for SCT					
0.00-0.125	12,770	19	0.1%	18,427	3.41%
0.125-0.25	12,770	4	0.03%	3,514	0.65%
0.00-0.25	12,770	23	0.2%	21,941	4.06%
0.25-0.50	12,770	38	0.3%	5,310	0.98%
0.00-0.50	12,770	61	0.5%	27,251	5.04%
Transit Region				540,545	

Implications for Transit and Land Use Planning

Decomposing transit mode results by land use place types has revealed a considerable range of variation within each transit mode, based upon the place type context of the station area. Each transit mode has its own areas of triumph and challenge.

It seems clear that there are multiple acting forces affecting each other in the shift of employment share and growth near the transit stations of our study. First, the transit station and vehicle design, which is both attracting and obstructing development depending on the context. Second, the nature of the surrounding neighborhood: how well-connected the streets, and the degree of access and land use mix. This factor includes, but also depends upon, the job sector groups that operate in the vicinity of the station, and their relative health over time. The land use mix that is most viable and effective at each station—the job sector mix that functions best—depends to a significant degree upon the accessibility and land use mix existing at the station and its immediate neighborhood. The intensity of development affects what job sectors and transit mode types will be most effective in any area.

In general, returns on transit station proximity correlated positively with the level of land use mix and accessibility. However, transit systems substantially vary in their response to level of mix and accessibility. CRT is more aimed at moderate levels of mix and accessibility. SCT performed best at moderate and high levels. BRT performed best at the “Mod MA” neighborhood level. LRT did best in the mid-range mix and accessibility levels.
For each transit mode:

- BRT proved to be quite flexible to the variations of each place type, showing robust growth across three four place types, shining in the two mid-range classes, while losing share slightly in the lowest-mix areas. This indicates, first, that BRT stations and technology need to adapt to the context of the outlying areas to better attract firms to these station areas. Second, it also may indicate that the challenges from low-density dispersed land use impede the efficient use of these stations, just as is the case for most other transit modes.

- CRT showed mostly modest gains in job share for the Low MA place type stations, to the first half mile. It had flat share gains or slight declines in three of the four place type stations. This might indicate that in these stations the firms are opting for locations farther from the station due to the disamenities involved in this large-scale transit mode, such as noise and air pollution. Newer systems such as that in Salt Lake City, Utah use quieter, less polluting train technology for these commuter-oriented stations. This update may be necessary in other metropolitan areas to attract further job share gain near these stations.

- LRT saw modest growth at the Poor MA station areas but saw great share gains in the Low MA and Mod MA place type areas, with acceptable gains in the High MA areas. This seems reasonable given the scale of the trains, the competition from SCT systems for the most urban land, and the low response to transit proximity in all of the transit mode stations. A great deal of focus could shift to the Poor MA station areas, to increase accessibility in the most outlying areas. This will provide gains across all segments of the transit network. The challenge of cost structures for providing greater-quality LRT may impede gains for the lowest-intensity place type. One option is to consider ways to increase integration of LRT and BRT systems to provide higher-quality transit connections to outlying areas.

- SCT did best in the context for which it was designed, the High MA and Mod MA areas. It did reasonably well in Low MA areas, which may include the streetcar suburbs of New Orleans. It saw a slight loss of job share in the Poor MA place type areas, for reasons that are likely to be similar to the other transit modes. However, the scale of the streetcar transit system, and the capacity of the trains may impact its utility in the most outlying areas. SCT, like LRT, may benefit from efforts at greater integration of BRT and other transport mode to increase the utility of the system for all place types.

We will apply shift share analysis by Place Typology to economic sectors and workers by wage groups in the next chapter.

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CHAPTER 3: The Link between Transit Station Proximity and Typology and Change in Jobs by Economic Groups and Wage Categories Over Time

OVERVIEW

Our research expands upon previous work by assessing the extent to which jobs by wage and economic group are attracted to transit stations over time. Station areas are assessed by transit mode, such as light rail, and by station typology. The types are characterized as lying somewhere along a continuum from low to high land use mix and accessibility. These types are based upon the relative intensity a combination of jobs, households, and the built environment. The analysis will advance the understanding of how transit stations effect the economy in a multimodal transportation system context. It will highlight these trends by wage and economic group stratifications. We allocate jobs by economic sector groups based upon NAICS classifications, and group jobs by wage based upon the salary levels of each sector. This chapter focuses on economic development outcomes first by job sector groups, then by job wage groupings. It follows up with summary findings, implications and recommendations.

Introduction and Literature Review

Agglomeration economies, according to extant research, accrue over time to transit stations. Such economies accrued to ports and railway stations prior to the widespread use of the automobile but were reduced by the automobile's massive and precipitous growth in the early and mid-twentieth century. Urban sprawl was "driven" by the automobile, but as planners and economists have come to realize the negative impacts of sprawling development, efforts have grown to draw back on this trend and return to more efficient, transit-friendly land use patterns. From 2000 to 2010, U.S. metropolitan areas urbanized land area disproportionate to urban population growth (Wilson et al. 2012). Glaeser and Kahn (Glaeser, Edward and Kahn, 2004) argue that while agglomeration economies were dispersed and enervated in part by sprawl, it produced some social benefits, such as reduced travel times and larger homes. As cities have grown, moreover, many population segments have opted out of the larger regions, heading to smaller metropolitan and micropolitan areas, usually in a stepwise pattern down the urban hierarchy to enjoy the benefits of not-too-strong urbanization and its congestion and price disamenities, which have overcome the earlier benefits of automobile-oriented sprawl (D. A. Plane, Henrie, and Perry 2005; David A. Plane 1984). In terms of transit systems, this migration and transfer of population seems to have corresponded with a growth of smaller-scale Fixed-Route Transit (FRT) systems, such as Tucson's streetcar transit system and West Valley City, Utah's Bus Rapid Transit system, both having recently been constructed.

This migration pattern has its impact upon firm location, as well. A variant of this larger-scale pattern has played out within metropolitan regions as firms have followed large segments of the population out of the urban core as they have moved outward from the CBD over the auto-centric decades of the twentieth century, first to the inner-ring suburbs, then the outer suburbs, and then on to the exurbs (the suburbs of the suburbs), with land use and travel time growing in kind. The result is a range of metropolitan region sizes, and a range of neighborhood-scale levels of land use intensity and mix, which affects relative accessibility. Transportation technology and infrastructure in turn influences accessibility by imposing various systemic limitations or failures upon the local and regional land use regime. Congestion caused by excessive reliance upon the automobile is accompanied by a mismatch in most places between land use and fixed-route transit systems, which rely upon the presence of a minimum level of land use efficiency and its concomitant density and intensity.

The urban picture across the United States is a multifarious and dynamic one, with economic, demographic and technological changes all influencing each other. Glaeser et al. (2008) posited that the poor live in cities because of the higher income elasticity of demand for transport relative to elasticity of demand for land: in accordance with the Alonso-Mills-Muth (AMM) urban land use theory, richer consumers will move further from the city in order to gain more land at a cheaper price per area. The model assumes one mode of transport for everyone and that the main cost is travel time (Alonso 1964; Mills 1972; Muth 1969). While of ongoing relevance, this theory has its limitations in application to current urban morphology. Land use regimes are of a wide variety across the metropolitan region. Such variety also exists in the urban economy, and the spatial location of firms, many of which no longer inhabit the CBD. We relax the AMM assumption that all jobs are concentrated in the CBD, and apply the attractive force of the CBD to the transit station areas, theorizing that firms will compete for land near stations in order to benefit from access to the regional transit system.

As research continues to gather evidence, we find economic benefits from urban design that focuses on providing a range of options in land use and transportation infrastructure and technology. Complete Streets projects urge engineering, design, and policies to create streets that serve a multimodal transportation regime.[3] A complete street optimizes all modes of transport together, from walking and bicycling for all segments of the population, including the elderly and those with ADA requirements, to automobiles of all kinds, and increasingly, fixed-route transit systems of a wide range of capacities. Housing markets reap benefits when the Missing Middle housing types (e.g., townhomes and quadplexes) are placed near more traditional single-family homes and high-density apartments (Parolek 2020). These land use and transportation systems interweave and influence each other to create a wide variety of place types and land use intensities across the built environment.

The urban economy should benefit from such an infusion of variety, but we need more evidence of the response of economic groups to the different combinations of transit modes and land use types. Different economic sector groups may benefit from transit proximity differently, and in a range that varies across the transit system modes and transit station typology.
Our research question is as follows:

> ***Is there a link between transit station proximity and change in workers by economic group, and does it vary across the range of transit station area land use mix and accessibility typology between the years of 2010 and 2016?***

We hypothesize that each economic sector group will respond differently to different combinations of land use intensity and transit mode. Some sector groups will prefer smaller-scale transit in highly intense land use areas while others will respond better—by locating disproportionately near transit stations—to heavier, higher capacity transit in areas with more dispersed land use intensities.

Research Design and Plan

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[3] See Smart Growth America's National Complete Streets Coalition website: https://smartgrowthamerica.org/program/national-complete-streets-coalition/. Accessed 11/21/2020.

We apply economic base theory to test our hypothesis through shift-share and location quotient analyses. We ascertain trends in concentration of jobs by sector group and wage group between the years 2010 and 2016 in urban areas across the United States.

Data Resources

The employment data come from the US Census Bureau's Longitudinal Employer-Household Dynamics data (LEHD) for 2010 and 2016. Transit system data come from the General Transit Feed Specification (GTFS).[4] Census blocks were downloaded from IPUMS HGIS website (Steven Manson, Jonathan Schroeder, David Van Riper 2018). Station typology data are outlined below.

Transit Station Typology – Place Types

To evaluate by place types, we aggregate the following built environment variables to the census block group, and then apply a data clustering method:

Longitudinal Employer-Household Survey (LEHD, 2017):

- Total jobs per acre
- Proportion of jobs that are retail or entertainment

American Community Survey (ACS, 2017, 5-year):

- Total residential population per acre
- Total households per acre
- Proportion of households with no kids (representing smaller dwelling units)
- Proportion of households that are owner occupied

Smart Location Database[5]

- Intersection density (an indication of connectivity)
- Proportion of intersections that are three-way to those that are four-way (an indication of connectivity)

We apply Jenks natural breaks to each variable to segment the spectrum of variables. Each "break" is ranked in terms of the urban intensity of the categories. The lowest density category has a score of 1, while the highest has a 5. The sum of these rankings, summing all variables together, provides an indication of the level of urban intensity and concentration for each block group. The sum of rankings is then divided into the number of categories of interest. For this study, we aggregated the place types into four categories labeled from 1 = most suburban to 4 = highly urban. An iterative verification process rotated between testing variables and ground-truthing them through spatial mapping and observations using Google Streetview.

The transit station areas usually contain multiple station place types. As seen in the maps below (Figures X), Austin's CRT stations and Denver's LRT stations consist of multiple land use intensities in different sectors around the transit stations.

Shift-Share Method

[4] See TransitFeeds.com for downloadable

[5] See https://www.epa.gov/smartgrowth/smart-location-mapping. Accessed 11-25-2020. Note that while this data is older, intersection density is not something that widely changes from decade to decade in most of the areas that are already developed enough to have FRT.

Economic development is often analyzed using economic base theory and measures spatial concentrations of jobs by sector or other segmentations, as well as their spatial and temporal dynamics. Shift-share analysis compares change of employment concentrations at the "regional" level, which is defined by the analyst at a chosen scale (e.g., national, state, or county), with changes in concentrations at the "local" level, which can also be defined at various scales by the analyst. The study assigns "transit-served" counties as regions (those counties with access to a transit system) and assigns transit neighborhoods as the "local" scale. The transit neighborhoods are further segmented into distance bands away from the station, in increments of one-eighth or one-quarter mile, up to a distance of 1 mile from the transit station centroid. The analytic method isolates the various sources of job change into 3 categories: 1) the Transit Region share, which references overall economic dynamics at the regional scale 2) the industry or job sector mix, which accounts for job dynamics as a result of change in a specific industry, and 3) FRT Station Shift, also called the "competitive effect," which measures the degree of change at the local spatial scale of the transit station neighborhood. It is a measure of the station's lagging and leading job sectors by isolating station area economic trends from those at the regional scale. The shift-share formula is as follows (Carnegie Mellon n.d.):

$$SS_i = TR_i + SM_i + FRT_i$$

Where:

SS_i = Shift-Share

TR_i = Transit Region share

SM_i = Sector Mix

FRT_i = FRT Station Shift

Each component is calculated with the following equations:

$TR = ({}_i\text{FRT Station Area}^{t-1} \times TR^{t} / TR^{t-1})$ (5-2)

$SM = [({}_i\text{FRT Station Area}^{t-1} \times {}_iTR^{t} / {}_iTR^{t-1}) - TR]$ (5-3)

$FRT = [{}_i\text{FRT Station Area}^{t-1} \times ({}_i\text{FRT Station Area}^{t} / {}_i\text{FRT Station Area}^{t-1} - {}_iTR^{t} / {}_iTR^{t-1})]$ (5-4)

Where:

${}_i$FRT Station Area = number of jobs in the FRT Station Area sector (i) at the beginning of the analysis period (t-1)

${}_i\text{FRT Station Area}^{t}$ = number of jobs in the FRT Station Area in sector (i) at the end of the analysis period (t)

TR^{t-1} = total number of jobs in the Transit Region at the beginning of the analysis period(t-1)

${}_iTR^{t}$ = total number of jobs in the Transit Region at the end of the analysis period (t)

iTR = number of jobs in the Transit Region in sector (i) at the beginning of the analysis period (t-1)

${}_iTR^{t}$ = number of jobs in the Transit Region in sector (i) at the end of the analysis period (t)

Location Quotients
Location Quotients (LQ) provide a spatial concentration measure that compares local concentrations of phenomena with a regional or global concentration of the same phenomena. For this study, transit station areas by eighth-mile distance bands provide the local context, while “transit-served counties,” or counties and groups of counties that are served by transit systems, provide the regional context. LQ metrics, along with shift-share analyses, are a proven methodological staple of economic development studies. The effectiveness of these methodologies at providing evidence of economic development highlight the spatial nature of the economy. Transit systems serve to provide network connectivity across local economies, connecting the geographies highlighted by these methodologies.

Results and Discussion

We first present the results of the analysis of job sector groups, followed by wage groupings, and discuss the findings, first referring to summed figures, and then by discussing key metropolitan areas.

Jobs by Sector, Selected Transit Systems and Station Types: Under-performers and Over-performers
This section will outline growth and spatial concentration trends of jobs by economic sector group for a sample of key transit mode-station typology combinations. Each combination will be summarized by 1) a table containing *FRT Station Shift* figures from the shift-share analysis results from each DB, 2) the rate of change for jobs at each DB, and 3) Location Quotient trends for the period, with scores above 1 denoting increases in spatial concentrations at the station relative to the regions (“Transit County”) served by the transit systems. Each table also contains a measure of the square miles each transit mode-station type contains, in incremental (“increm.”) and cumulative (“cum”) measures, which clearly demonstrate the disproportionate shift in job share toward the transit stations.

The North American Industry Classification System (NAICS) classifies job sectors. The study classifies job sectors into broad economic groups such as industrial, office, knowledge, and retail jobs. This section reviews the economic trends for separate sector groups. We indicate which transit modes and station types specific sector groups prefer by analyzing their trends in job share capture between 2010 and 2016. These trends are segmented by DB, up to 1 mile from the transit station.

For Poor MA, CRT lost concentration at the station in all economic groups except Knowledge and Light Industry. The latter gained significant spatial concentration at the station, or the first DB. Major gains were seen in most DB’s for Knowledge, Light Industry, and Office job groups. Education and Arts-Entertainment-Recreation jobs declined in many DB’s. Very close to the station, in the first quarter mile, Manufacturing, Light Industry, Retail-Lodging-Food, and Office gained substantial job share. Health did well at the station but declined just beyond the station. Overall, the job numbers were fairly small, especially relative to the region totals. It appears that Light Industry and economic groups that synergize with it outcompeted all other economic groups for a location at the station, providing these upper-income workers with easy access to transit. While job share declined strongly at the 1-mile DB, these station areas mostly gained share up to the 1-mile DB, demonstrating a market response to transit proximity beyond the common half-mile threshold.

Table 3.1
Combinations of NAICS Sectors into Economic Groups for Analysis

NAICS Code	NAICS Sector Title and Economic Group Name
	Industrial
31-33	Manufacturing
22	Utilities
	Light Industrial
42	Wholesale Trade
48-49	Transportation and Warehousing
	Retail-Lodging-Food ("Retail-Lodging")
44-45	Retail Trade
72	Accommodation and Food Services
	Knowledge
51	Information
54	Professional, Scientific, and Technical Services
	Office
52	Finance and Insurance
53	Real Estate and Rental and Leasing
55	Management of Companies and Enterprises
56	Administrative and Support, Waste Management, Remediation
81	Other Services (except Public Administration)
92	Public Administration
	Education
61	Educational Services
	Health
62	Health Care and Social Assistance
	Arts-Entertainment-Recreation ("Arts-Ent-Rec")
71	Arts, Entertainment, and Recreation

Source: Adapted from the North American Industrial Classification System by Arthur C. Nelson and Robert Hibberd, University of Arizona.
Note: Phrases in quotations and italics labels for the respective economic groups.

Table 3.2 CRT Poor MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*10*	*30*	*51*	*71*	*205*	*277*	*41,703*
Urban Square Miles – Cum.	*10*	*40*	*91*	*162*	*367*	*644*	*41,703*
Manufacturing	8,661	5,591	4,029	5,481	3,408	1,068	1,238,634
Light Industry	18,548	7,562	4,915	4,690	5,056	1,129	1,621,064
Retail-Lodging-Food	11,961	5,510	2,531	2,220	1,461	1,447	3,809,507
Knowledge	15,462	1,506	18,475	3,863	3,117	1,647	2,408,601
Office	32,893	4,993	7,223	8,398	3,187	4,935	4,199,409
Education	41,219	1,131	17,358	1,128	3,501	3,666	1,565,704
Health	11,215	545	3,967	2,874	4,304	1,925	2,328,226
Arts-Ent-Rec	2,668	156	313	577	1,164	407	382,686
Total Jobs	142,634	27,001	58,818	29,238	25,205	16,231	17,553,831

Poor MA: CRT. Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	1,712	2,595	(1,473)	(742)	845	(1,251)	(199,595)
Light Industry	5,618	1,268	2,066	(3,369)	3,598	(1,986)	3,183,866
Retail-Lodging-Food	2,573	3,173	(398)	(4,215)	381	(898)	415,822
Knowledge	(447)	167	2,971	1,290	1,351	(1,762)	543,440
Office	4,869	930	(185)	2,562	445	(1,003)	331,340
Education	2,888	(70)	2,785	(232)	(283)	(17,076)	179,340
Health	5,198	(284)	(2,186)	1,315	1,565	(1,780)	319,634
Arts-Ent-Rec	1,370	(42)	(120)	337	159	(9)	304,931
Total Jobs	23,781	7,737	3,460	(3,054)	8,061	(25,765)	5,078,778

Poor MA: CRT. Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	24.6%	86.6%	-26.8%	-11.9%	33.0%	-53.9%	8.1%
Light Industry	43.4%	20.1%	72.5%	-41.8%	*246.6%*	-63.7%	17.2%
Retail-Lodging-Food	27.4%	*135.7%*	-13.6%	-65.5%	35.2%	-38.3%	23.5%
Knowledge	-2.8%	12.5%	19.2%	50.1%	76.5%	-51.7%	21.8%
Office	17.4%	22.9%	-2.5%	43.9%	16.2%	-16.9%	4.8%
Education	7.5%	-5.8%	19.1%	-17.0%	-7.5%	-82.3%	4.8%
Health	86.4%	-34.2%	-35.5%	84.3%	57.1%	-48.0%	19.8%
Arts-Ent-Rec	105.5%	-21.1%	-27.6%	139.8%	15.8%	-2.2%	11.2%
Total Jobs	20.0%	40.2%	6.3%	-9.5%	47.0%	-61.3%	14.2%

Poor MA: CRT. LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	0.58	0.45	0.87	0.62	0.61	0.67	0.62	0.51
Light Industry	2.02	2.82	1.49	3.76	0.72	1.02	1.83	2.57
Retail-Lodging-Food	0.78	0.49	1.01	2.16	0.97	0.90	1.20	0.52

Knowledge	1.21	1.22	0.87	0.59	1.23	0.82	0.93	0.78
Office	0.80	0.90	0.86	0.49	0.82	0.99	0.89	0.37
Education	0.92	1.22	0.73	0.90	1.34	1.31	0.83	1.80
Health	0.57	1.87	1.45	0.43	1.52	0.82	1.02	0.65
Arts-Ent-Rec	0.87	2.63	2.18	0.56	1.63	1.88	0.59	0.59

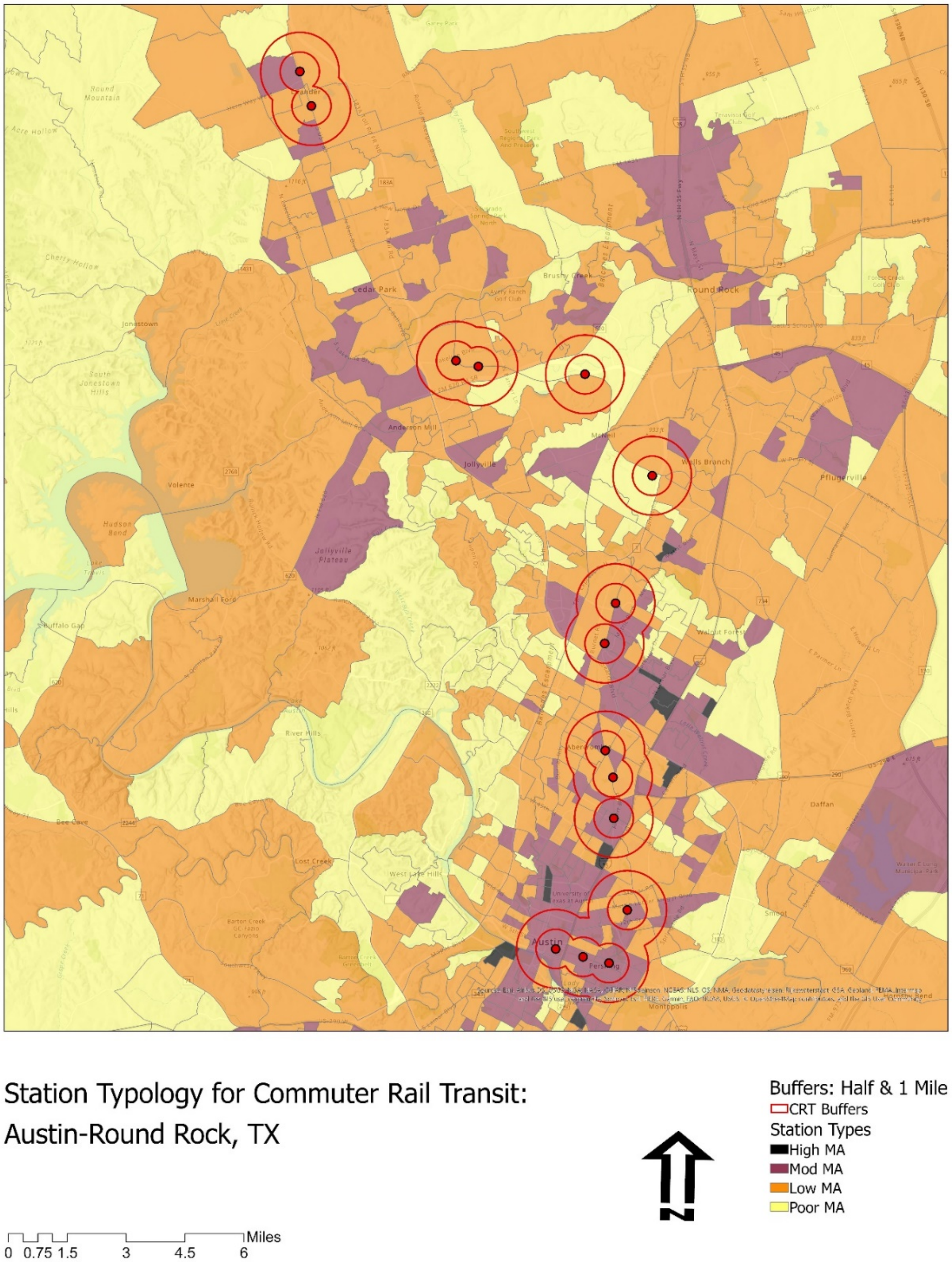

Figure 2. Austin CRT system covers an area of relatively low to moderate land use intensity, but connects the suburbs to the downtown.

Table 3.3 BRT Low MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	27	44	49	51	102	98	14,201
Urban Square Miles – Cum.	27	71	120	171	273	371	14,201
Manufacturing	60,886	4,894	6,143	18,473	6,154	25,779	830,769
Light Industry	75,070	10,730	8,743	29,346	10,841	21,435	818,346
Retail-Lodging-Food	130,376	11,904	10,284	16,133	13,865	13,781	1,970,975
Knowledge	112,227	17,101	9,238	10,169	3,900	15,298	1,309,013
Office	233,565	34,800	19,008	30,670	10,924	21,142	2,247,693
Education	58,304	21,997	5,909	21,942	20,411	2,939	863,140
Health	120,667	22,138	12,462	14,993	6,093	22,746	1,464,168
Arts-Ent-Rec	11,195	771	2,241	1,200	864	1,323	197,902
Total Jobs	802,297	124,342	74,035	142,933	73,059	124,450	9,702,006

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(124,133)	(40,453)	(7,574)	(22,179)	(8,051)	(1,560)	(145,037)
Light Industry	(190,532)	(39,737)	(9,647)	(27,102)	(33,215)	(7,307)	(31,845)
Retail-Lodging-Food	69,422	3,343	8,000	(3,510)	7,492	(16,307)	(9,243)
Knowledge	50,490	4,356	4,695	(14,824)	(5,447)	(5,401)	40,655
Office	125,609	21,475	9,841	15,134	(913)	6,317	34,291
Education	(36,297)	12,972	267	8,302	16,450	(10,679)	70,350
Health	(74,010)	(22,361)	1,262	(23,352)	(7,267)	4,481	194,081
Arts-Ent-Rec	(60,969)	(21,450)	(1,166)	(19,242)	(23,757)	(1,966)	6,694
Total Jobs	(240,420)	(81,855)	5,678	(86,773)	(54,708)	(32,422)	159,946

Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-67.1%	-89.2%	-55.2%	-54.6%	-56.7%	-5.7%	-62.2%
Light Industry	-71.7%	-78.7%	-52.5%	-48.0%	-75.4%	-25.4%	-76.6%
Retail-Lodging-Food	113.9%	39.0%	349.8%	-17.9%	117.5%	-54.2%	153.0%
Knowledge	81.8%	34.2%	103.3%	-59.3%	-58.3%	-26.1%	79.0%
Office	116.4%	161.2%	107.3%	97.4%	-7.7%	42.6%	34.0%
Education	-38.4%	143.7%	4.7%	60.9%	415.2%	-78.4%	-18.3%
Health	-38.0%	-50.2%	11.3%	-60.9%	-54.4%	24.5%	-33.2%
Arts-Ent-Rec	-84.5%	-96.5%	-34.2%	-94.1%	-96.5%	-59.8%	-76.2%
Total Jobs	-23.1%	-39.7%	8.3%	-37.8%	-42.8%	-20.7%	-25.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	1.95	4.66	2.02	1.14	2.05	1.10	2.28	0.70

Light Industry	2.56	2.67	2.14	1.13	3.20	2.19	1.66	1.00
Retail-Lodging-Food	0.35	0.42	0.23	0.74	0.17	0.26	0.45	1.69
Knowledge	0.43	0.46	0.54	1.56	0.31	1.40	0.42	1.10
Office	0.35	0.23	0.52	0.31	1.08	0.62	0.34	0.56
Education	1.34	0.27	1.11	0.42	1.07	0.12	1.21	3.95
Health	1.46	1.43	1.15	1.88	0.78	1.48	1.31	0.75
Arts-Ent-Rec	5.07	17.78	1.68	10.84	3.20	16.67	6.19	2.02

Figure 3. Tucson SunLink Streetcar. Source: hereandnow.wbur.org

For Low MA BRT station areas, Manufacturing and Retail-Lodging-Food, and Education declined near the station, across the first 1-mile range. Near the half-mile range, all economic groups but Retail saw large rates of job share gain. Knowledge and Health jobs exerted major competitive efforts to gain job share near the station, in the first and second DB's from the station. Light Industry jobs also gained share in large rates from 0.375-mile DB to the 0.75-mile DB. Beyond the half-mile DB, Health job increased substantially in concentrations relative to the regions, although rates of growth in Health dropped in the half-mile and 0.75-mile DB's. This is due to larger declines in the rest of the regions than those occurring at these DB's from the stations.

For Mod MA BRT station areas, response was quite negative, with most economic groups showing major negative growth rates. Growth rates turned very positive just beyond the station, however, with Manufacturing approaching a 50% growth rate. The LQ scores highlight that this high Manufacturing growth was also occurring at high rates across the whole of the region. Not so with Education, which saw a very high rate of growth at the quarter-mile DB (with mildly declining rates to 1-mile DB), as well as major increases in spatial concentration within the station neighborhood, with LQ scores such as 1.40 at the 0.375-mile DB being indicative. Unlike Low MA BRT stations, Retail-Lodging-Food jobs picked up steam with large rates of growth in job share to the 1-mile DB, with the exception of the 0.75-mile DB, which had a declining rate of growth. However, of importance to notice is that Retail did not enjoy at the same an increase in spatial concentration; its LQ scores were basically flat.

For High MA SCT stations, competition between economic groups is causing sorting of the land uses. Retail-Lodging-Food gained job share at the station to a distance of 0.75 miles, with some decline at the 1-mile DB. Office and Education declined in rates but gained spatial concentrations near the stations, due to larger declines at the regional scale. For many economic groups, this was the story: either growth rates were positive while LQ trends were negative, or vice-versa. These areas represent small proportions of the overall regional urbanized land, so a major shift in concentration may represent a small number of jobs. Two economic groups that gained in concentration, as well as rate of growth were Health and Arts-Entertainment-Recreation jobs. These economic groups valued being close to the station in a hotly competitive land market.

Table 3.4 LRT Mod MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Mod MA: LRT. Station Share of Job Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sums 2016*
Urban Square Miles – Increm.	*18*	*80*	*61*	*10*	*46*	*172*	*29,669*
Urban Square Miles – Cum.	*18*	*98*	*159*	*169*	*215*	*386*	*29,669*
Manufacturing	72,185	14,839	9,509	9,184	4,140	4,070	1,504,975
Light Industry	104,258	36,949	11,079	11,060	4,763	8,270	1,842,851
Retail-Lodging-Food	263,058	46,184	48,807	37,360	18,289	34,042	3,800,602
Knowledge	251,268	39,222	22,809	17,123	5,400	9,988	2,242,526
Office	556,074	78,022	62,169	55,012	29,933	20,464	4,609,558
Education	141,032	33,520	11,206	10,233	11,715	13,969	1,608,044
Health	192,496	28,976	40,490	56,838	18,227	16,582	2,630,962
Arts-Ent-Rec	46,901	5,855	3,504	5,083	800	3,836	353,302
Total Jobs	1,627,279	283,574	209,580	201,900	93,274	111,228	18,592,820

Mod MA: LRT. Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(27,144)	4,782	2,239	(1,303)	371	(763)	(247,069)
Light Industry	(83,660)	3,960	769	252	(660)	892	(26,098)
Retail-Lodging-Food	6,184	3,440	13,992	8,299	(2,591)	6,749	64,894
Knowledge	(7,340)	7,196	1,480	1,067	293	1,854	104,140
Office	(54,259)	5,489	11,382	3,512	10,611	768	152,352
Education	11,863	22,770	(994)	(1,344)	(1,692)	2,846	137,537
Health	(12,563)	(1,934)	6,477	6,162	3,268	7,455	378,107
Arts-Ent-Rec	1,655	(1,813)	693	(282)	(128)	2,188	25,271
Total Jobs	(165,264)	43,890	36,038	16,363	9,472	21,989	589,134

Mod MA: LRT. Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-27.3%	47.5%	30.8%	-12.4%	9.8%	-15.8%	6.2%
Light Industry	-44.5%	12.0%	7.5%	2.3%	-12.2%	12.1%	13.2%
Retail-Lodging-Food	2.4%	8.0%	40.2%	28.6%	-12.4%	24.7%	19.2%
Knowledge	-2.8%	22.5%	6.9%	6.6%	5.7%	22.8%	21.8%
Office	-8.9%	7.6%	22.4%	6.8%	54.9%	3.9%	10.6%
Education	9.2%	211.8%	-8.1%	-11.6%	-12.6%	25.6%	4.1%
Health	-6.1%	-6.3%	19.0%	12.2%	21.8%	81.7%	18.7%
Arts-Ent-Rec	3.7%	-23.6%	24.6%	-5.3%	-13.8%	132.7%	17.5%
Total Jobs	-9.2%	18.3%	20.8%	8.8%	11.3%	24.6%	14.0%

Mod MA: LRT. LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	1.03	0.66	0.76	1.02	0.82	0.84	1.10	1.22
Light Industry	1.55	1.00	1.07	1.01	1.24	1.20	1.06	1.05
Retail-Lodging-Food	0.87	1.08	0.85	0.83	0.91	1.25	0.95	0.98
Knowledge	0.95	0.99	1.15	1.04	1.05	1.07	1.10	1.04
Office	1.00	1.10	0.99	1.02	1.06	0.72	1.27	1.20
Education	0.88	0.40	1.40	1.31	1.84	1.35	0.70	1.05
Health	1.14	1.49	1.20	1.14	0.91	1.08	0.99	0.81
Arts-Ent-Rec	0.92	1.63	1.02	1.21	0.80	1.36	1.29	0.56

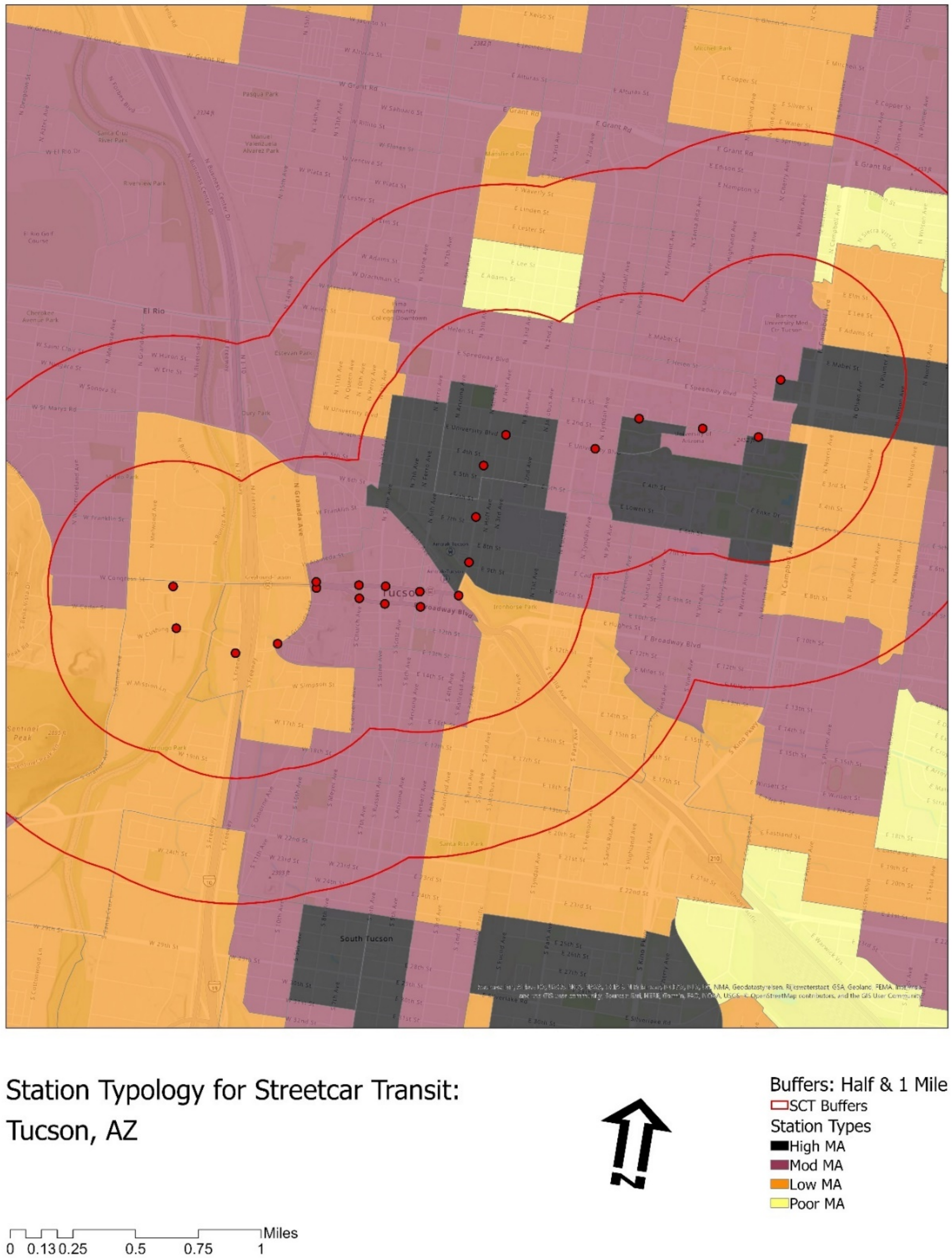

Figure 4. Map of Streetcar Transit system in downtown Tucson, AZ. The majority of the place types are in the Mod MA and the High MA.

Table 3.5 SCT High MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Mod High MA: SCT. Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*19*	*4*	*10*	*24*	*18*	*3*	*12,770*
Urban Square Miles – Cum.	*19*	*23*	*33*	*58*	*75*	*79*	*12,770*
Manufacturing	3,446	1,392	125	1,355	492	39	524,288
Light Industry	18,911	2,645	392	3,000	405	49	825,910
Retail-Lodging-Food	66,304	10,444	26,442	6,359	1,658	3,561	1,597,042
Knowledge	87,348	14,051	3,075	3,114	991	673	1,101,103
Office	107,562	18,331	2,837	5,798	822	1,715	1,981,603
Education	14,962	1,034	435	253	258	332	689,431
Health	33,059	10,618	1,897	6,126	268	762	1,035,329
Arts-Ent-Rec	9,063	1,062	1,080	1,648	27	113	185,019
Total Jobs	340,662	59,584	36,290	27,660	4,928	7,251	7,939,725

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(78)	193	(78)	766	47	11	(76,872)
Light Industry	(1,060)	(444)	(27)	36	194	(61)	(30,086)
Retail-Lodging-Food	9,750	842	18,103	2,363	617	(828)	(16,664)
Knowledge	21,873	(1,775)	145	(397)	155	(324)	34,442
Office	(35,890)	(6,759)	218	53	75	89	(35,118)
Education	(7,035)	(71)	3	(208)	97	25	46,586
Health	5,186	(264)	139	1,497	(27)	(412)	105,773
Arts-Ent-Rec	2,869	142	483	299	(31)	4	3,632
Total Jobs	(4,385)	(8,136)	18,986	4,409	1,127	(1,496)	31,693

Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-2.2%	16.1%	-38.2%	129.8%	10.5%	37.9%	7.5%
Light Industry	-5.3%	-14.4%	-6.4%	1.2%	91.5%	-55.0%	19.9%
Retail-Lodging-Food	17.2%	8.8%	217.1%	59.1%	59.2%	-18.9%	21.0%
Knowledge	33.4%	-11.2%	4.9%	-11.3%	18.5%	-32.5%	17.1%
Office	-25.0%	-26.9%	8.3%	0.9%	10.0%	5.5%	0.1%
Education	-32.0%	-6.4%	0.7%	-45.0%	59.9%	8.1%	13.7%
Health	18.6%	-2.4%	7.9%	32.3%	-9.1%	-35.1%	8.3%
Arts-Ent-Rec	46.3%	15.4%	80.8%	22.1%	-52.5%	3.6%	39.9%
Total Jobs	-1.3%	-12.0%	109.7%	19.0%	29.6%	-17.1%	11.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	0.87	0.66	2.94	0.45	2.67	1.02	1.72	0.52
Light Industry	0.99	0.98	2.14	1.12	1.61	0.65	0.68	1.76
Retail-Lodging-Food	0.83	0.79	0.65	0.73	0.79	0.80	0.53	1.00
Knowledge	0.77	1.03	2.08	1.39	1.15	1.14	0.93	1.28
Office	1.28	1.17	1.89	1.15	1.32	1.15	1.68	0.77
Education	1.58	1.03	2.27	2.36	1.33	0.88	8.78	0.84
Health	0.95	1.03	2.22	1.02	0.80	1.63	1.34	1.46
Arts-Ent-Rec	0.69	0.78	1.19	1.00	1.75	2.80	0.82	0.82

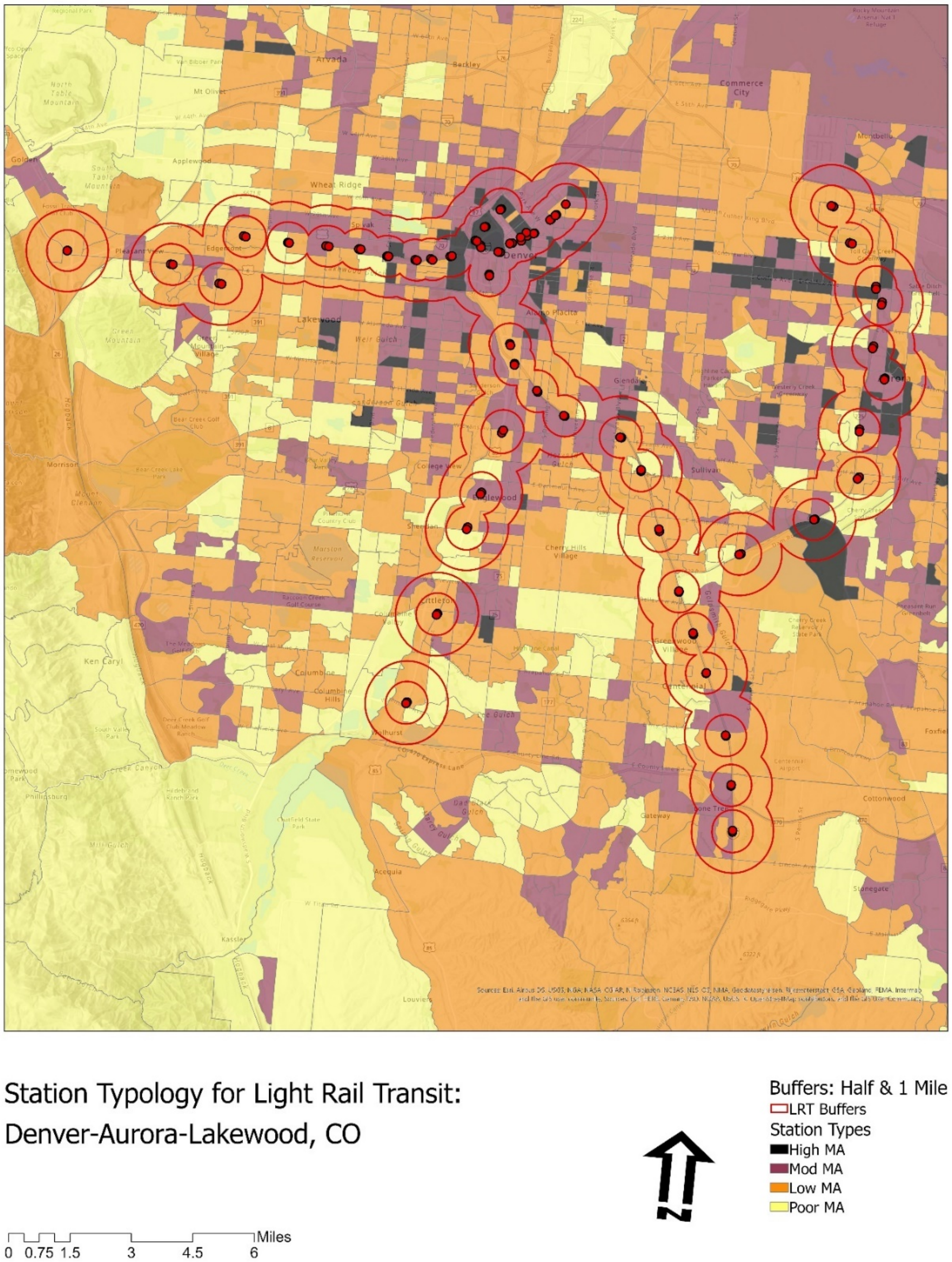

Figure 5. Light Rail Transit in Denver, Colorado show a wide variety of station place types. A brief visual inspection of the map implies that Low MA and Mod MA are the most prevalent station place types. Further, the map demonstrates the wide variety of place types at each individual transit station. Competition for revenue-generating land uses may be drawn into those higher-intensity areas, with a concomitant loss of land uses in less intense locations.

Jobs by Wage Group for Transit Systems and Station Types: Under-performers and Over-performers

The North American Industry Classification System (NAICS) classifies job sectors. The study further classified jobs by income based on NAICS wage averages. Lower-income job sectors consist mainly of retail and food service jobs. Middle-income jobs consist mainly of health care, real estate, transport, and mid-level public administration jobs. Upper-income jobs focus on industrial, professional, and management positions.

Table 3.6 Allocation of Workers by Lower-, Middle- and Upper-Wage Category

NAICS	Description	Mean Annual Wages, 2013	Wage Category	Share of Workers
44	Retail Trade	$25,779	Lower	
56	Administrative, Support, Waste Mgmt., Remediation	$35,931	Lower	
61	Educational Services	$35,427	Lower	
71	Arts, Entertainment and Recreation	$32,188	Lower	
72	Accommodation and Food Services	$17,453	Lower	
81	Other Services (except Public Administration)	$29,021	Lower	
	Weighted Mean Wages and National Share of Workers		*~$30,000*	*~33%*
48	Transportation and Warehousing	$45,171	Middle	
53	Real Estate and Rental and Leasing	$46,813	Middle	
62	Health Care and Social Assistance	$44,751	Middle	
92	Public Administration	$51,340	Middle	
	Weighted Mean Wages and National Share of Workers		*~$50,000*	*~33%*
22	Utilities	$94,239	Upper	
31	Manufacturing	$54,258	Upper	
42	Wholesale Trade	$65,385	Upper	
51	Information	$83,677	Upper	
52	Finance and Insurance	$88,677	Upper	
54	Professional, Scientific and Technical Services	$75,890	Upper	
55	Management of Companies and Enterprises	$105,138	Upper	
	Weighted Mean Wages and National Share of Workers		*~$70,000*	*34%*

Source: Adapted from County Business Patterns, 2013 by Arthur C. Nelson and Robert Hibberd, University of Arizona.

This section will outline growth and spatial concentration trends of jobs by wage group for the full set of transit mode-station typology combinations. Each combination will be summarized by 1) a table containing *FRT Station Shift* figures from the shift-share analysis results from each DB, 2) the rate of change for jobs at each DB, and 3) Location Quotient trends for the period, with scores above 1 denoting increases in spatial concentrations at the station relative to the regions ("Transit County") served by the transit systems.

Table 3.7. Poor MA BRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*15*	*20*	*22*	*24*	*53*	*57*	*14,201*
Urban Square Miles – Cum.	*15*	*35*	*57*	*81*	*134*	*191*	*14,201*
Upper Income Jobs	44,327	13,073	16,096	12,971	10,135	15,359	3,335,487
Middle Income Jobs	6,203	8,295	8,449	5,716	6,508	8,677	2,289,894
Lower Income Jobs	31,250	10,316	8,977	8,702	7,683	9,612	4,010,614
Total Jobs	81,782	31,686	33,524	27,391	24,328	33,650	9,635,995

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	27,390	9,254	10,331	7,850	4,995	10,623	(68,521)
Middle Income Jobs	(167,859)	(25,558)	(33,512)	(23,185)	(11,676)	(25,295)	169,035
Lower Income Jobs	(36,797)	610	(9,594)	(2,684)	503	(5,810)	61,107
Total Jobs	(177,266)	(15,694)	(32,775)	(18,019)	(6,178)	(20,482)	161,621

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	161.7%	242.2%	179.1%	153.2%	97.1%	224.2%	50.9%
Middle Income Jobs	-96.4%	-75.5%	-79.9%	-80.2%	-64.2%	-74.5%	-74.8%
Lower Income Jobs	-54.1%	6.3%	-51.7%	-23.6%	7.0%	-37.7%	34.6%
Total Jobs	-68.4%	-33.1%	-49.4%	-39.7%	-20.3%	-37.8%	-32.5%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	3.70	2.29	2.47	1.88	1.68	1.10	1.26	2.33
Middle Income Jobs	0.30	0.98	1.07	0.88	1.31	1.20	1.30	1.10
Lower Income Jobs	0.73	0.80	0.48	0.63	0.49	0.67	0.56	0.50

Station areas for BRT systems in Poor MA land types responded to proximity to the station by a reduction of job share in the first one-eighth mile DB from the station, which has direct access to the station and includes the station itself. All jobs together took a massive loss of 46%. Middle-income jobs dropped at a precipitous 74% during the study period. Only low-wage jobs responded positively to station proximity in the first quarter mile. Upper and lower-income jobs responded positively at a half mile from the station. Growth was considerably positive within the 0.75 and 1-mile DB's from the station. This indicates that firms chose against locations with direct access to the stations but opted for locations within an easy walk from those stations. The dispersed nature of the land uses may have caused this negative response.

At the same time that jobs moved away from the immediate neighborhood of Poor MA BRT stations, they gained in concentration near the stations relative to the remainder of the region, as evinced in the LQ score trends from 2010 to 2016. Middle income jobs lost concentrations while upper- and lower-income jobs increased. All job types gained growth at the half-mile to 1-mile distance band increments.

Table 3.7. Low MA BRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*27*	*44*	*49*	*51*	*102*	*98*	*14,201*
Urban Square Miles – Cum.	*27*	*71*	*120*	*171*	*273*	*371*	*14,201*
Upper Income Jobs	304,281	33,923	27,918	50,054	17,656	59,948	3,335,487
Middle Income Jobs	208,321	40,874	16,989	36,568	14,394	32,707	2,289,894
Lower Income Jobs	289,693	49,543	29,126	56,309	41,007	31,793	4,010,614
Total Jobs	802,297	124,342	74,035	142,933	73,059	124,450	9,635,995

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	201,025	10,785	3,434	21,308	466	36,471	(68,521)
Middle Income Jobs	(548,025)	(95,057)	(32,342)	(128,328)	(67,222)	(91,009)	169,035
Lower Income Jobs	23,953	17,596	14,158	284	21,408	(30,105)	61,107
Total Jobs	(323,047)	(66,676)	(14,750)	(106,736)	(45,348)	(84,643)	161,621

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*

Upper Income Jobs	194.7%	46.6%	14.0%	74.1%	2.7%	155.3%	50.9%
Middle Income Jobs	-72.5%	-69.9%	-65.6%	-77.8%	-82.4%	-73.6%	-74.8%
Lower Income Jobs	9.0%	55.1%	94.6%	0.5%	109.2%	-48.6%	34.6%
Total Jobs	-28.7%	-34.9%	-16.6%	-42.8%	-38.3%	-40.5%	-32.5%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.85	1.01	0.61	1.36	0.57	0.74	0.88	1.92
Middle Income Jobs	1.04	1.24	1.11	1.04	1.13	0.77	1.21	1.19
Lower Income Jobs	0.77	1.19	1.17	0.88	1.34	1.70	0.95	0.43

Firms near Low MA BRT stations responded fairly tepidly to BRT station proximity, with losses at the station for low-income jobs, losses for middle-income jobs just beyond the station at the quarter-mile DB, considerable growth in job share at the 0.375-mile DB, but mostly loss of job share to the 1 mile DB. This may indicate a negative response to the low-intensity land use in the local area beyond the station, as well as to the transit connection itself. While these transit counties mostly lost jobs, LQ trends were positive for upper and middle-income job groups near the station. Lower-income jobs had a negative LQ trend, denoting loss of local concentration of these jobs relative to the regional concentrations. This may indicate that much of the reduction of transit area job share was in hospitality, entertainment, and other retail services.

Table 3.8. Mod MA: BRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*23*	*38*	*39*	*36*	*61*	*50*	*14,201*
Urban Square Miles – Cum.	*23*	*61*	*100*	*136*	*196*	*246*	*14,201*
Upper Income Jobs	293,352	23,759	26,643	19,165	21,890	8,713	3,335,487
Middle Income Jobs	215,707	19,605	22,042	25,236	18,375	35,867	2,289,894
Lower Income Jobs	316,532	43,805	29,498	36,780	33,892	20,470	4,010,614
Total Jobs	825,593	87,171	78,185	81,183	74,159	65,052	9,635,995

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	143,537	(3,477)	(2,450)	(15,444)	3,196	(11,472)	(68,521)
Middle Income Jobs	(886,237)	(63,132)	(36,900)	(57,810)	(68,378)	(68,541)	169,035
Lower Income Jobs	(31,913)	17,666	17,335	19,348	14,101	9,850	61,107
Total Jobs	(774,613)	(48,943)	(22,015)	(53,906)	(51,081)	(70,163)	161,621

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	95.8%	-12.8%	-8.4%	-44.6%	17.1%	-56.8%	50.9%
Middle Income Jobs	-80.4%	-76.3%	-62.6%	-69.6%	-78.8%	-65.6%	-74.8%
Lower Income Jobs	-9.2%	67.6%	142.5%	111.0%	71.2%	92.7%	34.6%
Total Jobs	-48.4%	-36.0%	-22.0%	-39.9%	-40.8%	-51.9%	-32.5%

LQ Percent Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.70	0.61	0.52	0.41	1.22	0.88	0.26	0.40
Middle Income Jobs	1.02	0.99	1.28	1.36	1.11	0.96	1.18	1.91
Lower Income Jobs	0.88	1.31	1.56	1.76	0.61	1.45	2.75	2.01

Firms responded to BRT near Mod MA stations by distancing themselves from the immediate vicinity of the stations themselves, while growing in job share just beyond the station. Lower-income jobs grew in the quarter-mile DB, while upper and lower-income jobs had considerable growth to the 0.75 DB. Middle-income jobs declined in most DB's, with mild growth in the 0.375 DB. This indicates that Mod MA neighborhoods attract mainly upper-income jobs; lower-income jobs are attracted at a lesser rate, while middle-income jobs are moving away, perhaps as a result of competition from firms in the other income groups. LQ trends were mostly flat for middle-income groups, indicating that they did not increase in concentration near BRT stations relative to their concentrations in the broader regions. Job share rates indicate that jobs can be too close or too far from the station. Direct proximity results in negative change, as does the 1-mile DB. The Mod MA land use type may therefore respond best to walkable and bikeable spaces and distances. Distances beyond the half-mile DB seem too far from the station for middle-income jobs, while the upper-and lower-income jobs seemed to respond negatively to distances farther than the 0.75-mile DB.

Table 3.9. High MA: BRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*4*	*7*	*6*	*5*	*8*	*6*	*14,201*
Urban Square Miles – Cum.	*4*	*11*	*17*	*22*	*30*	*36*	*14,201*
Upper Income Jobs	166,902	10,060	7,799	5,084	1,722	553	3,335,487
Middle Income Jobs	82,712	17,212	4,273	3,017	1,482	674	2,289,894
Lower Income Jobs	164,399	16,125	24,874	40,512	7,980	6,671	4,010,614
Total Jobs	414,015	43,399	36,948	48,615	11,186	7,900	9,635,995

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	120,582	(4,073)	(464)	(4,379)	(2,423)	(3,057)	(68,521)
Middle Income Jobs	(335,825)	(21,085)	(28,036)	(24,313)	(8,439)	(3,807)	169,035
Lower Income Jobs	19,041	7,895	18,820	36,067	5,933	5,985	61,107
Total Jobs	(196,202)	(17,263)	(9,680)	7,375	(4,929)	(879)	161,621

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	260.3%	-28.8%	-5.6%	-46.3%	-58.4%	-84.6%	50.9%
Middle Income Jobs	-80.2%	-55.1%	-86.8%	-89.0%	-85.1%	-85.0%	-74.8%
Lower Income Jobs	13.1%	95.9%	310.8%	811.2%	289.7%	871.2%	34.6%
Total Jobs	-32.2%	-28.5%	-20.8%	17.9%	-30.6%	-10.0%	-32.5%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	2.37	0.44	0.53	0.20	0.17	0.27	0.06	0.08
Middle Income Jobs	0.78	1.68	0.45	0.25	0.86	0.58	2.74	0.45
Lower Income Jobs	0.84	1.37	2.60	3.87	3.22	2.81	2.10	5.41

High MA BRT stations attracted upper-income jobs at the station, which may have pushed middle and especially lower-income jobs further away from the stations. All income groups had robust percent economic change within most DB's to 1 mile from the stations. Upper and middle-income jobs gained the greatest share in the closest DB's, while lower-income jobs grew substantially in share from the half-mile to the 1-mile DB. The LQ trends show strong growth in concentration for upper-income jobs nearest the stations, while lower-income jobs gained very significantly in concentrations in the half-mile and 0.624-mile DB's. Overall, these station areas attracted jobs at high rates to the 1-mile DB, much higher than the regional growth rates. Growth remained strong at the 1-mile DB for lower-and middle-income jobs, and the latter grew in concentration considerably from the half-mile DB to the 1-mile DB.

Table 3.10. Poor MA: CRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*10*	*30*	*51*	*71*	*205*	*277*	*41,703*
Urban Square Miles – Cum.	*10*	*40*	*91*	*162*	*367*	*644*	*41,703*
Upper Income Jobs	44,914	10,563	28,796	15,617	9,409	4,662	5,695,896
Middle Income Jobs	25,600	7,257	5,589	5,835	7,794	3,084	4,003,309
Lower Income Jobs	72,118	9,179	24,431	7,784	8,000	8,483	7,817,123
Total Jobs	142,634	27,001	58,818	29,238	25,205	16,231	17,516,328

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	4,778	2,481	2,949	1,691	4,061	(3,754)	(62,703)
Middle Income Jobs	8,420	1,693	(2,376)	(639)	3,101	(3,791)	299,555
Lower Income Jobs	10,583	3,563	2,887	(4,106)	899	(18,220)	256,188
Total Jobs	23,781	7,737	3,460	(3,054)	8,061	(25,765)	493,040

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	11.9%	30.7%	11.4%	12.1%	75.9%	-44.6%	14.6%
Middle Income Jobs	49.0%	30.4%	-29.8%	-9.9%	66.1%	-55.1%	5.2%
Lower Income Jobs	17.2%	63.4%	13.4%	-34.5%	12.7%	-68.2%	18.9%
Total Jobs	20.0%	40.2%	6.3%	-9.5%	47.0%	-61.3%	14.1%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	0.93	0.93	1.04	1.23	1.01	1.19	1.05	1.43
Middle Income Jobs	1.35	1.01	0.72	1.08	1.17	1.23	0.93	1.26
Lower Income Jobs	0.94	1.12	1.02	0.69	0.85	0.74	0.82	0.79

CRT stations in the Poor MA transit station type neighborhoods saw robust rates of job growth for all income levels. Middle-income jobs grew at a considerable 49% at the station (the 0.125 DB). The other income groups also grew substantially at the station, and just beyond, in the quarter-mile DB. It fell off for middle and lower-income groups at approximately the half-mile DB, then grew considerably for upper and middle-income groups at the 0.75-mile DB, then declined significantly at the 1-mile DB. These figures indicate that all job groups see a benefit in direct access to the station in outlying areas but prefer overall to be just beyond the station. LQ trends show greater concentrations at the station of middle-income jobs relative to the regions as a whole, with both upper and lower-income groups gaining concentrations at the quarter and half-mile DB, and also at the 0.75-mile and 1-mile DB's. Lower-income jobs are gaining concentration near the station but are being outcompeted in the other DBs to one mile from the station. While these regions lost upper-income jobs as a whole, transit stations in lower-intensity areas gained considerably in job share over the time period.

Table 3.11. Low MA: CRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*17*	*51*	*81*	*105*	*261*	*307*	*41,703*
Urban Square Miles – Cum.	*17*	*68*	*149*	*254*	*515*	*822*	*41,703*
Upper Income Jobs	215,824	82,035	45,133	96,343	54,561	65,232	5,695,896
Middle Income Jobs	145,142	24,166	35,777	42,975	20,819	63,831	4,003,309
Lower Income Jobs	225,585	57,995	37,538	77,521	54,739	71,614	7,817,123
Total Jobs	586,553	164,198	118,450	216,841	130,121	200,679	17,516,328

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	24,958	21,928	5,480	11,512	5,734	8,437	(62,703)
Middle Income Jobs	6,692	1,511	2,532	3,619	(808)	14,205	299,555
Lower Income Jobs	28,123	9,259	2,715	14,780	(1,189)	13,164	256,188
Total Jobs	59,773	32,698	10,727	29,911	3,737	35,806	493,040

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	13.1%	36.5%	13.8%	13.6%	11.7%	14.9%	14.6%
Middle Income Jobs	4.8%	6.7%	7.6%	9.2%	-3.7%	28.6%	5.2%
Lower Income Jobs	14.2%	19.0%	7.8%	23.6%	-2.1%	22.5%	18.9%
Total Jobs	11.3%	24.9%	10.0%	16.0%	3.0%	21.7%	14.1%

LQ Percent Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.01	1.09	1.03	0.97	0.95	1.08	1.12	0.94
Middle Income Jobs	1.02	0.93	1.06	1.02	1.09	1.01	0.74	1.15
Lower Income Jobs	0.98	0.91	0.94	1.02	1.02	0.91	1.16	0.97

CRT stations in Low MA station type neighborhoods attracted jobs, gaining share of jobs mostly in the upper-income group, with middle-income jobs being outcompeted from both upper and lower-income jobs groups. All groups saw positive trends in job share to the 1-mile DB, aside from a small decline in middle-income jobs at the 0.75-mile DB. Middle-income jobs relatively modest growth rates compared to the other wage groups to the 1-mile DB, at which it gained employment share at the highest rate of growth of all groups, at a very strong 28%. Location Quotients indicate that lower-income jobs lost concentrations in most of the DB’s, with an exception at the 0.875-mile DB. Lower-income jobs were likely attracted to these areas as a secondary effect of upper-income jobs being attracted to these stations. Retail and food services are often attracted by office workers and management. These CRT stations gained shares overall in jobs well above the rates of regional growth.

Table 3.12. Mod MA: CRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*9*	*25*	*38*	*47*	*110*	*124*	*41,703*
Urban Square Miles – Cum.	*9*	*33*	*71*	*118*	*229*	*352*	*41,703*
Upper Income Jobs	365,333	43,638	29,105	86,526	34,768	32,054	5,695,896
Middle Income Jobs	238,943	30,006	39,896	76,269	35,558	24,093	4,003,309
Lower Income Jobs	359,806	63,802	32,535	90,111	64,731	54,135	7,817,123
Total Jobs	964,084	137,448	101,538	252,908	135,059	110,284	17,516,328

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	45,452	(4,205)	(463)	17,144	3,094	6,858	(62,703)
Middle Income Jobs	(82,656)	(29,049)	7,002	5,528	(12,355)	(5,830)	299,555
Lower Income Jobs	(10,000)	(4,149)	(1,612)	26,481	6,616	17,710	256,188
Total Jobs	(47,204)	(37,403)	4,927	49,153	(2,645)	18,738	493,040

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	14.2%	-8.8%	-1.6%	24.7%	9.8%	27.2%	14.6%
Middle Income Jobs	-25.7%	-49.2%	21.3%	7.8%	-25.8%	-19.5%	5.2%
Lower Income Jobs	-2.7%	-6.1%	-4.7%	41.6%	11.4%	48.6%	18.9%
Total Jobs	-4.7%	-21.4%	5.1%	24.1%	-1.9%	20.5%	14.1%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.19	1.16	0.93	1.00	1.01	1.11	0.99	1.05
Middle Income Jobs	0.85	0.70	1.25	0.94	1.10	0.82	0.88	0.73
Lower Income Jobs	0.98	1.15	0.87	1.10	0.94	1.09	1.16	1.18

In Mod MA station areas, CRT stations attracted upper-income jobs to the station area. Middle-income jobs declined in concentrations and saw negative job share change in most DB's. Upper-income jobs grew significantly in concentration in the first two DB's and grew at a rate of 14% at the station. Job figures declined in the first quarter-mile DB for middle and lower-income jobs. Mild upper-income job losses occurred in the quarter-mile and 0.375-mile DB's, but were otherwise positive. Both middle and lower-income jobs lost concentrations at the station, being outcompeted by upper-income jobs. Lower-income jobs gained in concentration from 0.75-mile DB to the 1-mile DB, also gaining share at very strong rates the half-mile DB to the 1-mile DB.

Table 3.13. High MA: CRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*1*	*3*	*4*	*5*	*12*	*14*	*41,703*
Urban Square Miles – Cum.	*1*	*3*	*7*	*12*	*24*	*38*	*41,703*
Upper Income Jobs	40,863	10,980	37,661	31,643	1,526	10,746	5,711,287
Middle Income Jobs	19,455	13,751	23,037	12,877	11,197	4,219	4,082,268
Lower Income Jobs	32,607	12,753	25,496	18,145	8,875	21,879	7,639,070
Total Jobs	92,927	37,486	86,196	62,667	21,600	36,846	17,432,625

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	4,004	1,402	6,134	(1,079)	(734)	(692)	3,894,354
Middle Income Jobs	(14,418)	(1,946)	(3,679)	(1,696)	1,491	421	2,816,473
Lower Income Jobs	941	1,997	2,783	1,107	722	4,031	5,264,279
Total Jobs	(9,473)	1,453	5,238	(1,668)	1,479	3,760	11,975,106

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	10.9%	14.6%	19.5%	-3.3%	-32.5%	-6.0%	14.9%
Middle Income Jobs	-42.6%	-12.4%	-13.8%	-11.6%	15.4%	11.1%	7.2%
Lower Income Jobs	3.0%	18.6%	12.3%	6.5%	8.9%	22.6%	16.2%
Total Jobs	-9.3%	4.0%	6.5%	-2.6%	7.4%	11.4%	13.6%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.21	1.09	1.11	0.98	1.08	0.62	1.07	0.83
Middle Income Jobs	0.67	0.89	0.86	0.96	0.65	1.14	1.13	1.06
Lower Income Jobs	1.11	1.11	1.03	1.07	1.04	0.99	0.93	1.08

Competition for urban land is evident in the High MA land areas of CRT stations. Jobs mostly declined for middle-income jobs at the stations. Upper and lower-income jobs outcompeted middle-income jobs for scarce land in the urban core. It appears that upper-income jobs also outcompeted lower-income jobs for land, as well. Concentrations of jobs at the station relative to the region as a whole icnreased up to the 0.625-mile DB. After that DB, middle-income jobs gained positive trends in percent change, as well as LQ concentrations. The numbers of jobs at these stations changed in small numbers of jobs relative to other transit modes and station types. This may suggest, along with the evident competition for land, that many CRT stations in the urban core are approaching full capacity. This may result in further competition for space between job sectors within each income group.

Table 3.14. Poor MA: LRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*3*	*19*	*20*	*5*	*8*	*48*	*29,669*
Urban Square Miles – Cum.	*3*	*22*	*42*	*46*	*55*	*103*	*29,669*
Upper Income Jobs	104,283	13,830	9,943	11,998	49,185	8,781	6,348,275
Middle Income Jobs	26,590	4,244	5,671	6,198	12,757	5,013	4,376,463
Lower Income Jobs	46,774	9,993	21,179	8,310	14,198	5,017	7,795,428
Total Jobs	177,649	28,069	36,795	26,508	76,142	18,813	18,520,166

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	23,963	1,877	(272)	1,162	4,944	1,225	(26,908)
Middle Income Jobs	(812)	941	1,427	1,404	3,167	678	347,957
Lower Income Jobs	1,056	3,403	1,864	555	2,023	(10)	269,224
Total Jobs	24,207	6,221	3,019	3,121	10,134	1,893	590,273

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	29.8%	15.7%	-2.7%	10.7%	11.2%	16.2%	13.7%
Middle Income Jobs	-3.0%	28.5%	33.6%	29.3%	33.0%	15.6%	9.6%
Lower Income Jobs	2.3%	51.6%	9.7%	7.2%	16.6%	-0.2%	16.1%
Total Jobs	15.8%	28.5%	8.9%	13.3%	15.4%	11.2%	13.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.12	0.90	0.89	0.98	1.01	0.96	1.00	1.04
Middle Income Jobs	0.87	1.04	1.27	1.18	1.06	1.20	1.08	1.08
Lower Income Jobs	0.87	1.16	0.99	0.93	0.92	0.99	0.94	0.88

Middle-income jobs dominated LRT stations at the Poor MA station type neighborhoods in terms of percent change and LQ concentration trends, but upper-income jobs gained more job share in terms of raw change figures. Growth was most substantial at the station for upper-income jobs, while all jobs gained significant share at the quarter-mile DB. Considerable growth in upper-income jobs occurred at the station. All wage groups grew substantially just beyond the station across all DB's to the 1 mile DB. Small job declines occurred for middle-income group at the station, while upper-income jobs declined in small numbers at the 0.375 DB. Lower-income jobs showed a negligible job loss at the 1-mile DB.
The market responded well to LRT in the lowest-intensity land use areas of the served regions. Overall, the increase in job numbers was modest. On the other hand, the numbers represent significant rates of growth, especially in the middle-income level, which saw approximately 30% rate for all DB's from 0.25 to 0.75, and 15% growth at the 1-mile DB. Overall, growth at the station grew at rates higher than that of the respective regions.

Table 3.15. Low MA: LRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*45*	*9*	*14*	*69*	*56*	*10*	*29,669*
Urban Square Miles – Cum.	*45*	*55*	*68*	*137*	*193*	*203*	*29,669*
Upper Income Jobs	462,323	61,804	35,922	84,031	55,551	81,993	6,348,275
Middle Income Jobs	309,124	42,802	43,330	54,894	40,316	57,046	4,376,463
Lower Income Jobs	396,017	61,198	50,160	91,115	49,784	77,584	7,795,428
Total Jobs	1,167,466	165,806	129,414	230,042	145,653	216,625	18,520,166

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	5,071	(5,369)	(19,891)	2,277	8,973	(4,876)	(26,908)
Middle Income Jobs	(2,510)	(190)	(7,546)	(5,118)	774	2,978	347,957
Lower Income Jobs	(12,000)	(9,114)	(2,020)	17,831	380	(9,984)	269,224
Total Jobs	(9,439)	(14,673)	(29,457)	14,990	10,127	(11,882)	590,273

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	1.1%	-8.0%	-35.6%	2.8%	19.3%	-5.6%	13.7%
Middle Income Jobs	-0.8%	-0.4%	-14.8%	-8.5%	2.0%	5.5%	9.6%
Lower Income Jobs	-2.9%	-13.0%	-3.9%	24.3%	0.8%	-11.4%	16.1%
Total Jobs	-0.8%	-8.1%	-18.5%	7.0%	7.5%	-5.2%	13.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.02	1.00	0.79	0.96	1.05	1.11	0.95	1.00
Middle Income Jobs	1.04	1.12	1.08	0.89	1.03	0.98	1.09	1.15
Lower Income Jobs	0.96	0.93	1.16	1.14	0.95	0.92	0.98	0.92

LRT stations in Low MA areas declined in jobs overall within the first half-mile neighborhood. At the Low MA stations, LRT attracted 5,000 upper-income jobs at the station. Otherwise, all income groups lost job share to the half-mile DB. Upper and lower-income jobs grew at the half-mile and 0.75-mile DB's, while middle-income jobs mostly declined at these distances. Lower-income jobs gained share substantially at the half-mile DB, while upper-income jobs gained substantially at the 0.75-mile DB. Middle-income jobs then gained job share at the 1-mile DB. LQ trends reveal modest growth in concentration of upper and middle-income jobs at the station, while lower-income jobs slightly declined in concentration relative to the included regions. Overall, growth appears to have been stronger at the regional scale than at these LRT stations.

Table 3.16. Mod MA: LRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*18*	*80*	*61*	*10*	*46*	*172*	*29,669*
Urban Square Miles – Cum.	*18*	*98*	*159*	*169*	*215*	*386*	*29,669*
Upper Income Jobs	588,572	97,163	60,159	49,511	32,252	26,591	6,348,275
Middle Income Jobs	425,961	68,051	62,335	84,109	21,546	21,876	4,376,463
Lower Income Jobs	612,744	118,358	87,084	68,278	39,474	62,759	7,795,428
Total Jobs	1,627,279	283,574	209,580	201,900	93,274	111,228	18,520,166

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	(61,228)	16,973	10,920	3,924	15,068	2,156	(26,908)
Middle Income Jobs	(108,788)	(2,466)	7,580	6,736	1,984	8,476	347,957
Lower Income Jobs	4,752	29,383	17,538	5,703	(7,580)	11,357	269,224
Total Jobs	(165,264)	43,890	36,038	16,363	9,472	21,989	590,273

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	-9.4%	21.2%	22.2%	8.6%	87.7%	8.8%	13.7%
Middle Income Jobs	-20.3%	-3.5%	13.8%	8.7%	10.1%	63.2%	9.6%
Lower Income Jobs	0.8%	33.0%	25.2%	9.1%	-16.1%	22.1%	16.1%
Total Jobs	-9.2%	18.3%	20.8%	8.8%	11.3%	24.6%	13.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.00	1.02	1.01	1.00	0.96	1.69	0.84	0.87
Middle Income Jobs	0.91	0.85	0.98	1.04	1.17	1.03	1.23	1.36
Lower Income Jobs	1.09	1.10	1.02	0.98	0.94	0.74	1.01	0.96

LRT stations gained very significant share of jobs, especially of upper-income sectors overall for the first mile from the stations. The station area lost share of jobs for all but lower-income jobs. Middle-income jobs lost spatial concentration from the station to a half-mile distance. Only lower-income jobs saw a notable increase in LQ scores near the station, and only for the first two DB's from the station. Middle-income jobs trended very positively from the half-mile to 1-mile DB. Upper-income jobs increased in LQ score considerably at the 0.75-mile DB. All income groups grew at the 0.375 and half-mile DB's. In these trends competition among the income levels appears evident. Strong growth rates and increases in concentration occurred at the 0.75-mile and 1-mile DB's. Each income group, however had its largest growth rates and concentrations at different DB's, evidence of a competitive sorting process at the station. Overall, these station areas gained job share at much higher rates than their respective regions.

Table 3.17. High MA: LRT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*124*	*19*	*56*	*173*	*116*	*17*	*29,669*
Urban Square Miles – Cum.	*124*	*143*	*199*	*372*	*488*	*504*	*29,669*
Upper Income Jobs	239,859	10,248	30,745	18,420	2,607	7,045	6,348,275
Middle Income Jobs	162,373	28,058	21,683	19,080	3,141	6,823	4,376,463
Lower Income Jobs	211,838	31,482	54,918	29,057	13,624	11,809	7,795,428
Total Jobs	614,072	69,790	107,348	66,559	19,374	25,679	18,520,166

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	28,299	(131)	14,272	1,174	(328)	3,246	(26,908)
Middle Income Jobs	(21,544)	10,893	3,151	2,733	(783)	721	347,957
Lower Income Jobs	(13,667)	5,562	29,232	5,977	2,282	3,571	269,224
Total Jobs	(6,912)	16,324	46,655	9,884	1,171	7,538	590,273

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	13.4%	-1.3%	86.6%	6.8%	-11.2%	85.4%	17.8%
Middle Income Jobs	-11.7%	63.5%	17.0%	16.7%	-19.9%	11.8%	12.7%
Lower Income Jobs	-6.1%	21.5%	113.8%	25.9%	20.1%	43.3%	19.3%
Total Jobs	-1.1%	30.5%	76.9%	17.4%	6.4%	41.5%	17.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.14	0.75	1.05	0.90	0.87	0.83	1.17	1.30
Middle Income Jobs	0.93	1.30	0.69	1.03	1.07	0.78	0.83	0.82
Lower Income Jobs	0.93	0.91	1.19	1.05	1.01	1.11	1.01	0.99

LRT stations grew in job share considerably in High MA locations, with competitive sorting evident at many DB's. At the station, upper-income jobs gained share while middle and lower-income jobs declined in growth rate and concentrations. Middle-income jobs outcompeted the other wage categories at the quarter-mile DB; upper- and lower-income jobs gained substantially at the 0.375-mile DB; then, lower-income jobs gained share most prominently at the half-mile DB. Low-income jobs gained substantial share from the quarter-mile to the 1-mile DB. Upper-income jobs gained concentration at the 0.875-mile and 1-mile DB's. Upper and lower-income jobs gained share at rates much higher overall than the regions.

Table 3.18. Poor MA: SCT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*2*	*6*	*10*	*4*	*4*	*10*	*12,770*
Urban Square Miles – Cum.	*2*	*8*	*18*	*22*	*25*	*35*	*12,770*
Upper Income Jobs	NA	212	237	18	7,597	6,172	2,711,230
Middle Income Jobs	NA	3,234	13	82	2,703	3,757	1,866,830
Lower Income Jobs	NA	369	144	NA	1,920	2,792	3,363,486
Total Jobs	NA	3,817	396	205	12,222	12,723	7,941,546

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	NA	(163)	(26)	5	371	(927)	(35,061)
Middle Income Jobs	NA	3,051	(185)	10	584	1,332	56,941
Lower Income Jobs	NA	(10)	(196)	104	(102)	(707)	23,518
Total Jobs	NA	2,878	(407)	119	853	(302)	45,398

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	NA	-43.4%	-9.8%	35.7%	5.1%	-13.1%	12.3%
Middle Income Jobs	NA	1658.2%	-93.0%	13.7%	27.5%	54.9%	3.0%
Lower Income Jobs	NA	-2.6%	-57.5%	NA	-5.0%	-20.2%	16.5%
Total Jobs	NA	306.2%	-50.6%	136.8%	7.5%	-2.3%	11.6%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	NA	0.14	1.82	0.57	0.97	0.97	1.19	0.88
Middle Income Jobs	NA	4.69	0.15	0.52	3.19	1.29	0.94	1.72
Lower Income Jobs	NA	0.23	0.83	NA	0.37	0.85	0.57	0.78

Table 3.19 indicates that SCT stations did not contain the Poor MA land use type at the first DB from the station. It indicates that middle-income jobs gained tremendously in share of jobs at the quarter-mile DB, lost at 0.375 DB, and gained robust share to 1 mile DB. Lower-income jobs lost share across all DB's for this station type, suggesting that firms providing these jobs prefer to disperse more broadly in outlying areas than to concentrate near SCT stations. Middle-income jobs competed most strongly for position near these stations. Upper-income jobs gained share at the half-mile DB, then dropped off. Middle-income jobs continued to grow at significant rates and concentrations from the half-mile to the 1-mile DB.

Table 3.19. Low MA: SCT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*11*	*4*	*5*	*11*	*10*	*3*	*12,770*
Urban Square Miles – Cum.	*11*	*15*	*19*	*30*	*40*	*44*	*12,770*
Upper Income Jobs	39,532	22,378	11,356	12,323	7,268	12,890	2,711,230
Middle Income Jobs	19,030	58,391	4,269	20,279	3,330	6,389	1,866,830
Lower Income Jobs	28,025	46,487	25,894	12,426	6,652	12,851	3,363,486
Total Jobs	86,589	127,258	41,521	45,030	17,252	32,132	7,941,546

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	4,717	(4,982)	7,863	318	1,654	617	(35,061)
Middle Income Jobs	1,593	(31,152)	(1,337)	8,603	(2,573)	380	56,941
Lower Income Jobs	(4,944)	(3,151)	7,739	2,889	(243)	929	23,518
Total Jobs	1,366	(39,285)	14,265	11,810	(1,162)	1,926	45,398

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	13.5%	-18.2%	225.0%	2.6%	29.5%	5.0%	12.3%
Middle Income Jobs	9.1%	-34.8%	-23.8%	73.7%	-43.6%	6.3%	3.0%
Lower Income Jobs	-15.0%	-6.3%	42.6%	30.3%	-3.5%	7.8%	16.5%
Total Jobs	1.6%	-23.6%	52.3%	35.5%	-6.3%	6.4%	11.6%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.11	1.06	2.12	0.75	1.06	1.37	0.99	0.98
Middle Income Jobs	1.16	0.92	0.54	1.39	1.00	0.65	1.20	1.08
Lower Income Jobs	0.80	1.17	0.90	0.92	0.95	0.99	0.88	0.97

SCT stations in Low MA station areas saw robust growth for upper- and middle-income jobs. The responses to proximity varied broadly between DB's. Upper- and middle-income groups gained share at the stations, while lower-income groups declined. The most significant growth occurred in the 0.375-mile and half-mile DB's, with upper-income jobs gaining shares at a very high rate of 225%, and with middle-income jobs gaining shares at a strong 74% rate. All jobs lost share at the quarter-mile DB.

Table 3.20. Mod MA: SCT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*5*	*12*	*10*	*3*	*9*	*25*	*12,770*
Urban Square Miles – Cum.	*5*	*16*	*26*	*29*	*38*	*62*	*12,770*
Upper Income Jobs	236,738	24,291	18,226	6,613	6,754	31,027	2,711,230
Middle Income Jobs	145,471	39,678	20,722	15,176	5,496	19,425	1,866,830
Lower Income Jobs	217,857	31,790	42,752	9,854	12,783	32,523	3,363,486
Total Jobs	600,068	95,761	81,702	31,645	25,035	82,977	7,941,546

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	589	(2,686)	(1,497)	(22)	(806)	883	(35,061)
Middle Income Jobs	(31,123)	(36,267)	(2,058)	(2,096)	(14)	(11,214)	56,941
Lower Income Jobs	(24,224)	4,229	24,225	(887)	1,683	5,376	23,518
Total Jobs	(54,758)	(34,724)	20,670	(3,005)	863	(4,955)	45,398

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	Transit County
Upper Income Jobs	0.2%	-10.0%	-7.6%	-0.3%	-10.7%	2.9%	12.3%
Middle Income Jobs	-17.6%	-47.8%	-9.0%	-12.1%	-0.3%	-36.6%	3.0%
Lower Income Jobs	-10.0%	15.3%	130.7%	-8.3%	15.2%	19.8%	16.5%
Total Jobs	-8.4%	-26.6%	33.9%	-8.7%	3.6%	-5.6%	11.6%

LQ Percent Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.09	1.22	0.69	1.08	1.20	0.86	1.03	1.08
Middle Income Jobs	0.97	0.77	0.74	1.04	1.06	1.04	1.75	0.73
Lower Income Jobs	0.94	1.51	1.65	0.96	0.88	1.07	0.91	1.22

Lower-income jobs grew the most at the Mod MA SCT stations. Middle and lower-income jobs declined at large rates and lost spatial concentration at the stations, while upper-income jobs gained share at the station, to the quarter-mile DB, and then declined in most DB's to 1 mile. Middle-income jobs declined at significant rates in all but the 0.75-mile DB. Station areas gained lower-income job share for most DB's. These jobs gained in concentrations in the quarter-mile and 0.375-mile DB's to a substantial degree. These figures and trends suggest that SCT is most suitable for lower-income jobs in Mod MA place type station areas.

Table 3.21. High MA: SCT

Station Share of Job Shift 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*19*	*4*	*10*	*24*	*18*	*3*	*12,770*
Urban Square Miles – Cum.	*19*	*23*	*33*	*58*	*75*	*79*	*12,770*
Upper Income Jobs	149,760	23,483	4,338	5,834	1,910	905	2,711,230
Middle Income Jobs	65,691	20,433	2,546	10,026	495	980	1,866,830
Lower Income Jobs	125,209	15,666	29,404	11,798	2,521	5,364	3,363,486
Total Jobs	340,662	59,584	36,290	27,660	4,928	7,251	7,941,546

Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	12,505	(1,444)	116	380	321	(506)	(35,061)
Middle Income Jobs	(3,373)	(6,238)	91	504	5	(479)	56,941
Lower Income Jobs	(13,517)	(454)	18,779	3,525	801	(511)	23,518
Total Jobs	(4,385)	(8,136)	18,986	4,409	1,127	(1,496)	45,398

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Upper Income Jobs	9.1%	-5.8%	2.7%	7.0%	20.2%	-35.8%	12.3%
Middle Income Jobs	-4.9%	-23.4%	3.7%	5.3%	1.0%	-32.8%	3.0%
Lower Income Jobs	-9.7%	-2.8%	176.7%	42.6%	46.5%	-8.7%	16.5%
Total Jobs	-1.3%	-12.0%	109.7%	19.0%	29.6%	-17.1%	11.6%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Upper Income Jobs	1.10	1.06	0.49	0.89	0.68	0.92	1.13	0.77
Middle Income Jobs	1.04	0.94	0.54	0.96	1.50	0.84	0.53	0.88
Lower Income Jobs	0.88	1.06	1.26	1.15	0.94	1.08	1.33	1.06

Upper-income jobs displaced other income groups at the station, but lower-income jobs were dominant in the distance from 0.375 to 0.75 miles from the station. All wage groups lost share at significant rates at a mile from the station, but these rates represent only a small number of jobs. This may indicate that these station areas are reaching build-out. This can be further intimated from the declines at the station concomitant to the upper-income job growth there, as upper-income jobs outcompeted the other wage groups. The transit regions as a whole saw modest growth in this period, as well. SCT station areas gained significant share of jobs, nonetheless, as the economy continued its shift towards station areas, a move shown to increase resiliency to economic downturns.

Summary of Results

Variations are widespread between transit mode-station typology combinations. A brief summary follows that reiterates key findings for each combination above, for wage groups and economic groups.

BRT stations across station place types responded as follows:

- Poor MA: upper-income jobs are attracted to the station (one-eighth DB), and low-income jobs are attracted to the station across all bands to 1-mile DB. Retail, Knowledge and Office showed high rates of growth at the first two DB's, while other sectors declined. Manufacturing and Light Industry gained concentrations at the station relative to the regional trends.
- Low MA: lower-income jobs are repelled by proximity to the station. All wage levels respond tepidly to the direct vicinity of the station, with substantial growth in the mid DB's, and mixed results beyond, to one mile. Knowledge, Education, Health and Arts economic groups had the most overall growth at these stations to 1 mile.
- Mod MA: just as in the case of Low MA, BRT repelled all wage groups at the station. Upper and lower-income jobs competed for land beyond, to 0.75-mile DB, while middle-income jobs mostly declined from the station to the 1-mile DB. Knowledge, Office, and especially Retail grew at high rates at the station. While these had the highest gains in LQ scores, as well, Education, Health and Arts-Entertainment-Recreation also gained in concentration just beyond the first quarter-mile DB.
- High MA: this station place type grew in job share substantially for all wage groups. Upper-income jobs dominated the station area, while it shared growth with middle-income jobs to half a mile, upon which lower-income jobs dominated the growth trend. High rates of growth occurred for all wage groups at different DB's to 1 mile from the station. Retail, Knowledge, Office, and Arts grew at the highest rates and spatial concentrations at this place type.

CRT stations across station place types responded as follows:

- Poor MA: Middle-income jobs grew at a considerable 49% at the station (the 0.125 DB). The other income groups also grew substantially at the station, and just beyond, in the quarter-mile DB. The 1-mile DB saw declining rates for all wage groups. Light Industry and Knowledge jobs had the most significant portion of the growth. Office also had positive rates across most DB's. Light Industry, Knowledge, Arts and Health jobs gained in spatial concentration; the latter two declined in concentration at the station but gained just beyond the station.
- Low MA: Upper and lower-income wage groups grew at large rates up to the 0.75-mile DB. Middle-income groups saw tepid growth or decline throughout. Education declined, while Light Industry and the Arts gained in growth rate and concentration.

- Mod MA: Upper-income jobs dominated at the station area, while lower-income grew most substantially from half-mile to the 1-mile DB. Upper-income jobs also saw notable growth at the half-mile to 1-mile DB. Competition between sector groups was quite evident at the station. Manufacturing, Light Industry, Retail and Knowledge gained at the station, while Office, Education, and Health declined in first quarter and then mostly gained between 0.375 and 1-mile DB's.
- High MA: Competition for urban land is evident in the High MA land areas of CRT stations. Jobs mostly declined for middle-income jobs at the stations. Upper and lower-income jobs outcompeted middle-income jobs for scarce land very near the station, while dominating the growth rates farther out to 1 mile from the station. Retail and Knowledge had positive growth rates at the station, while Office declined. Health did well just beyond the station.

LRT stations across station place types responded as follows:

- Poor MA: Middle-income jobs dominated LRT stations at the Poor MA station type neighborhoods in terms of percent change and LQ concentration trends, but upper-income jobs gained more job share in terms of raw job figures. Knowledge, Office and Health did gained the highest share at the station, while Manufacturing and Industry also gained share at the station. Knowledge, Office, and Health gained most in spatial concentration near the station.
- Low MA: Job growth rates and figures were flat or in decline at or near the station. Some growth occurred in upper- and lower-income jobs at half a mile and 0.75 miles from the station. Retail, Knowledge, Health and Arts grew at the station, while the quarter-and 0.375-mile DB's declined in most industry groups.
- Mod MA: Jobs for all wage groups were repelled from the station, while growing at high rates of job share growth from the 0.25-mile DB to 1 mile from the station. Light Industry, Office, and Health job groups dominated the growth in the overall station area to 1 mile.
- High MA: LRT did exceptionally well at all distances to 1 mile from the station, except at the station, where upper-income jobs pushed out the other wage groups, which declined in growth rates. Retail, Knowledge, Health, and Arts showed positive rates of growth and spatial concentration near the station. Light Industry gained at positive rates in the 0.375-mile and 0.5-mile DB's. At the same time, Light Industry, Office and Education lost concentration at the station.

SCT stations across station place types responded as follows:

- Poor MA: these station areas had no land area of this place type at the station, and rates of growth declined until the half-mile DB, with some growth thereafter to 1 mile from the station. Health, Knowledge, and Office jobs saw notable positive outcomes in growth rates.
- Low MA: Upper- and middle-income jobs had healthy growth at the station, pushing lower-income to decline. All groups declined at the quarter-mile DB. High rates of growth, with competitive sorting occurred from the 0.375 to the 0.75-mile DB. All declined at the 1-mile DB. All industries saw gains in share at the station, except Manufacturing and Education. Office jobs gained the most share and concentration at the station.
- Mod MA: Growth mostly occurred in lower-income jobs. Upper-and lower-income jobs were repelled by the station in the first quarter mile from the station. Lower-income jobs grew across most DB's to 1 mile. Middle-income jobs mostly declined. Light Industry, Retail, Knowledge, and Arts did well at the first DB (at the station). Office declined in all DB's to 1 mile. Education and Health declined at the first DB.

- High MA: Upper-income jobs were attracted to the station area, but jobs were repelled from the quarter-mile DB, with considerable growth mostly in lower-income jobs. Upper-income jobs also grew in share at the half-mile and substantially at the 0.75-mile DB. Rates went into decline for all wage groups at the 1-mile DB. There was considerable competition at the first two DB's from the station. Retail, Knowledge, Health, and Arts-Entertainment-Recreation did the best at this highly competitive urban station type. Office, Education and Light Industry declined at these distances.

Implications for Transit and Land Use Planning

Overall Trends

These figures reveal important context for these transit modes. CRT's performance at the lower levels of land use mix and accessibility shows its utility to the suburban commuter. LRT's highest performance in the middle ranges of the mix and accessibility continuum (Moderate and Low MA) may be due to the size and capacity of this mode. BRT did very well at all levels, showing exceptional adaptability to the land use context. BRT was the best-performing at the Poor MA Place Type. SCT clearly demonstrates its urban configuration, being the most successful at High MA places or urban core level.

Each transit mode has its most useful application, which is true of the transit place types, as well. The winning combinations are all of a minimum threshold of land use efficiency. The Poor MA place type struggled with low job numbers, but all transit modes but SCT gained respectable shares of jobs. At the Low MA place type areas, with the exception of CRT, job groups were repelled from the station. This could be due to the larger scale of parcels and the higher degree of automobile dependency at this place level. Stations of the Mod MA type repelled jobs from the station, with exception of upper-wage jobs at CRT stations. High MA areas mostly suffered from competition, with most wage and economic groups competing to be near the stations. These are job destinations for those riding CRT and LRT; they are place destinations for SCT riders, while BRT attracts everyone.

CRT and BRT did the best in the "Poor MA" neighborhoods. Still growth was miniscule for all transit modes in Poor MA. SCT actually declined at the "Poor MA" level. BRT and LRT had significant growth in job share at the "Low MA" neighborhoods. All modes grew, moreover; SCT and CRT showed modest growth, which was nevertheless disproportionate to the land area of the stations, compared to their share of regional urbanized area. BRT and LRT had significant growth at transit typology level 3, "Mod MA." SCT had strong growth. CRT showed very modest growth, almost remaining flat. At the most urban neighborhood type, SCT had robust growth, and BRT grew at a tremendous rate. LRT showed respectable rates of growth, while CRT was again flat in growth.

Bus Rapid Transit performed well across all station types. The Poor MA type performed at the lowest rate of all types, with the land nearest the station declining in share and land in the next distance bands doing well. BRT systems did the best of all modes in the Poor MA category, implying that it may well be the best option for connecting outlying suburbs to more urban locales and rail transit. The implication for the low response of the market to the BRT station at the Poor MA station type is that the relative lack of walkability, as well as the auto-centric nature of transport leads to a poor response nearest the station, but a more robust response further away from the station. The lack of enthusiasm for the area nearest the station reflects the design conflicts that lead to negative spillovers. Examples include poor street connectivity to the station area and low-density development that does not respond to transit proximity as well as higher density areas. The introduction of gentle density increases and "missing middle" housing in these areas could be combined with more street and sidewalk network connections between residential and station areas to increase the response to and use of the station (Arthur C. Nelson 2013; Dunham-Jones and Williamson 2011; Parolek 2020).

CRT also did better than LRT and SCT in the Poor MA station type. It reflected the same negative response at the station, with the neighborhoods beyond the station responding very positively to station proximity. CRT's low response to the high and moderate station types but robust response at the Low MA level reflects that its best applicability at present is in lower-

density neighborhoods, with riders being most likely commuters for the light industry and other sectors. The example of Austin, Texas points out, however, that the CRT systems may be relying considerably upon their regional connection to the CBD. While many stations along the CRT systems are of lower-intensity development, they are typically connecting to an endpoint within an urban core with high intensity access and land use mix.
The LRT system as a whole performed best at the middle of the access and land use mix scale. This is likely due to the large size of these systems, which are usually above ground and not as well-connected to the built environment as the heavy rail systems of cities like New York or Washington, D.C. Further, the streetcar systems of many cities likely pull away some of the returns for LRT in the High MA category, as they are smaller and more amenable in design to the urban core. Notable exceptions include Salt Lake City's TRAX and Denver's LRT system. This may be due to a largely nonexistent SCT presence in the vicinity of these cities' LRT systems.

Streetcar Transit performed well in the highest station type, High MA, and poorest in the "Poor MA" areas. This is due largely to the focus of streetcar systems on the urban core. The example of Tucson, Arizona is the quintessential example of a successful SCT system. The high performance of Tucson's streetcar is partly due to the planning policies involved, such as the City of Tucson's Rio Nuevo District, a tax-increment financing (TIF) district. However, the most important characteristic of the Tucson streetcar is its placement along the city's most walkable, most accessible, and highest land use mix blocks. These areas include the downtown, the 4th Avenue shopping district, and the University of Arizona campus, including its flagship hospital. The scale of the built environment is well-matched to the scale of the SCT system. However, in all but the Office and Education sector groups, the SCT LQ declined at the station, while improving just beyond.

For all but CRT stations, the stations themselves are mostly seen as a disamenity from which to escape. Station areas are mostly unpopular, with the exception of low-density CRT stations at the Poor MA and Low MA levels; and, for LRT at the Low MA level. For those who are attracted to the station for upper-income jobs, the distances just beyond the station are not attractive enough to draw upon that enthusiasm. Even SCT stations in the urban core are unpopular except to upper-income jobs. This may be due, however, to the competitive sorting process.

Trends by Job Economic and Wage Groupings
Competition between economic sector groups and wage groups is evident at stations for many transit mode-place type combinations. Also very evident is a trend away from the DB closest to the station, or the station area itself, for many transit modes at many station place types. In highly competitive station areas, land use policy may be of help in improving the utility of under-utilized land parcels, to bring them into alignment with the most productive level of mix and intensity for the context. Also true is that many stations repelled firms away from the first DB, at the station itself.

In many station areas, upper and lower-income jobs are partners in growth trends, co-locating in the same DB or nearby. This has left many stations with relatively low growth rates in the middle-income jobs. This is also in part due to the nature of those sector groups, which include such occupations as transport and warehousing. They often require an inordinate land area for the first mile from a station.
For BRT, CRT and LRT, transit share of job shift in this time period was most pronounced at the Low MA and Mod MA place types. For SCT, that trend was most pronounced at the Mod MA and High MA place types. This highlights the urban orientation of the SCT systems.

For SCT, job growth and concentration at the station (the 0.125-mile DB) was the highest at the Low MA place type, possibly due to the built-out nature of the more intensely developed locations. For CRT and LRT, growth at the station was highest at the Poor MA place type. For BRT, growth was quite pronounced at all stations *for the upper-income jobs.* The rest mostly declined at the BRT station. CRT saw upper-income jobs grow at the Mod MA type, while both upper and lower-income jobs grew at the High MA type. This indicates that upper-income jobs pushed away other jobs at the Mod MA level while lower-income jobs supported upper-income jobs at the High MA level where low-income jobs can support upper-income jobs. This phenomenon is present at the Mod MA LRT, as well, with middle-income jobs declining seemingly as a result of significant growth of the upper and lower-income jobs in the same locations.

For some place types, industries gained spatial concentration at a lower rate than the region as a whole, which resulted in negative LQ trends at the station. This occurred for Education, Office and Light Industry at the High MA LRT stations. This may point to these industries losing the competition for transit-proximate land to those who gained in concentration such as Retail and the Arts-Entertainment-Recreation groups. This also happened in the Poor MA SCT stations, as Health and Knowledge outcompeted Retail and Light Industry.

These results indicate the market responses to transit proximity across a range of place types and transit modes. Various policy approaches could be taken in these areas, including 1) encouraging the most competitive land uses to increase their presence at a given station place type and transit mode, 2) increasing the land use mix, intensity and accessibility at specific stations by place type and transit mode by encouraging target land uses to the stations to fill the gaps needed for mixed-use development, and 3) make modifications to the local built environment and zoning code that will support the desired targets.

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CHAPTER 4: Toward an Index of Employment-Worker Balance by Transit Station Mode

OVERVIEW

An “Employment-Worker Balance” (EWB) is created. It is viewed as a key to economic growth through agglomeration economies is also a key to social equity. This is due to its ability to both increase workers’ access to employment and firms’ access to a strong, diverse, and resilient workforce. Smart Growth advocates frequently identify Employment-Worker Balance as a key metric in compact urban design. Because of its potential synergistic effects with EWB, another key element of Smart Growth, Fixed-Rail Transit systems (FRT), needs to be studied for its effects on EWB: is the latter improved by the former, and for which job sectors and which workers? Principle Component Analysis will be used to produce a EWB Index that is able to map EWB across multifarious spatial contexts across the U.S., taking into its scope the multiple types of transit system modes, real estate types, and the many sectors of the economy that surround FRT stations. The EWB Index will provide a tool for practitioners and researchers to utilize in regression analysis, and policy and decision support. This chapter follows up on this significant increase of available evidence to work towards further theoretical refinement of EWB.

Introduction

There has been a long-standing and continuous debate regarding the relative merits of accessibility and mobility as separate paradigms of human flows. The EWB inherently is built upon a measure of access; however, the mode of travel between places changes the salient components of access. The built environment must support whatever transportation technology is chosen to reach one’s destination. Some researchers assert the lack of a strong connection between accessibility and the built environment, citing instead the importance of individual behavior and constraints placed upon individuals by social structures(1,2). However, mobility is one way to increase accessibility. It is most available and enjoyed by those who can pay to use mobilizing infrastructures and technologies. These, moreover, are ever-costlier to jurisdictions as they are required to support the transport of ever-larger magnitudes of people across ever-longer distances. Sprawling development necessitates the near-complete human reliance upon the automobile-as-prosthetic-device, and thus the infrastructure to facilitate its use. The continuance of sprawling development will exacerbate financial excesses in real estate development and public infrastructure spending (3). Others emphasize the need to balance mobility and accessibility. The former is the ability to move about the region in order to access needed land uses; the latter is “the relative connectedness of an area” (4). Paez et al. (5) provide clarification in their definition, describing accessibility as “the joint result of a transportation network and the geographical distribution of activities.” Regianni et al. (6) describe accessibility as “the potential of opportunity for interaction,” which aids in economic growth. Mode of transportation is also critical. The empirical data measured by studies such as Ewing & Hamidi (7) and Levin (8) demonstrate the importance of the built environment to accessibility. Relative accessibility is measured by one’s ability to utilize needed land uses.

Questions & Hypotheses

Can we directly measure the effect on EWB from transit stations via an index that is sensitive to different kinds and levels of transit across metros?

- Hypothesis 1: Different combinations of economic sectors and transit modes will load on different PCs
- Hypothesis 2: Different modes of travel will load differently on the Employment-Worker Balance Index (EWBI).
- Hypothesis 3: These differential loadings will produce a variety of EWB regimes or clusters.

Literature Review

Graaskamp (9) emphasized the value (situs) of a site as “related to the functional needs of the activity and not the site.” Linkages between a site and the surrounding region facilitate accessibility, and the “costs of friction” are those of the stress, time, and costs accruing to each of the needed linkages for a specific activity (9). Employment-worker balance enhances those linkages between sites, both for the workforce and for the workplace, easing the costs of friction through greater accessibility. TOD enhances the EWB inasmuch as it is relevant, through built environment characteristics and transit node interconnectivity that draws people to utilize the site for both land uses and access to the regional transit network. Levine (8) argued that while “commute time remains a strong determinate of residential location at the regional scale,” the salient improvement in accessibility accruing from an employment-worker balance derives from the increased match between workplace and residential location due to a greater range of options from which to choose in both housing and transportation. This principle is consistent with the theory of the gravity model, as a multitude of land uses in close proximity will increase the pull effect of a location. Relaxing zoning regulations that promote and subsidize spatially separated, single-use and lower-density development may promote better EWB, as demonstrated by Levine’s (8) discrete choice model.

Worker accessibility is of significant value to both worker and employer. The “drive till you qualify” crowd living out in the suburbs or exurbs pay thousands of dollars more annually for transportation costs, when considering both monetary cost and time spent, and many choose to live nearer to work when given the option. The positive market response to development of residences nearer employment clusters negates the argument that a regulatory promotion of EWB is an interference with the market (8). Moreover, firms regularly demonstrate the importance of workforce accessibility to the health of the firm. Employers regularly place firms on the basis of an analysis of local workforce educational attainment and spatial concentration (10).

Data & Methods

The quantitative analysis of multivariate processes and phenomena in the social sciences requires the combination of many indicators of these phenomena, which further requires a structured paradigm or theory to both formulate and to interpret the analysis. A common definition of an index is informative: it is a measure of an abstract theory that combines multiple indicators.

Method examples for creation of indices in the literature include both Factor or Principal Component Analysis (PCA) and multiple regression. In the PCA realm, Ewing & Hamidi (7) use the Census Tract to provide local “sprawl-like” measures, applying their PCA methodology, which was originally used at the metropolitan area scale. The PCA combines many correlated covariates in vector space to reveal the latent processes jointly explained by the correlated variables. In the realm of regression, the U.S. Department of Housing and Urban Development’s (HUD) Location Affordability Index (LAI) relies upon a complex Structural Equation model (SEM), which maps out direct and indirect causal pathways between endogenous variables.

The choice of either method requires weighing the tradeoffs of positive and negative aspects of each, given the unique requirements of each study undertaken. PCA is non-parametric, a probable source of advantage over regression. Regression modeling with fixed effects may provide some advantages over PCA, as it can control for noisy differences between unique places using various fixed effects (11).

Transit systems for this study were derived from General Transit Feed Specification (GTFS) static files, which most transit authorities across the United States provide in accordance with the Google GTFS data standard. Transit authorities prepare their data about stops and routes along the various modes of public transportation available in their communities, including local, express, and rapid bus routes, commuter rail transit, light rail, streetcar rail, and heavy rail subway-metro systems. The GTFS standard tables were processed through ArcGIS Model Builder.

The study will review transit systems for the year 2016 in the cities of Atlanta, Cleveland, Eugene, and Minneapolis. These cases represent a wide variety in terms of region, population size, economy, transit modes (e.g., streetcar or bus rapid transit), and urban form. The study area is restricted to the U.S. Census Urbanized Area of the counties of the metropolitan area that are served by transit systems. The transit system modes for each city are as follows:

- Atlanta: streetcar (SCT), heavy rail transit (HRT)
- Cleveland: light rail (LRT), bus rapid transit (BRT)
- Eugene: bus rapid transit (BRT)
- Minneapolis: LRT, BRT & commuter rail (CRT)

Commutesheds from LEHD Origin-Destination Tables

The data tables for jobs and workers were gathered from the U.S. Census Bureau's Longitudinal Employment-Housing Database (LEHD) job data tables for census blocks were downloaded from the U.S. Census Bureau's On the Map website in shapefile format. The LEHD Origin- Destination Employment Statistics (LODES) tables provide full counts, rather than samples, of wage and salary jobs covered by unemployment insurance, with strict enforcement of privacy for individual respondents. These tables provided the variables for study about the location of jobs and their pay level, as well as workers and their pay scale. The former are found in the Work Area Characteristics (WAC) files, detailing the workplace location and other data for the employees that are enumerated in the file. Jobs totals are provided, along with a breakout of jobs by age of employee, by pay ranges, and by jobs according to the North American Industry Classification System (NAICS) job sector categorization. The Residence Area Characteristics (RAC) file provides data on the residence location of workers, including the same variables as the WAC file, but from the basis of the residence location of the enumerated workers, which may or may not include the residence census block. Benner & Karner (12) point out the limitations of the LEHD earnings classification, including the lack of an index to inflation and the significant variation in the number of workers who fall into each category as one controls for metropolitan statistical area. This study will utilize a classification of income based on NAICS job sectors, following Nelson and Ganning (13). Street and intersection data will come from the U.S. Census Bureau's TIGER Line data set, with post-processing done in GIS.

Commuteshed sums of workers for a dissimilarity index and internal capture ("residence ratio" in Kain (14)) is measured using an origin-destination cost matrix, which maps the Euclidean distance from each origin to each destination to which it is connected. The distance method is a 3-mile cutoff.

The commuteshed is derived in GIS by a search from each origin census block group to all CBGs listed as destinations. An origin-destination cost matrix selects all destinations within the 3-mile Euclidean distance threshold. A one-to-many relationship exists between origins and destination. Therefore, the cost matrix provided the required lookup table between origins and destinations. Summing the workers in the commuteshed of each CBG was calculated as follows:

$$workers\ in\ CBG\ commuteshed\ = \sum_i^n \sum_j^m C_{ij} \qquad (1)$$

Where the total number of workers commuting from an origin *i*, to a destination, *j*, or C_{ij}, within the 3-mile range is considered part of the commuteshed. The number of origins, *i*, is denoted by *n*, and *m* is the number of destinations *j* per origin, *i*. This calculation is done by summing each origin-destination CBG pair, and then again for the origin CBG. The origin census block group ID provided the basis for summing those workers working at job sites within about 3 miles from home. This method was used for both the numerator and the denominator in the internal capture equation. Each census block group gets evaluated for the number of workers at each destination, and a sum is made of workers who live or work and who both live and work in the commute shed. This enables use of the equation for internal capture in each cluster:

$$internal\ capture = \frac{2*workers\ living\ \&\ working}{workers\ living + workers\ working} \qquad (2)$$

Commuteshed sums for the dissimilarity index were calculated with the same method. The dissimilarity index gives a measure of distribution or concentration of subsets of a data population. This study applies it to the level of “income match” in a CBG commuteshed. Income match (15) determines the relative balance in a location of workers and relevant housing by income. The dissimilarity index is computed thusly:

$$DI = 0.5 \sum_{i=3}^{N} \left| \frac{r_i}{R} - \frac{w_i}{W} \right| \qquad (3)$$

Where r_i is the number of workers of a given income level subset residing in the commuteshed, R is the number of all workers residing in the commuteshed, w_i is the number of workers of a given income level subset working in the commuteshed, and W is the number of all workers working in the commuteshed.

Spatial Cluster Analysis – Identifying Centers & Sub-Centers

Centers of employment and residential land use will be identified through spatial cluster analysis, which relies upon spatial dependency or autocorrelation between objects in terms of one measured variable. Moran's I, a global measure of spatial autocorrelation, a spatially-weighted version of the Pearson correlation coefficient (16), is the most appropriate analysis to begin with, as it determines overall levels of spatial clustering in a given region or total study area. Then, if it identifies statistically significant clustering, this finding indicates that more neighborhood-level measures can be used (and at what distance band), such as the Getis & Ord Gi* statistic, which identifies neighborhood-level hot or cold spots of a given variable, assigning z scores and p values for quantification. The most intense employment cluster in the region is the CBD (17).

Moran’s *I* is defined as

$$I = \left(\frac{1}{s_y^2}\right) \frac{\sum_i^N \sum_{\{j:i\neq j\}}^N w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_i^N \sum_{\{j:i\neq j\}}^N w_{ij}} \qquad (4)$$

Where $\bar{y} = \sum_i {y_i}/{N}$, $s_y^2 = \frac{1}{N} \sum_{i=1}^N (y_i - \bar{y})^2$. y_i are counts, although alternative versions of Moran’s *I* utilize continuous values (16). The metric provides a cross-product, as it sums the covariance between each point and each of its neighbors, providing the sum of covariance (deviation from the mean at y_i multiplied by the deviation from the mean at y_j) for all sets of adjacent neighbors, and then it divides it by the global variance, s_y^2. The resulting index ranges between -1 and 1, from a spatially dispersed pattern, to a spatially clustered one. This metric can be used at various distance bands, defined in the equation by assigning all features within the desired distance band a value of 1 in the matrix, w_{ij}. The various peaks in the score can represent neighborhoods in which the underlying spatial associations are strongest, and it is not necessarily true that each phenomenon has only one peak.[6] The researcher may then choose the peak distance band at which the phenomenon being studied is operative (Figure 4.1).

The Getis and Ord Gi* metric measures the degree of association resulting from the concentration of weighted points or areas and the other weighted points or areas within a given neighborhood, which is defined by distance *d* from the origin *i*. The Gi* metric is defined as follows,

$$Gi^*(d) = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij}(d) x_i x_j}{\sum_{i=1}^n \sum_{j=1}^n x_i x_j} \qquad (5)$$

[6] ESRI ArcGIS Desktop Help. “Incremental Spatial Autocorrelation.” Accessed 7-25-2017. http://desktop.arcgis.com/en/arcmap/10.4/tools/spatial-statistics-toolbox/incremental-spatial-autocorrelation.htm.

Where w_{ij} is the matrix of weighted points within each neighborhood, $w_{ij}(d)$. The matrix is a set of binary values designating whether each location *j* is within distance *d* of the origin location *i.* Each weighted point has the attribute value, x_i or x_j. The metric has a null hypothesis of spatial independence (18). Moran's *I* is a useful starting point for using local-scaled metrics of spatial association, by defining distance bands at which association may be strongest. This distance then becomes the definition for the neighborhoods in the Gi* statistic (distance *d* in equation 2 above).

Centering is evaluated using non-parametric global and local spatial autocorrelation metrics, and sub-centering is evaluated using non-parametric geographically weighted regression (GWR). It fits a separate regression model to each observation according to a sample of observations taken from a neighborhood kernel centered on the observation. The kernel can be fixed in size or adjusted at each observation for size to capture *k* observations to make the sample sufficiently large. The result is a set of unique coefficients and error terms associated with each observation in the study sample. This produces a local statistic that answers for a lack of structural integrity in some explanatory variables that vary significantly across space. It is specified thusly:

$$Y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i)\, X_{ik} + \varepsilon_i \quad i = 1, \ldots, n \qquad (6)$$

It answers for spatial non-stationarity by fitting a regression to each observation, *i,* estimating the dependent variable by estimating a constant, β_0, and a vector of parameters, β_k, at each spatial location designated by the coordinates of *i*, (u_i, v_i). The error term is also determined for each location, *i.* The parameters $\beta_k(u_i, v_i)$ are estimated by adding a spatial weights matrix, $W(u_i, v_i)$ to the traditional OLS parameter estimation equation. The W matrix models spatial relationships using either a fixed or adaptive continuous kernel, with a distance decay function estimating the spatial relationship. Common forms are a Gaussian distance decay or bisquare weighting function. The adaptive kernel chooses a varying distance bandwidth in order to capture the same number of nonzero weights per observation *i* (19).

To evaluate centering, one identifies and culls those centers with employment that consist of more than 75% of all jobs in one single economic sector (20). This eliminates large single-sector land uses. Standard deviations of the Gi* statistic will be used to evaluate the magnitude of centering. Positive residuals from GWR regression of employment density on distance from CBD represent sub-centers. One threshold employment density for sub-centers is 20 jobs per acre. Alternatively, the magnitude of the positive residuals, proxies for the intensity of centering, with 2.5 standard errors being used in the literature as a cutoff (17,20). The study will use the latter approach to generalize the results to multiple levels of density across the urban hierarchy.

TABLE 4.1. Place-Based Job Sectors in the Study Allocated by Wage Category

NAICS	Description	Mean Annual Wages, 2013	Wage Category	Share of Jobs
44	Retail Trade	$25,779	Lower	
56	Administrative, Support, Waste Mgmt., Remediation	$35,931	Lower	
61	Educational Services	$35,427	Lower	
71	Arts, Entertainment and Recreation	$32,188	Lower	
72	Accommodation and Food Services	$17,453	Lower	
81	Other Services (except Public Administration)	$29,021	Lower	
	Weighted Mean Wages and National Share of Jobs		*~$30,000*	*~33%*
48	Transportation and Warehousing	$45,171	Middle	
53	Real Estate and Rental and Leasing	$46,813	Middle	
62	Health Care and Social Assistance	$44,751	Middle	
92	Public Administration	$51,340	Middle	
	Weighted Mean Wages and National Share of Jobs		*~$50,000*	*~33%*
22	Utilities	$94,239	Upper	
31	Manufacturing	$54,258	Upper	
42	Wholesale Trade	$65,385	Upper	
51	Information	$83,677	Upper	
52	Finance and Insurance	$88,677	Upper	
54	Professional, Scientific and Technical Services	$75,890	Upper	
55	Management of Companies and Enterprises	$105,138	Upper	
	Weighted Mean Wages and National Share of Jobs		*~$70,000*	*34%*

Source: Adapted from (13).

Principal Component Analysis
Factor analysis reveals latent variables from a series of highly correlated observed variables. One major variant, Principal Component Analysis (PCA), reduces the noise in a set of correlated variables, revealing with greater clarity the underlying signal of the phenomena being explained by the variables by highlighting their shared variance and removing white noise. Each component is a group of correlated variables that load highly on the component, meaning they are closely related to it. It is also known as Empirical Orthogonal Functions (EOF) due to non-parametric fitting of eigenvectors to highly correlated covariates. Each EOF is orthogonal to the others.

The two most common applications of PCA involve explaining the variance across 1) a time series (21), or 2) a set of variables (22). The first approach reduces the noise in a single variable across many time periods, while the second approach reduces noise for many variables for a single-year cross-sectional data set. The study relies upon PCA to reveal job growth dynamics in redlined zones and nearby transit stations, hypothesizing that transit proximity increased job growth over the years of the study, but did not provide this benefit to all segments of the population.

Table 4.2 lists the variables to be used in the PCA, with justifications from the literature. The variables' data sources include the US Census Bureau's ACS and LEHD data sets, the GTFS transit data format, and various GIS and R-derived spatial processes.

The method consists of taking four matrices to translate from variables to component scores for each observation in space. The process begins with a) the base matrix of *N* observations by *M* variables translated into standardized z-score format, also known as a centered matrix, and next, b) the correlation coefficient matrix is taken, producing a square matrix of *M* dimensions. Then, c) the singular value decomposition method (SVD) creates matrices of eigenvectors (as wells as eigenvalues in a separate matrix). The eigenvalues are presented as the diagonal of the S matrix in SVD, and the proportion between each value of the diagonal and the trace (the sum of the diagonal) provides the explained variance of each eigenvector. Finally, d) the eigenvectors, found in the U matrix of the SVD output, are used as weights in linear combination with the original data values to produce the components (i.e., signals or scores). The individual elements of the components in (d) are also known as score coefficients.

The literature cites four reasons to rotate the vector space (a linear transformation process). Rotation provides such advantages as insensitivity to the shape of the spatial domain and subdomains underlying the data, no trouble with sampling error, and an accurate picture of physical relationships within the original data (23). Also, rotated space typically increases the explained variance and the loadings of each component on the relevant original variables, by better fitting the components to the data (24). Further, rotating and gaining a better fit of the components to the variable vectors also reduces secondary loadings of the variable vectors on the components, in effect causing each factor to represent one process captured by the clustering (i.e., correlated) variable vectors (22,23).

TABLE 4.2
Variables Included in EWBI, Justification & Literature Sources

Variables	Description & Justification	Selected Literature
Distance to nearest FRT stations by mode and station's centering intensity (GWR score)	Vector of measures of node and place attributes of neighborhood transit stations.	(25), (17,20,26)
Place-Based Employment by sector group, age, and income	Categorized vectors of employment, they are a necessary input to capture demographic interactions. Firms compete for location.	(13,14,27)
Place-Based Workers by sector group, age, and income	Vector of workers. Worker demographics greatly affects commute.	(13,14)
Housing by tenure and quality	Vector of housing. Renters can move residences easier than owners. Housing quality increases in newer development, with fewer vacancies.	(15)
Commuting mode, time	EWB highly dependent upon commute mode and shed, a vector measured in time or distance. Link between station proximity and mode choice to work.	(15,25)
Vehicles per Household	Vector proxy for automobile dependency	(25,28)
Intersection density	A measure of urban compactness and walkability.	(7,15)
Road network density	A measure of urban compactness and walkability.	(15,27)
Strength of employment density; centering/subcentering	Higher EWB results in lower VMT and VHT and facilitates substitution of other travel modes for the automobile.	(7,17,20,28)
Strength of housing density	Higher EWB results in lower VMT& VHT and facilitates substitution of other travel modes for the automobile. Clustering of housing should increase EWB.	(7,17,20)
Distance to CBD	Regional context of the neighborhood	(20,27)
Dissimilarity Index of income match for place-based jobs	Degree to which the neighborhood employment sectors is matched with workers' job sectors	(15)
Internal capture	Workers living and working in the same commute shed as % of total	(14,15,20)

Diagnostic tests for the PCA include Kaiser's Criterion, which calls for keeping only those components that have an eigenvalue of 1 or higher, due to lower eigenvalues providing insufficient information to retain. The Broken Stick test employs a line above which the components are considered significant, by applying a random component distribution, above which the eigenvalues of the components should fall to be retained.

Mapping the EWBI to the underlying census enumeration units will be done following the method in Plane & Rogerson (22). Each component of interest to the study will be mapped onto the underlying block groups. This is done by a linear combination of the vector of weighted normalized variables used in each component. Each component produces a "component score coefficient" for each variable. This coefficient is used to weight a vector for each variable. Then the weighted vectors are linearly combined and the resulting component scores can be mapped in GIS to visualize the spatial distribution of each component, classified by component score ranges (less than -1, -1 to 0, 0 to 1, and greater than 1). These maps will reveal spatial concentrations of high or low values of EWB, with multiple compound characteristic regimes, denoting various types or varieties of what may be considered EWB. These types may be delineated by various demographics groups or employment sectors, or other heretofore unconsidered subgroups.

Analysis outputs will include:

- Global Moran's *I* plots
- tables of loadings and explained variance
- scree plots showing variance for each PC
- component significance tests
- thematic maps of component scores

Results & Discussion

The Moran's *I* results show significant variation in spatial autocorrelation intensity and scale across the four metropolitan areas of the study. Figure 3 shows z-scores at 2,000-meter intervals. Atlanta shows a major peak at approximately four kilometers, with a precipitous drop in intensity thereafter. Cleveland's intensity is high at two kilometers, also dropping precipitously thereafter. Eugene shows a markedly different pattern, with a peak at approximately three kilometers, and two thereafter. Its highest z-score is about 2, considerably lower than the other metropolitan areas. Minneapolis demonstrates larger-scale land use concentrations than the other metropolitan areas in the study. It has relatively low intensity at the local scale and begins a sharp climb to its peak at five kilometers, drops until ten kilometers, and then climbs considerably to sixteen kilometers. Its intensity of concentration is high.

The results for the varimax rotation were unsuitable, as most of the loadings were near zero. Therefore, the rotated components were dropped from the study. The original PCA results are utilized for the study. The Broken Stick test indicated that the following PCs were retainable, as they were above the expected component value in the case of a random component distribution. For Atlanta, the first 3; for Cleveland, 3; for Eugene, 4; and, for Minneapolis, 3.

Only significant components with 9% or more variance explained were retained, the first two for Atlanta and Cleveland, and the first 3 for Eugene and Minneapolis. The strength of the loadings are modest for all components, but the expected patterns emerge, with multiple regimes displayed across the different components. All loadings will be evaluted in this context. Each city shows varying intensity of response to transit by mode, and to jobs by sector and income.

The loadings (Table 4.3) show, most saliently, that in the study cities the location of jobs and residences are not loading on the same components. In Atlanta, the places with jobs also have the strongest access to transit, but the spatial relationship between workers' residences and transit stations is weak. Atlanta's jobs load on the same PC across various income levels and sector groups. Retail, Lodging and Food jobs load on the same PC as Office and Knowledge jobs. The same is the case in Cleveland. For all of the study cities, the jobs and worker residences load on different PCs, indicating that their locations are not highly correlated. In Minneapolis, jobs and residences do not load highly on any PCs, which may indicate a lack of strong spatial concentration of these variables. Eugene's loadings suggest that it is mainly a suburb for workers in Portland, as residences load highly but jobs load negatively. Atlanta and Cleveland show residents loading highly on PC1 and jobs loading highly on PC2. Minneapolis residents load highly on PC1 and jobs load negatively on PC2 and somewhat highly on PC3. This suggests that Minneapolis consists of more complex spatial regimes than the other cities. As Atlanta is also a large and complex city, the results also demonstrate the explanatory limitations of the study methods, and the need to further the scale effects of these cities' spatial regimes.

The commuting modes show the ongoing dominance of the automobile. All cities show a dominant pattern of commuters driving alone to work, followed by carpooling. Work from home loaded more highly for all cities than did transit use. For Eugene, walking to work loaded highly on the same PC as proximity to BRT. Transit proximity loaded in varying ways across the cities, and all but Minneapolis responded positively to proximity to transit stations, with modestly negative loadings on the distance to the transit station. As stated above, a negative loading on distance indicates a positive loading on transit station proximity, which may be interpreted as a positive response to station proximity by the surrounding land uses. In Atlanta and Cleveland, job locations and transit station proximity loaded highly on the same PC, suggesting that job locations are more highly served than residential neighborhoods. Eugene responded well to proximity to BRT stations, but its job variables loaded negatively on all components, which further supports the interpretation of Eugene as a suburb of Portland.

Households with no vehicle loaded weakly on the components all cities, and households with 2 or more loaded most highly. Longer commute times loaded most highly across all the cities. Density and distance to CBD varied in relevance across the cities. Job density loaded positively in Atlanta and Cleveland, but negatively in Eugene and Minneapolis. Population density loaded positively in Eugene, but elsewhere was weak or negative. Total occupied housing was most relevant in all cities, with owners being more relevant than renters in most contexts, but renters loaded more highly than owners in Eugene. Centering and subcentering (polycentric development) loaded positively in Atlanta, Cleveland, and Eugene, but loaded negatively in Minneapolis. This suggests a more polycentric development in the first 3 cities, but a more dispersed development in Minneapolis. The built environment appears to be less walkable in all of these cities but Eugene, as the road network and intersection densities loaded weakly or negatively in all but Eugene, which had positive loadings on PC3, which also has high loadings from proximity to BRT.

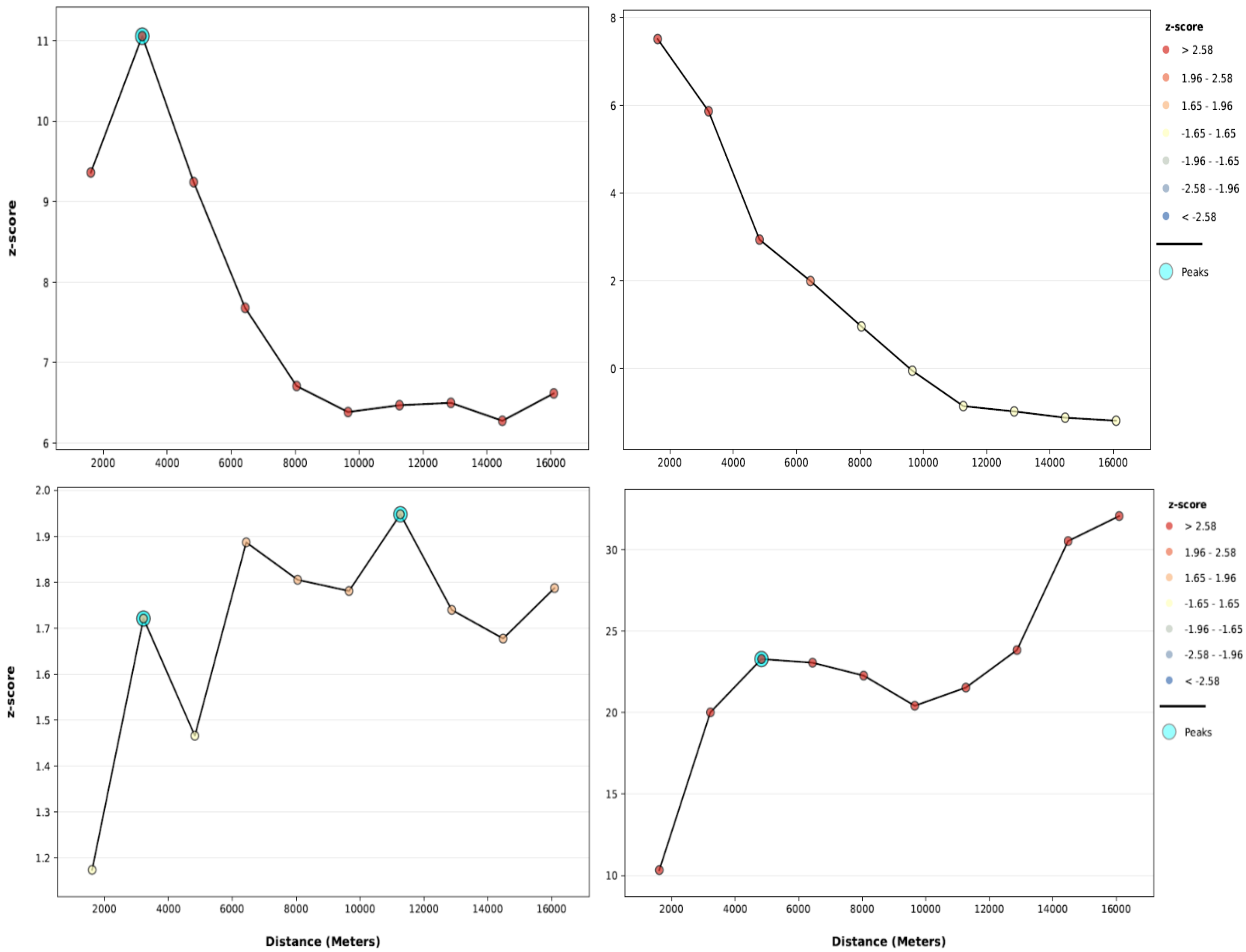

Figure 4.1 Results of Global Moran's I at various scales.

TABLE 4.3
Loadings & Explained Variance

	Atlanta		Cleveland		Eugene			Minneapolis		
	PC1	PC2	PC1	PC2	PC1	PC2	PC3	PC1	PC2	PC3
Total Jobs	0.07	0.31	0.06	0.31	-0.03	-0.33	-0.13	0.04	-0.30	0.18
Upper Income Jobs	0.07	0.27	0.05	0.28	-0.02	-0.26	-0.19	0.04	-0.26	0.19
Mid Income Jobs	0.03	0.21	0.02	0.18	-0.05	-0.24	-0.03	0.02	-0.22	0.08
Lower Income Jobs	0.06	0.26	0.06	0.29	-0.02	-0.27	0.07	0.04	-0.23	0.13
Manufacturing Jobs	0.03	0.10	0.02	0.10	0.00	-0.13	-0.19	0.04	-0.08	0.11
Light Industry Jobs	0.05	0.14	0.05	0.18	0.00	-0.15	-0.20	0.04	-0.15	0.14
Retail-Lodging-Food Jobs	0.08	0.22	0.07	0.22	-0.01	-0.26	-0.09	0.04	-0.22	0.13
Knowledge Jobs	0.06	0.27	0.05	0.29	-0.03	-0.25	-0.06	0.03	-0.25	0.16
Office Jobs	0.05	0.26	0.06	0.28	-0.02	-0.30	-0.08	0.03	-0.26	0.18
Education Jobs	0.01	0.10	0.03	0.24	-0.02	-0.07	0.00	0.01	-0.09	0.03
Health Jobs	0.02	0.16	0.00	0.14	-0.05	-0.19	-0.01	0.02	-0.14	-0.01
Arts-Ent-Rec Jobs	0.03	0.17	0.05	0.26	-0.02	-0.20	-0.02	0.03	-0.20	0.09
Total Workers	0.23	-0.04	0.22	-0.03	0.25	-0.03	0.00	0.23	0.02	-0.03
Upper Income Workers	0.20	0.03	0.21	-0.02	0.25	-0.02	-0.02	0.23	0.03	0.02
Mid Income Workers	0.20	-0.08	0.20	-0.03	0.25	-0.01	-0.02	0.22	0.02	-0.08
Lower Income Workers	0.22	-0.06	0.21	-0.03	0.24	-0.05	0.04	0.22	0.00	-0.09
Manufacturing Workers	0.20	-0.06	0.19	-0.04	0.21	-0.01	-0.05	0.20	0.08	0.06
Light Indus Workers	0.21	-0.07	0.20	-0.05	0.23	-0.01	-0.06	0.22	0.06	0.05
Retail-Lodging-Food Wrkrs	0.21	-0.07	0.20	-0.03	0.23	-0.06	-0.01	0.22	0.01	-0.07
Knowledge Workers	0.16	0.07	0.20	0.02	0.22	-0.03	0.05	0.20	-0.02	-0.03
Office Workers	0.23	-0.03	0.21	-0.01	0.24	-0.05	0.04	0.22	-0.01	-0.06
Education Workers	0.19	-0.05	0.19	-0.05	0.16	0.00	0.10	0.19	0.01	-0.07
Health Workers	0.21	-0.07	0.19	-0.02	0.25	-0.02	0.00	0.20	0.00	-0.11

Arts-Ent-Rec Workers	0.19	-0.01	0.19	0.02	0.19	-0.03	0.04	0.21	-0.03	-0.10
Standard deviation	4.21	2.90	4.52	2.97	3.88	2.78	2.23	4.19	2.95	2.29
Proportion of Variance	33%	16%	38%	16%	28%	15%	9%	32%	16%	10%
Cumulative Proportion	33%	48%	38%	54%	28%	43%	52%	32%	48%	57%
Broken Stick Sig. Test	ATL: 3 PCs		CLV: 3 PCs		EUG: 4 PCs			MINN: 3 PCs		

TABLE 4.3 (Continued) Loadings & Explained Variance

	Atlanta		Cleveland		Eugene			Minneapolis		
	PC1	PC2	PC1	PC2	PC1	PC2	PC3	PC1	PC2	PC3
Drove Alone to work	0.22	-0.02	0.21	-0.05	0.24	-0.01	0.00	0.22	0.03	-0.02
Carpooled to work	0.11	-0.03	0.10	-0.01	0.13	-0.01	-0.03	0.11	-0.01	-0.10
Transit to work	0.03	0.04	0.01	0.07	0.05	-0.07	0.18	0.03	-0.12	-0.25
Walked to work	0.03	0.15	0.04	0.15	-0.05	-0.11	0.22	0.02	-0.20	-0.11
Work at Home	0.13	0.03	0.11	-0.02	0.07	0.02	0.03	0.11	0.00	-0.01
Distance to LRT			0.12	-0.09				0.11	0.13	0.25
Distance to HRT	0.11	-0.13								
Distance to BRT			0.14	-0.10	-0.02	0.08	-0.21	0.10	0.11	0.23
Distance to SCT	0.11	-0.12								
Distance to CRT								0.02	0.07	0.14
Households - No Vehicle	0.03	0.07	0.01	0.09	0.00	-0.17	0.18	0.02	-0.17	-0.21
Households - 1 Vehicle	0.17	0.08	0.13	0.05	0.13	-0.11	0.13	0.11	-0.14	-0.18
Households - 2+ Vehicles	0.20	-0.08	0.20	-0.08	0.22	0.04	-0.07	0.21	0.08	0.04
Commute Time Fwr 5 Min	0.07	0.06	0.08	0.04	0.02	-0.06	-0.03	0.07	-0.07	-0.02
Commute Time 5 to 14	0.15	0.11	0.16	0.03	0.13	-0.11	0.14	0.16	-0.10	-0.10
Commute Time 15 to 29	0.18	0.04	0.18	-0.02	0.21	0.00	0.09	0.18	-0.04	-0.14
Commute Time 30 to 44	0.17	-0.06	0.19	-0.05	0.13	-0.01	-0.01	0.19	0.03	-0.03
Commute Time Grtr 45	0.17	-0.10	0.15	-0.04	0.11	0.02	-0.01	0.17	0.05	0.00
Distance to CBD	0.11	-0.12	0.12	-0.10	-0.03	0.08	-0.23	0.10	0.14	0.25
Population Density / mile	0.00	0.08	-0.06	-0.01	-0.03	-0.04	0.33	-0.04	-0.09	-0.28
Worker Density / mile	0.03	0.27	0.01	0.25	-0.07	-0.22	0.02	0.01	-0.29	0.09
Total Occupied Housing	0.22	0.01	0.19	0.01	0.21	-0.08	0.07	0.21	-0.06	-0.12
Owner Occupied	0.17	-0.08	0.18	-0.09	0.19	0.08	-0.17	0.19	0.09	0.07
Renter Occupied	0.13	0.09	0.07	0.10	0.07	-0.17	0.24	0.06	-0.17	-0.23
Vacancy Rate	-0.07	0.05	-0.11	0.05	-0.08	-0.10	-0.05	-0.03	-0.06	-0.03
Median Year Built	0.14	-0.01	0.14	-0.04	0.10	-0.04	-0.16	0.13	0.02	0.16
Dissimilarity Index - Income Match	-0.04	-0.02	-0.05	-0.02	-0.01	0.03	-0.03	-0.04	0.03	-0.02
Internal Capture	0.16	-0.05	0.18	-0.05	-0.01	0.06	-0.19	0.15	0.03	0.03
GWR subcenter Std. Dev.	0.07	0.29	0.06	0.31	-0.03	-0.32	-0.18	0.05	-0.29	0.19
Gi* Centering Z Score	0.03	0.20	0.06	0.17	-0.07	-0.16	0.22	0.02	-0.12	-0.08
Road Network Density	-0.05	0.16	-0.12	0.07	-0.07	-0.05	0.31	-0.09	-0.11	-0.24
Intersection Density	-0.06	0.16	-0.13	0.07	-0.08	-0.07	0.33	-0.10	-0.14	-0.25
Standard deviation	4.21	2.90	4.52	2.97	3.88	2.78	2.23	4.19	2.95	2.29
Proportion of Variance	33%	16%	38%	16%	28%	15%	9%	32%	16%	10%
Cumulative Proportion	33%	48%	38%	54%	28%	43%	52%	32%	48%	57%
Broken Stick Sig. Test	ATL: 3 PCs		CLV: 3 PCs		EUG: 4 PCSs			MINN: 3 PCs		

Note: Negative values for loadings on transit modes denote a proximity-based positive influence.

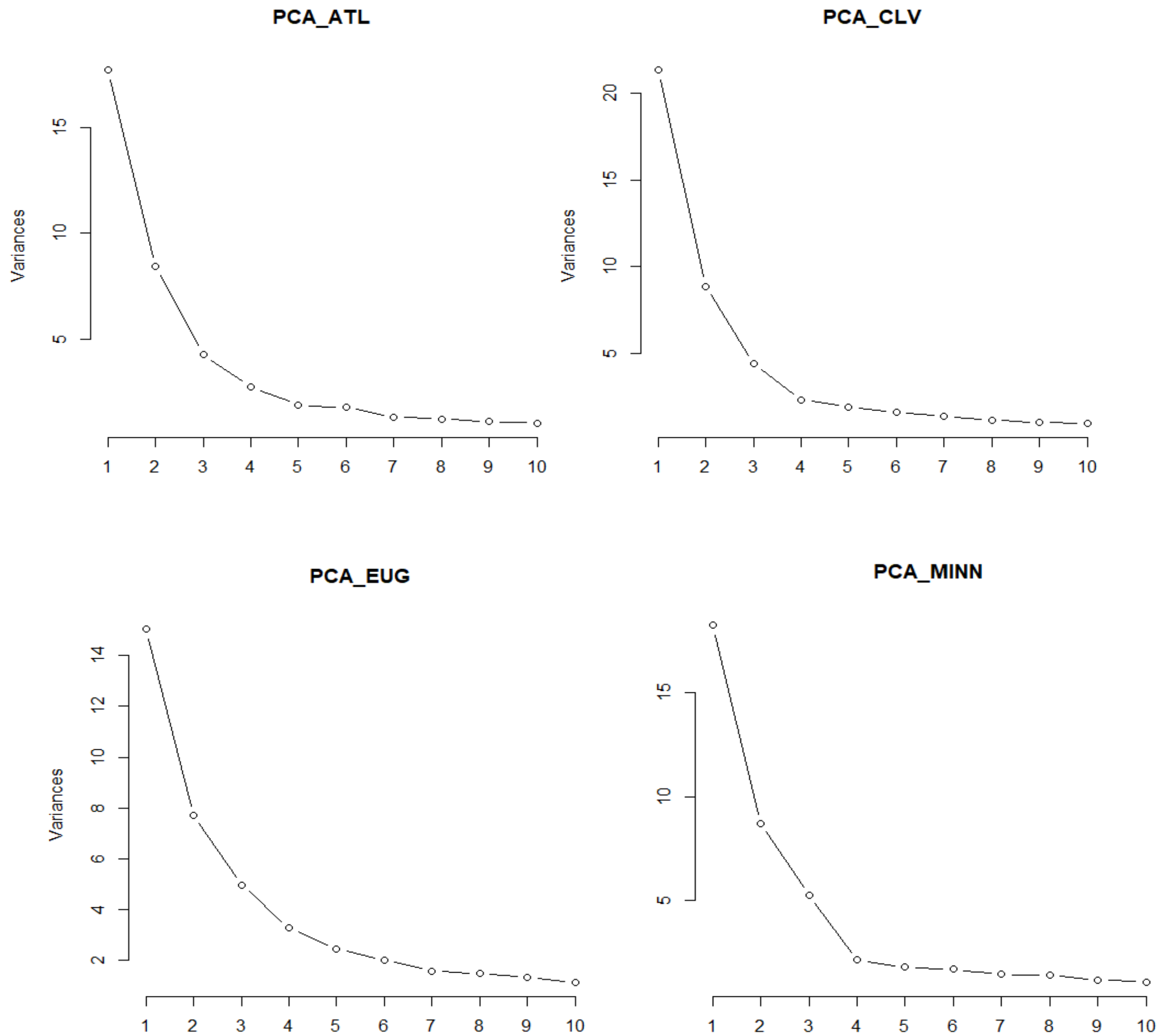

Figure 4.2
PCA Scree plots, showing PCs by variance

All study cities demonstrated weak loadings from income match and internal capture measures. This is an expected outcome, with a manifest need in most US cities for a greater emphasis on employment-worker balance.

Maps of PC1 scores (Figure 4.3) reveal a wide variation in the index across the study cities. Each city shows some degree of high intensity along road networks. This is quite pronounced in Cleveland and seen in a radial pattern of low intensity in Atlanta, and in the north region of Minneapolis.

Conclusions and Implications for Transit and Land Use Planning

Theoretical implications of the employment-worker balance phenomenon are drawn from the spatial and attribute clusters revealed by the EWBI. A more accessible workplace translates to a more productive and resilient workforce through potential improvements in work-life balance and overall cost of living, which in turn benefits the firm through higher output. Additionally, existing discrepancies in EWB near transit stations reveal low-hanging fruit for planners who wish to increase economic and housing resiliency. The employment-worker spatial regimes identified in this study through PCA may require targeted solutions to increase EWB. This may reveal some significant patterns of outcomes to transit development. One main implication is that there is a great deal of potential to develop spatial balance between employment and worker residence. The built environment in Eugene far better supports walkability than in the other larger cities of the study. The built environment also plays a role in a positive response to transit proximity. Road and intersection densities seem to correlate well with a positive response to transit.

Workers remain separated from their workplaces. This may be seen by a portion of the population as a significant benefit, but many are paying excessive transportation costs, spending excessive time to commute, and high municipal taxes to support this separation of land uses. These results have significant workforce as well as workplace implications, as accessibility outcomes provide agglomeration economies. The regions in which workers have greater TOD-driven access to firms also provide a more business-friendly environment with increased *situs* via a more accessible, active workforce. When appropriate housing is provided for workers of all sectors of the economy, greater economic diversification is possible.

The results indicate a modestly positive response to TOD. The political implications of increasing employment-worker balance depend upon the local typology of imbalance needing correction. In neighborhoods that are job-rich and housing poor for a lower- to moderate-income worker, challenges may include potential for local opposition from businesses that benefit from larger numbers of workers than residents, businesses seeking to protect their market share from newcomer firms, or from residents who fear negative externalities of lower or moderate-income housing development in their neighborhoods. Neighborhoods with upper-income jobs that seek to improve EWB may face gentrification pressures. Bedroom communities for blue-collar workers needing more jobs may face challenges from industrial externalities (10).

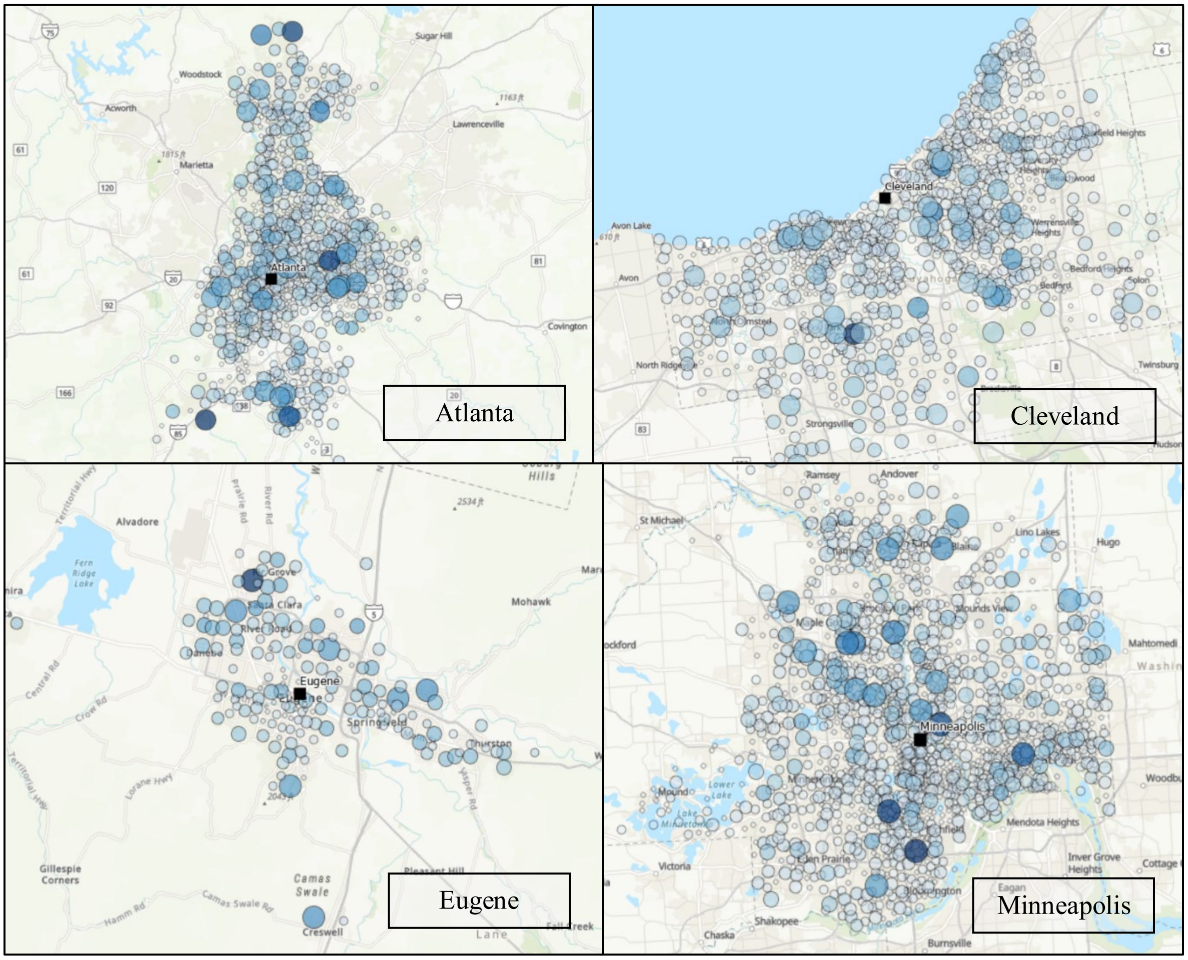

Figure 4.3

PC1 Scores for Atlanta, Cleveland, Eugene, And Minneapolis.

Graduated symbols range from small to large circles in light to dark blue, and high to low transparency to denote score magnitude. Atlanta's scores range from -2.3 to 27. Cleveland's scores range from -3.2 to 35.6. Eugene's scores range from -3.3 to 19.8. Scores range from -1.7 to 31.4 for Minneapolis. *Base Map Sources:* Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors and the GIS User Community

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APPENDIX D

All study tables are significance tested. All z scores denote significance at the .10 level for 2-tailed test.

Appendix D is for chapter 3 tables.

Table 3A.1 BRT Poor MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	15	20	22	24	53	57	14,201
Urban Square Miles – Cum.	15	35	57	81	134	191	14,201
Manufacturing	6,194	1,091	3,036	3,320	2,768	2,353	830,769
Light Industry	6,207	3,460	3,884	3,270	1,695	8,169	818,346
Retail-Lodging-Food	2,928	2,031	2,268	3,699	1,780	2,473	1,970,975
Knowledge	29,975	6,383	7,038	6,161	4,693	6,194	1,309,013
Office	12,400	9,609	7,974	4,316	6,679	8,042	2,247,693
Education	20,194	1,735	2,067	2,160	1,768	2,131	863,140
Health	3,468	5,575	7,027	4,086	4,692	3,400	1,464,168
Arts-Ent-Rec	409	1,795	223	372	246	881	197,902
Total Jobs	81,782	31,686	33,524	27,391	24,328	33,650	9,702,006

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(26,398)	(12,698)	(5,689)	(3,498)	(1,813)	(3,497)	(145,037)
Light Industry	(58,456)	(5,431)	(9,515)	(5,055)	(3,613)	(2,327)	(31,845)
Retail-Lodging-Food	(17,180)	1,269	(2,124)	821	(1,830)	(1,017)	(9,243)
Knowledge	16,250	(1,266)	2,476	2,647	3,636	(1,101)	40,655
Office	(9,188)	6,962	3,151	714	5,168	4,418	34,291
Education	(11,483)	(2,646)	(6,092)	(3,467)	(286)	(1,694)	70,350
Health	(27,460)	(1,721)	(2,681)	(231)	805	(4,835)	194,081
Arts-Ent-Rec	(24,706)	(39)	(2,195)	(1,701)	(818)	(1,114)	6,694
Total Jobs	(158,621)	(15,570)	(22,669)	(9,770)	1,249	(11,167)	159,946

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-81.0%	-92.1%	-65.2%	-51.3%	-39.6%	-59.8%	-62.2%
Light Industry	-90.4%	-61.1%	-71.0%	-60.7%	-68.1%	-22.2%	-76.6%
Retail-Lodging-Food	-85.4%	165.9%	-48.3%	28.5%	-50.7%	-29.1%	153.0%
Knowledge	118.4%	-16.5%	54.3%	75.3%	343.3%	-15.1%	79.0%
Office	-42.6%	262.9%	65.3%	19.8%	341.8%	121.9%	34.0%
Education	-36.2%	-60.4%	-74.7%	-61.6%	-13.9%	-44.3%	-18.3%
Health	-88.8%	-23.6%	-27.6%	-5.3%	20.7%	-58.7%	-33.2%
Arts-Ent-Rec	-98.4%	-2.1%	-90.8%	-82.1%	-76.9%	-55.8%	-76.2%
Total Jobs	-66.0%	-32.9%	-40.3%	-26.3%	5.4%	-24.9%	-25.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	1.11	0.23	1.15	1.31	2.50	1.13	0.54	1.06
Light Industry	0.90	1.86	1.55	1.71	3.40	0.97	4.83	3.32
Retail-Lodging-Food	0.13	1.17	0.26	0.52	0.10	0.14	0.22	0.28
Knowledge	2.68	0.52	1.08	0.99	0.29	1.76	0.70	0.47
Office	0.94	3.02	1.55	0.91	2.14	2.34	1.33	1.65
Education	1.72	0.54	0.39	0.48	1.68	0.75	0.69	0.68
Health	0.37	1.28	1.36	1.44	0.77	1.28	2.07	0.62
Arts-Ent-Rec	0.15	4.59	0.49	0.76	0.39	0.69	0.63	1.85
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.2 CRT Poor MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*10*	*30*	*51*	*71*	*205*	*277*	*41,703*
Urban Square Miles – Cum.	*10*	*40*	*91*	*162*	*367*	*644*	*41,703*
Manufacturing	8,661	5,591	4,029	5,481	3,408	1,068	1,238,634
Light Industry	18,548	7,562	4,915	4,690	5,056	1,129	1,621,064
Retail-Lodging-Food	11,961	5,510	2,531	2,220	1,461	1,447	3,809,507
Knowledge	15,462	1,506	18,475	3,863	3,117	1,647	2,408,601
Office	32,893	4,993	7,223	8,398	3,187	4,935	4,199,409
Education	41,219	1,131	17,358	1,128	3,501	3,666	1,565,704
Health	11,215	545	3,967	2,874	4,304	1,925	2,328,226
Arts-Ent-Rec	2,668	156	313	577	1,164	407	382,686
Total Jobs	142,634	27,001	58,818	29,238	25,205	16,231	17,553,831

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	1,712	2,595	(1,473)	(742)	845	(1,251)	(199,595)
Light Industry	5,618	1,268	2,066	(3,369)	3,598	(1,986)	3,183,866
Retail-Lodging-Food	2,573	3,173	(398)	(4,215)	381	(898)	415,822
Knowledge	(447)	167	2,971	1,290	1,351	(1,762)	543,440
Office	4,869	930	(185)	2,562	445	(1,003)	331,340
Education	2,888	(70)	2,785	(232)	(283)	(17,076)	179,340
Health	5,198	(284)	(2,186)	1,315	1,565	(1,780)	319,634
Arts-Ent-Rec	1,370	(42)	(120)	337	159	(9)	304,931
Total Jobs	23,781	7,737	3,460	(3,054)	8,061	(25,765)	5,078,778

Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	24.6%	86.6%	-26.8%	-11.9%	33.0%	-53.9%	8.1%
Light Industry	43.4%	20.1%	72.5%	-41.8%	*246.6%*	-63.7%	17.2%
Retail-Lodging-Food	27.4%	*135.7%*	-13.6%	-65.5%	35.2%	-38.3%	23.5%
Knowledge	-2.8%	12.5%	19.2%	50.1%	76.5%	-51.7%	21.8%
Office	17.4%	22.9%	-2.5%	43.9%	16.2%	-16.9%	4.8%
Education	7.5%	-5.8%	19.1%	-17.0%	-7.5%	-82.3%	4.8%
Health	86.4%	-34.2%	-35.5%	84.3%	57.1%	-48.0%	19.8%
Arts-Ent-Rec	105.5%	-21.1%	-27.6%	139.8%	15.8%	-2.2%	11.2%
Total Jobs	20.0%	40.2%	6.3%	-9.5%	47.0%	-61.3%	14.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	0.58	0.45	0.87	0.62	0.61	0.67	0.62	0.51
Light Industry	2.02	2.82	1.49	3.76	0.72	1.02	1.83	2.57
Retail-Lodging-Food	0.78	0.49	1.01	2.16	0.97	0.90	1.20	0.52

Knowledge	1.21	1.22	0.87	0.59	1.23	0.82	0.93	0.78
Office	0.80	0.90	0.86	0.49	0.82	0.99	0.89	0.37
Education	0.92	1.22	0.73	0.90	1.34	1.31	0.83	1.80
Health	0.57	1.87	1.45	0.43	1.52	0.82	1.02	0.65
Arts-Ent-Rec	0.87	2.63	2.18	0.56	1.63	1.88	0.59	0.59

Table 3A.3 LRT Poor MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	3	19	20	5	8	48	*29,669*
Urban Square Miles – Cum.	3	22	42	46	55	103	*29,669*
Manufacturing	29,701	5,567	2,379	2,689	7,412	763	1,504,975
Light Industry	23,489	6,959	1,948	3,376	5,344	4,835	1,842,851
Retail-Lodging-Food	12,756	1,493	3,742	2,934	5,392	578	3,800,602
Knowledge	42,352	2,149	2,475	5,123	35,918	1,725	2,242,526
Office	46,574	8,704	7,516	6,506	10,853	7,223	4,609,558
Education	9,177	1,191	14,366	1,282	2,762	1,515	1,608,044
Health	10,941	1,903	3,932	4,307	7,956	1,870	2,630,962
Arts-Ent-Rec	2,652	96	430	284	498	297	353,302
Total Jobs	177,649	28,069	36,795	26,508	76,142	18,813	18,592,820
Economic Change 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	3,867	828	(673)	(1,162)	(5,107)	(350)	(247,069)
Light Industry	5,054	1,050	(147)	602	(821)	1,257	(26,098)
Retail-Lodging-Food	(1,203)	(313)	(345)	586	1,396	(165)	64,894
Knowledge	12,965	311	(185)	1,464	11,591	2	104,140
Office	10,362	4,013	1,875	202	1,274	1,016	152,352
Education	(4,766)	(227)	1,719	(105)	(272)	(96)	137,537
Health	(2,417)	522	829	1,589	1,900	182	378,107
Arts-Ent-Rec	345	37	(54)	(55)	173	47	25,271
Total Jobs	24,207	6,221	3,019	3,121	10,134	1,893	589,134
Percent Economic Change 2010-2016							
Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	15.0%	17.5%	-22.0%	-30.2%	-40.8%	-31.4%	6.2%
Light Industry	27.4%	17.8%	-7.0%	21.7%	-13.3%	35.1%	13.2%
Retail-Lodging-Food	-8.6%	-17.3%	-8.4%	24.9%	34.9%	-22.2%	19.2%
Knowledge	44.1%	16.9%	-7.0%	40.0%	47.6%	0.1%	21.8%
Office	28.6%	85.5%	33.2%	3.2%	13.3%	16.4%	10.6%
Education	-34.2%	-16.0%	13.6%	-7.6%	-9.0%	-6.0%	4.1%
Health	-18.1%	37.8%	26.7%	58.4%	31.4%	10.8%	18.7%
Arts-Ent-Rec	14.9%	61.7%	-11.1%	-16.2%	53.1%	18.7%	17.5%
Total Jobs	15.8%	28.5%	8.9%	13.3%	15.4%	11.2%	14.0%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)								
Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	1.07	0.98	0.77	0.66	1.00	0.55	0.92	0.66
Light Industry	1.11	0.92	0.86	1.08	0.93	0.76	1.36	1.22
Retail-Lodging-Food	0.75	0.62	0.80	1.05	0.95	1.12	0.69	0.67
Knowledge	1.17	0.85	0.80	1.16	1.54	1.20	1.26	0.84
Office	1.15	1.49	1.26	0.94	0.83	1.01	0.89	1.08
Education	0.62	0.72	1.14	0.89	1.29	0.86	1.28	0.93
Health	0.68	1.03	1.12	1.34	1.08	1.09	0.89	0.96
Arts-Ent-Rec	0.96	1.22	0.79	0.72	1.22	1.29	1.12	1.04
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.4 SCT Poor MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	2	6	10	4	4	10	12770
Urban Square Miles – Cum.	2	8	18	22	25	35	12770
Manufacturing	0	43	1	NA	3,764	1,903	524,288
Light Industry	0	33	38	1	5,187	6,953	825,910
Retail-Lodging-Food	0	143	12	NA	606	619	1,597,042
Knowledge	0	51	164	16	337	242	1,101,103
Office	0	295	58	116	2,103	2,126	1,981,603
Education	0	NA	118	NA	46	313	689,431
Health	0	3,214	(1)	69	122	106	1,035,329
Arts-Ent-Rec	0	32	(1)	NA	50	454	185,019
Total Jobs	0	3,817	396	205	12,222	12,723	7,939,725

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	0	5	(15)	0	(153)	(623)	(76,872)
Light Industry	0	(13)	(81)	(3)	836	806	(30,086)
Retail-Lodging-Food	0	(131)	(38)	0	(604)	(318)	(16,664)
Knowledge	0	17	(76)	9	22	(125)	34,442
Office	0	(45)	(37)	108	668	(43)	(35,118)
Education	0	0	(79)	0	2	29	46,586
Health	0	3,051	(76)	5	54	68	105,773
Arts-Ent-Rec	0	(6)	(5)	0	28	(96)	3,632
Total Jobs	0	2,878	(407)	119	853	(302)	31,693

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	0	12.8%	-88.2%	NA	-3.9%	-24.7%	7.5%
Light Industry	0	-27.7%	-67.5%	-60.0%	19.2%	13.1%	19.9%
Retail-Lodging-Food	0	-47.6%	-74.5%	NA	-49.9%	-33.9%	21.0%
Knowledge	0	48.6%	-31.5%	112.5%	7.0%	-34.0%	17.1%

Office	0	-13.2%	-38.5%	1200.0%	46.5%	-2.0%	0.1%
Education	0	NA	-39.9%	NA	4.4%	10.2%	13.7%
Health	0	1860.4%	-100.0%	7.7%	78.3%	174.4%	8.3%
Arts-Ent-Rec	0	-15.4%	-100.0%	NA	121.7%	-17.4%	39.9%
Total Jobs	0	306.2%	-50.6%	136.8%	7.5%	-2.3%	11.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	0	0.17	0.14	0.00	3.26	4.66	6.71	2.27
Light Industry	0	0.09	1.20	0.09	3.52	4.08	0.89	5.25
Retail-Lodging-Food	0	0.19	1.17	0.00	0.27	0.25	0.07	0.24
Knowledge	0	0.10	0.03	0.60	0.79	0.20	0.62	0.14
Office	0	0.31	0.46	2.28	0.77	0.69	0.56	0.67
Education	0	0.00	0.06	0.00	0.00	0.04	0.00	0.28
Health	0	6.46	0.17	2.61	0.33	0.08	1.62	0.06
Arts-Ent-Rec	0	0.37	0.21	0.00	0.83	0.18	0.60	1.53
Total Jobs	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.5 BRT Low MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	27	44	49	51	102	98	14,201
Urban Square Miles – Cum.	27	71	120	171	273	371	14,201
Manufacturing	60,886	4,894	6,143	18,473	6,154	25,779	830,769
Light Industry	75,070	10,730	8,743	29,346	10,841	21,435	818,346
Retail-Lodging-Food	130,376	11,904	10,284	16,133	13,865	13,781	1,970,975
Knowledge	112,227	17,101	9,238	10,169	3,900	15,298	1,309,013
Office	233,565	34,800	19,008	30,670	10,924	21,142	2,247,693
Education	58,304	21,997	5,909	21,942	20,411	2,939	863,140
Health	120,667	22,138	12,462	14,993	6,093	22,746	1,464,168
Arts-Ent-Rec	11,195	771	2,241	1,200	864	1,323	197,902
Total Jobs	802,297	124,342	74,035	142,933	73,059	124,450	9,702,006

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(124,133)	(40,453)	(7,574)	(22,179)	(8,051)	(1,560)	(145,037)
Light Industry	(190,532)	(39,737)	(9,647)	(27,102)	(33,215)	(7,307)	(31,845)
Retail-Lodging-Food	69,422	3,343	8,000	(3,510)	7,492	(16,307)	(9,243)
Knowledge	50,490	4,356	4,695	(14,824)	(5,447)	(5,401)	40,655
Office	125,609	21,475	9,841	15,134	(913)	6,317	34,291
Education	(36,297)	12,972	267	8,302	16,450	(10,679)	70,350
Health	(74,010)	(22,361)	1,262	(23,352)	(7,267)	4,481	194,081
Arts-Ent-Rec	(60,969)	(21,450)	(1,166)	(19,242)	(23,757)	(1,966)	6,694
Total Jobs	(240,420)	(81,855)	5,678	(86,773)	(54,708)	(32,422)	159,946

Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-67.1%	-89.2%	-55.2%	-54.6%	-56.7%	-5.7%	-62.2%
Light Industry	-71.7%	-78.7%	-52.5%	-48.0%	-75.4%	-25.4%	-76.6%
Retail-Lodging-Food	113.9%	39.0%	349.8%	-17.9%	117.5%	-54.2%	153.0%
Knowledge	81.8%	34.2%	103.3%	-59.3%	-58.3%	-26.1%	79.0%
Office	116.4%	161.2%	107.3%	97.4%	-7.7%	42.6%	34.0%
Education	-38.4%	143.7%	4.7%	60.9%	415.2%	-78.4%	-18.3%
Health	-38.0%	-50.2%	11.3%	-60.9%	-54.4%	24.5%	-33.2%
Arts-Ent-Rec	-84.5%	-96.5%	-34.2%	-94.1%	-96.5%	-59.8%	-76.2%
Total Jobs	-23.1%	-39.7%	8.3%	-37.8%	-42.8%	-20.7%	-25.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	1.95	4.66	2.02	1.14	2.05	1.10	2.28	0.70
Light Industry	2.56	2.67	2.14	1.13	3.20	2.19	1.66	1.00
Retail-Lodging-Food	0.35	0.42	0.23	0.74	0.17	0.26	0.45	1.69
Knowledge	0.43	0.46	0.54	1.56	0.31	1.40	0.42	1.10
Office	0.35	0.23	0.52	0.31	1.08	0.62	0.34	0.56
Education	1.34	0.27	1.11	0.42	1.07	0.12	1.21	3.95
Health	1.46	1.43	1.15	1.88	0.78	1.48	1.31	0.75
Arts-Ent-Rec	5.07	17.78	1.68	10.84	3.20	16.67	6.19	2.02

Table 3A.6 CRT Low MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*17*	*51*	*81*	*105*	*261*	*307*	*41703*
Urban Square Miles – Cum.	*17*	*68*	*149*	*254*	*515*	*822*	*41703*
Manufacturing	55,517	26,333	18,869	29,459	10,373	17,045	1,238,634
Light Industry	94,796	23,904	16,107	30,271	9,165	28,948	1,621,064
Retail-Lodging-Food	92,744	21,644	14,049	28,244	15,645	31,044	3,809,507
Knowledge	75,477	32,165	10,847	27,922	20,544	27,174	2,408,601
Office	142,853	34,513	26,310	67,651	33,850	40,797	4,199,409
Education	57,462	12,069	4,549	5,030	24,685	14,627	1,565,704
Health	58,376	11,499	25,808	25,517	14,411	35,356	2,328,226
Arts-Ent-Rec	9,321	2,064	1,904	2,740	1,441	5,681	382,686
Total Jobs	586,553	164,198	118,450	216,841	130,121	200,679	17,553,831

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(5,255)	3,712	990	(6,137)	(5,847)	714	(199,595)
Light Industry	22,890	3,099	5,891	5,945	(5,992)	7,206	3,183,866
Retail-Lodging-Food	14,487	5,120	418	3,084	(1,005)	4,658	415,822
Knowledge	13,104	13,046	659	3,994	4,881	6,584	543,440
Office	16,165	5,268	2,390	19,885	9,829	526	331,340
Education	(6,872)	(1,268)	(375)	(2,390)	(37)	5,814	179,340
Health	1,916	3,422	836	4,931	1,870	8,250	319,634
Arts-Ent-Rec	3,338	299	(82)	599	38	2,054	304,931
Total Jobs	59,773	32,698	10,727	29,911	3,737	35,806	5,078,778

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-8.6%	16.4%	5.5%	-17.2%	-36.0%	4.4%	8.1%
Light Industry	31.8%	14.9%	57.7%	24.4%	-39.5%	33.1%	17.2%
Retail-Lodging-Food	18.5%	31.0%	3.1%	12.3%	-6.0%	17.7%	23.5%
Knowledge	21.0%	68.2%	6.5%	16.7%	31.2%	32.0%	21.8%
Office	12.8%	18.0%	10.0%	41.6%	40.9%	1.3%	4.8%
Education	-10.7%	-9.5%	-7.6%	-32.2%	-0.1%	66.0%	4.8%
Health	3.4%	42.4%	3.3%	24.0%	14.9%	30.4%	19.8%
Arts-Ent-Rec	55.8%	16.9%	-4.1%	28.0%	2.7%	56.6%	11.2%
Total Jobs	11.3%	24.9%	10.0%	16.0%	3.0%	21.7%	14.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*

Manufacturing	0.87	0.98	1.01	0.75	1.05	0.66	0.99	0.91
Light Industry	1.15	0.90	1.40	1.05	1.04	0.57	1.08	1.07
Retail-Lodging-Food	0.98	0.97	0.87	0.89	0.92	0.84	1.16	0.89
Knowledge	1.02	1.26	0.91	0.94	0.82	1.19	1.27	1.02
Office	1.10	1.03	1.09	1.33	1.09	1.49	0.76	0.91
Education	0.87	0.79	0.92	0.64	1.25	1.06	1.24	1.49
Health	0.88	1.09	0.90	1.02	0.90	1.06	0.91	1.02
Arts-Ent-Rec	1.44	0.96	0.90	1.13	1.50	1.02	2.97	1.32
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.7 LRT Low MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*45*	*9*	*14*	*69*	*56*	*10*	*29,669*
Urban Square Miles – Cum.	*45*	*55*	*68*	*137*	*193*	*203*	*29,669*
Manufacturing	121,939	15,017	13,114	25,105	10,952	27,840	1,504,975
Light Industry	134,821	13,214	9,758	33,984	18,426	16,463	1,842,851
Retail-Lodging-Food	139,259	21,952	23,005	25,210	18,521	18,844	3,800,602
Knowledge	143,697	24,077	9,814	15,270	16,018	30,214	2,242,526
Office	321,977	54,720	32,385	68,144	44,941	41,618	4,609,558
Education	108,468	10,235	6,857	35,109	8,187	33,151	1,608,044
Health	181,892	24,043	32,860	25,041	27,342	46,912	2,630,962
Arts-Ent-Rec	15,406	2,541	1,614	2,172	1,259	1,576	353,302
Total Jobs	1,167,466	165,806	129,414	230,042	145,653	216,625	18,592,820

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	1,059	(83)	(7,265)	887	(721)	(11,720)	(247,069)
Light Industry	(5,691)	(1,069)	(12,121)	1,980	1,229	(665)	(26,098)
Retail-Lodging-Food	6,561	(5,307)	(906)	510	(603)	1,054	64,894
Knowledge	7,455	(648)	(858)	(1,502)	2,403	6,420	104,140
Office	(506)	(4,545)	(5,639)	8,663	7,085	3,508	152,352
Education	(27,175)	(4,716)	(1,533)	12,324	(628)	(14,280)	137,537
Health	6,613	1,492	(1,202)	(8,595)	2,234	3,184	378,107
Arts-Ent-Rec	2,245	203	67	723	(872)	617	25,271
Total Jobs	(9,439)	(14,673)	(29,457)	14,990	10,127	(11,882)	589,134

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	0.9%	-0.5%	-35.6%	3.7%	-6.2%	-29.6%	6.2%
Light Industry	-4.1%	-7.5%	-55.4%	6.2%	7.1%	-3.9%	13.2%
Retail-Lodging-Food	4.9%	-19.5%	-3.8%	2.1%	-3.2%	5.9%	19.2%
Knowledge	5.5%	-2.6%	-8.0%	-9.0%	17.6%	27.0%	21.8%
Office	-0.2%	-7.7%	-14.8%	14.6%	18.7%	9.2%	10.6%
Education	-20.0%	-31.5%	-18.3%	54.1%	-7.1%	-30.1%	4.1%
Health	3.8%	6.6%	-3.5%	-25.6%	8.9%	7.3%	18.7%
Arts-Ent-Rec	17.1%	8.7%	4.3%	49.9%	-40.9%	64.3%	17.5%

Total Jobs	-0.8%	-8.1%	-18.5%	7.0%	7.5%	-5.2%	14.0%	
LQ Trend 2010-2016 (LQ 2016 / LQ 2010)								
Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	1.09	1.16	0.85	1.04	1.24	0.94	0.98	0.80
Light Industry	0.97	1.01	0.55	1.00	0.66	1.00	0.70	1.02
Retail-Lodging-Food	1.01	0.84	1.13	0.91	0.97	0.86	0.90	1.07
Knowledge	1.00	0.99	1.06	0.80	1.21	1.02	1.08	1.25
Office	1.04	1.04	1.08	1.10	0.98	1.14	1.00	1.19
Education	0.88	0.82	1.10	1.58	0.92	0.95	1.14	0.81
Health	1.01	1.12	1.14	0.67	1.08	0.97	1.14	1.09
Arts-Ent-Rec	1.14	1.15	1.24	1.36	1.34	0.53	1.42	1.68
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.8 SCT Low MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*11*	*4*	*5*	*11*	*10*	*3*	*13727*
Urban Square Miles – Cum.	*11*	*15*	*19*	*30*	*40*	*44*	*13727*
Manufacturing	7,905	3,028	3,957	4,311	661	3,125	524,288
Light Industry	12,519	10,147	4,119	7,199	1,877	7,862	825,910
Retail-Lodging-Food	12,074	9,005	2,105	3,799	1,721	5,940	1,597,042
Knowledge	12,156	7,733	3,232	1,796	2,209	2,677	1,101,103
Office	27,392	48,196	6,039	11,077	6,396	7,748	1,981,603
Education	1,867	25,572	18,483	1,015	461	2,367	689,431
Health	8,773	22,471	2,347	14,854	2,371	2,234	1,035,329
Arts-Ent-Rec	3,896	1,099	1,232	972	1,549	172	185,019
Total Jobs	86,589	127,258	41,521	45,030	17,252	32,132	7,939,725
Economic Change 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(423)	(354)	3,280	681	(71)	521	(76,872)
Light Industry	1,067	(4,647)	3,436	94	(578)	931	(30,086)
Retail-Lodging-Food	756	(3,601)	251	653	(601)	648	(16,664)
Knowledge	1,017	(3,455)	1,062	(702)	984	(122)	34,442
Office	4,607	(28,264)	3,599	3,201	700	776	(35,118)
Education	(7,568)	(886)	3,671	(181)	11	(1,029)	46,586
Health	858	1,805	(2,035)	7,850	(2,151)	177	105,773
Arts-Ent-Rec	1,052	117	1,001	214	544	24	3,632
Total Jobs	1,366	(39,285)	14,265	11,810	(1,162)	1,926	31,693
Percent Economic Change 2010-2016							
Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-5.1%	-10.5%	483.8%	18.8%	-9.7%	20.0%	7.5%
Light Industry	9.3%	-31.4%	502.3%	1.3%	-23.5%	13.4%	19.9%
Retail-Lodging-Food	6.7%	-28.6%	13.5%	20.7%	-25.9%	12.2%	21.0%
Knowledge	9.1%	-30.9%	48.9%	-28.1%	80.3%	-4.4%	17.1%
Office	20.2%	-37.0%	147.4%	40.6%	12.3%	11.1%	0.1%

Education	-80.2%	-3.3%	24.8%	-15.1%	2.4%	-30.3%	13.7%
Health	10.8%	8.7%	-46.4%	112.1%	-47.6%	8.6%	8.3%
Arts-Ent-Rec	37.0%	11.9%	431.5%	28.2%	54.1%	16.1%	39.9%
Total Jobs	1.6%	-23.6%	52.3%	35.5%	-6.3%	6.4%	11.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)								
Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	0.97	1.22	3.98	0.91	0.94	1.00	1.89	1.17
Light Industry	1.00	0.84	3.68	0.70	0.98	0.76	0.86	0.99
Retail-Lodging-Food	0.97	0.86	0.69	0.82	1.09	0.73	0.85	0.97
Knowledge	1.02	0.86	0.93	0.51	0.78	1.84	0.76	0.86
Office	1.32	0.92	1.81	1.16	1.33	1.34	0.76	1.16
Education	0.19	1.24	0.80	0.62	0.72	1.07	1.04	0.64
Health	1.12	1.47	0.36	1.61	0.75	0.58	1.44	1.05
Arts-Ent-Rec	1.08	1.17	2.79	0.76	0.81	1.31	0.35	0.87
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.9 BRT Mod MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*23*	*38*	*39*	*36*	*61*	*50*	*14201*
Urban Square Miles – Cum.	*23*	*61*	*100*	*136*	*196*	*246*	*14201*
Manufacturing	51,349	1,867	3,492	2,849	3,617	1,374	830,769
Light Industry	51,591	6,180	7,325	5,884	6,283	1,481	818,346
Retail-Lodging-Food	180,124	21,199	18,828	18,907	15,633	13,758	1,970,975
Knowledge	143,145	11,936	18,985	11,360	10,612	4,580	1,309,013
Office	198,473	18,233	9,607	16,401	20,538	17,824	2,247,693
Education	45,852	13,065	2,597	5,492	1,881	2,852	863,140
Health	139,041	13,094	14,562	19,393	13,687	22,467	1,464,168
Arts-Ent-Rec	16,011	1,590	2,782	890	1,901	709	197,902
Total Jobs	825,593	87,171	78,185	81,183	74,159	65,052	9,702,006
Economic Change 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(276,551)	(14,751)	(17,771)	(32,429)	(29,955)	(63,350)	(145,037)
Light Industry	(352,266)	(30,361)	(15,256)	(22,252)	(24,641)	(25,580)	(31,845)
Retail-Lodging-Food	128,046	18,963	14,990	16,045	12,832	12,973	(9,243)
Knowledge	89,196	5,904	11,387	5,261	4,555	2,638	40,655
Office	19,477	(390)	(2,506)	2,243	7,043	6,379	34,291
Education	(120,853)	949	(1,159)	(2,294)	(7,237)	(3,808)	70,350
Health	(180,593)	(10,213)	2,838	(8,911)	(14,998)	(39,558)	194,081
Arts-Ent-Rec	(92,589)	(3,571)	1,039	(3,327)	(2,922)	(4,209)	6,694
Total Jobs	(786,133)	(33,470)	(6,438)	(45,664)	(55,323)	(114,515)	159,946
Percent Economic Change 2010-2016							
Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-84.3%	-88.8%	-83.6%	-91.9%	-89.2%	-97.9%	-62.2%
Light Industry	-87.2%	-83.1%	-67.6%	-79.1%	-79.7%	-94.5%	-76.6%
Retail-Lodging-Food	245.9%	846.9%	390.3%	560.0%	457.6%	1646.3%	153.0%

Knowledge	165.3%	97.8%	149.8%	86.2%	75.2%	135.7%	79.0%	
Office	10.9%	-2.1%	-20.7%	15.8%	52.2%	55.7%	34.0%	
Education	-72.5%	7.8%	-30.8%	-29.5%	-79.4%	-57.2%	-18.3%	
Health	-56.5%	-43.8%	24.2%	-31.5%	-52.3%	-63.8%	-33.2%	
Arts-Ent-Rec	-85.3%	-69.2%	59.6%	-78.9%	-60.6%	-85.6%	-76.2%	
Total Jobs	-48.8%	-27.7%	-7.6%	-36.0%	-42.7%	-63.8%	-25.2%	
LQ Trend 2010-2016 (LQ 2016 / LQ 2010)								
Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	0.61	0.31	0.35	0.25	2.80	0.37	0.60	0.12
Light Industry	0.80	0.75	1.12	1.05	0.82	1.14	0.71	0.48
Retail-Lodging-Food	2.00	3.88	1.57	3.05	0.20	2.88	7.53	14.26
Knowledge	2.16	1.14	1.13	1.22	0.90	1.28	0.74	2.72
Office	1.21	0.76	0.48	1.01	0.98	1.48	0.29	2.40
Education	0.49	1.37	0.69	1.01	0.53	0.33	1.69	1.08
Health	0.95	0.87	1.51	1.20	1.85	0.93	1.97	1.12
Arts-Ent-Rec	0.90	1.34	5.43	1.04	0.56	2.16	0.49	1.25
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.10 CRT Mod MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*9*	*25*	*38*	*47*	*110*	*124*	*41,703*
Urban Square Miles – Cum.	*9*	*33*	*71*	*118*	*229*	*352*	*41,703*
Manufacturing	56,280	4,529	2,670	9,027	6,568	4,847	1,238,634
Light Industry	98,084	15,083	8,152	14,963	4,444	7,566	1,621,064
Retail-Lodging-Food	177,748	32,957	18,341	42,194	37,395	24,695	3,809,507
Knowledge	177,444	23,657	11,022	41,357	15,400	18,052	2,408,601
Office	287,208	39,049	42,845	99,171	35,839	18,951	4,199,409
Education	62,813	8,527	4,150	19,058	7,172	14,386	1,565,704
Health	86,509	9,435	12,549	20,331	23,072	15,351	2,328,226
Arts-Ent-Rec	17,991	4,204	1,802	6,800	5,162	6,429	382,686
Total Jobs	964,084	137,448	101,538	252,908	135,059	110,284	17,553,831
Economic Change 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	2,513	(1,788)	(372)	(331)	2,092	(586)	(199,595)
Light Industry	15,577	(717)	3,095	1,602	(200)	780	3,183,866
Retail-Lodging-Food	19,963	1,625	(345)	8,939	7,720	8,019	415,822
Knowledge	32,940	701	(4,205)	14,219	431	5,834	543,440
Office	(86,935)	(32,817)	1,448	10,839	(9,414)	(8,409)	331,340
Education	(41,025)	(1,257)	219	13,279	(507)	7,626	179,340
Health	9,792	(2,240)	4,891	426	(2,587)	3,860	319,634
Arts-Ent-Rec	(29)	(910)	196	180	(180)	1,614	304,931

Total Jobs	(47,204)	(37,403)	4,927	49,153	(2,645)	18,738	5,078,778

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	4.7%	-28.3%	-12.2%	-3.5%	46.7%	-10.8%	8.1%
Light Industry	18.9%	-4.5%	61.2%	12.0%	-4.3%	11.5%	17.2%
Retail-Lodging-Food	12.7%	5.2%	-1.8%	26.9%	26.0%	48.1%	23.5%
Knowledge	22.8%	3.1%	-27.6%	52.4%	2.9%	47.7%	21.8%
Office	-23.2%	-45.7%	3.5%	12.3%	-20.8%	-30.7%	4.8%
Education	-39.5%	-12.8%	5.6%	229.7%	-6.6%	112.8%	4.8%
Health	12.8%	-19.2%	63.9%	2.1%	-10.1%	33.6%	19.8%
Arts-Ent-Rec	-0.2%	-17.8%	12.2%	2.7%	-3.4%	33.5%	11.2%
Total Jobs	-4.7%	-21.4%	5.1%	24.1%	-1.9%	20.5%	14.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	1.16	0.96	0.88	0.82	1.42	1.58	1.01	0.78
Light Industry	1.22	1.18	1.49	0.88	0.79	0.95	1.24	0.90
Retail-Lodging-Food	1.09	1.24	0.86	0.94	1.05	1.19	1.18	1.14
Knowledge	1.21	1.23	0.65	1.15	0.94	0.98	0.98	1.15
Office	0.88	0.75	1.07	0.98	0.86	0.88	0.98	0.63
Education	0.69	1.21	1.09	2.90	0.97	1.04	0.98	1.92
Health	1.13	0.98	1.49	0.78	1.86	0.87	0.73	1.06
Arts-Ent-Rec	1.08	1.07	1.10	0.85	0.67	1.01	1.15	1.14
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.11 LRT Mod MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Job Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sums 2016*
Urban Square Miles – Increm.	*18*	*80*	*61*	*10*	*46*	*172*	*29,669*
Urban Square Miles – Cum.	*18*	*98*	*159*	*169*	*215*	*386*	*29,669*
Manufacturing	72,185	14,839	9,509	9,184	4,140	4,070	1,504,975
Light Industry	104,258	36,949	11,079	11,060	4,763	8,270	1,842,851
Retail-Lodging-Food	263,058	46,184	48,807	37,360	18,289	34,042	3,800,602
Knowledge	251,268	39,222	22,809	17,123	5,400	9,988	2,242,526
Office	556,074	78,022	62,169	55,012	29,933	20,464	4,609,558
Education	141,032	33,520	11,206	10,233	11,715	13,969	1,608,044
Health	192,496	28,976	40,490	56,838	18,227	16,582	2,630,962
Arts-Ent-Rec	46,901	5,855	3,504	5,083	800	3,836	353,302
Total Jobs	1,627,279	283,574	209,580	201,900	93,274	111,228	18,592,820

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(27,144)	4,782	2,239	(1,303)	371	(763)	(247,069)
Light Industry	(83,660)	3,960	769	252	(660)	892	(26,098)
Retail-Lodging-Food	6,184	3,440	13,992	8,299	(2,591)	6,749	64,894
Knowledge	(7,340)	7,196	1,480	1,067	293	1,854	104,140
Office	(54,259)	5,489	11,382	3,512	10,611	768	152,352
Education	11,863	22,770	(994)	(1,344)	(1,692)	2,846	137,537
Health	(12,563)	(1,934)	6,477	6,162	3,268	7,455	378,107
Arts-Ent-Rec	1,655	(1,813)	693	(282)	(128)	2,188	25,271
Total Jobs	(165,264)	43,890	36,038	16,363	9,472	21,989	589,134

Percent Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-27.3%	47.5%	30.8%	-12.4%	9.8%	-15.8%	6.2%
Light Industry	-44.5%	12.0%	7.5%	2.3%	-12.2%	12.1%	13.2%
Retail-Lodging-Food	2.4%	8.0%	40.2%	28.6%	-12.4%	24.7%	19.2%
Knowledge	-2.8%	22.5%	6.9%	6.6%	5.7%	22.8%	21.8%
Office	-8.9%	7.6%	22.4%	6.8%	54.9%	3.9%	10.6%
Education	9.2%	211.8%	-8.1%	-11.6%	-12.6%	25.6%	4.1%
Health	-6.1%	-6.3%	19.0%	12.2%	21.8%	81.7%	18.7%
Arts-Ent-Rec	3.7%	-23.6%	24.6%	-5.3%	-13.8%	132.7%	17.5%
Total Jobs	-9.2%	18.3%	20.8%	8.8%	11.3%	24.6%	14.0%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	1.03	0.66	0.76	1.02	0.82	0.84	1.10	1.22
Light Industry	1.55	1.00	1.07	1.01	1.24	1.20	1.06	1.05
Retail-Lodging-Food	0.87	1.08	0.85	0.83	0.91	1.25	0.95	0.98
Knowledge	0.95	0.99	1.15	1.04	1.05	1.07	1.10	1.04
Office	1.00	1.10	0.99	1.02	1.06	0.72	1.27	1.20
Education	0.88	0.40	1.40	1.31	1.84	1.35	0.70	1.05
Health	1.14	1.49	1.20	1.14	0.91	1.08	0.99	0.81
Arts-Ent-Rec	0.92	1.63	1.02	1.21	0.80	1.36	1.29	0.56

Table 3A.12 SCT Mod MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*5*	*12*	*10*	*3*	*9*	*25*	*13,727*
Urban Square Miles – Cum.	*5*	*16*	*26*	*29*	*38*	*62*	*13,727*
Manufacturing	14,710	1,968	3,302	1,149	781	1,024	524,288
Light Industry	32,836	3,618	4,847	3,571	3,025	4,007	825,910
Retail-Lodging-Food	77,747	9,509	6,223	4,672	6,580	17,658	1,597,042
Knowledge	123,693	13,440	9,268	2,438	3,574	24,115	1,101,103
Office	202,501	29,399	11,730	5,458	6,517	23,864	1,981,603
Education	70,981	10,458	28,729	1,404	1,029	2,140	689,431
Health	57,470	26,575	16,636	12,592	2,806	8,798	1,035,329
Arts-Ent-Rec	20,123	787	960	354	716	1,364	185,019
Total Jobs	600,068	95,761	81,702	31,645	25,035	82,977	7,939,725

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(3,512)	(2,193)	(1,395)	197	(134)	54	(76,872)
Light Industry	3,612	836	(1,497)	1,002	95	(88)	(30,086)
Retail-Lodging-Food	2,143	2,265	1,394	(5)	1,211	4,875	(16,664)
Knowledge	1,607	473	1,345	(445)	351	(175)	34,442
Office	(25,139)	(47,050)	(7,680)	(977)	(1,161)	(11,561)	(35,118)
Education	(17,608)	2,903	23,687	(379)	334	1,452	46,586
Health	(17,117)	9,203	4,396	(2,454)	(75)	550	105,773
Arts-Ent-Rec	1,256	(1,161)	420	56	242	(62)	3,632
Total Jobs	(54,758)	(34,724)	20,670	(3,005)	863	(4,955)	31,693

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-19.3%	-52.7%	-29.7%	20.7%	-14.6%	5.6%	7.5%
Light Industry	12.4%	30.0%	-23.6%	39.0%	3.2%	-2.1%	19.9%
Retail-Lodging-Food	2.8%	31.3%	28.9%	-0.1%	22.6%	38.1%	21.0%
Knowledge	1.3%	3.6%	17.0%	-15.4%	10.9%	-0.7%	17.1%
Office	-11.0%	-61.5%	-39.6%	-15.2%	-15.1%	-32.6%	0.1%
Education	-19.9%	38.4%	469.7%	-21.2%	48.0%	210.7%	13.7%
Health	-22.9%	53.0%	35.9%	-16.3%	-2.6%	6.7%	8.3%
Arts-Ent-Rec	6.7%	-59.6%	77.6%	18.7%	50.9%	-4.3%	39.9%
Total Jobs	-8.4%	-26.6%	33.9%	-8.7%	3.6%	-5.6%	11.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1*
Manufacturing	0.92	0.67	0.55	1.37	1.06	0.86	2.17	1.16
Light Industry	1.14	1.65	0.53	1.42	0.58	0.93	0.97	0.97
Retail-Lodging-Food	1.04	1.65	0.89	1.01	0.71	1.09	1.01	1.35
Knowledge	1.05	1.35	0.83	0.88	1.41	1.02	1.10	1.00
Office	1.08	0.58	0.50	1.04	1.27	0.91	2.08	0.80
Education	0.86	1.85	4.18	0.85	1.06	1.40	0.68	3.24
Health	0.87	2.15	1.05	0.94	1.10	0.97	1.59	1.17
Arts-Ent-Rec	0.93	0.44	1.06	1.04	1.05	1.16	1.54	0.81
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.13 BRT High MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	*4*	*7*	*6*	*5*	*8*	*6*	*14,201*
Urban Square Miles – Cum.	*4*	*11*	*17*	*22*	*30*	*36*	*14,201*
Manufacturing	4,986	309	633	1,007	196	292	830,769
Light Industry	23,047	529	3,362	296	212	89	818,346
Retail-Lodging-Food	93,809	11,358	13,557	32,258	6,480	4,815	1,970,975
Knowledge	101,339	6,615	4,952	2,612	1,204	86	1,309,013
Office	131,062	7,073	3,800	4,360	1,577	1,077	2,247,693
Education	15,823	1,128	8,206	5,883	241	1,132	863,140
Health	32,035	15,967	1,988	1,934	865	375	1,464,168
Arts-Ent-Rec	11,907	413	443	258	404	27	197,902
Total Jobs	414,015	43,399	36,948	48,615	11,186	7,900	9,702,006

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(89,048)	(14,330)	(2,600)	(2,830)	(1,587)	(211)	(145,037)
Light Industry	(150,311)	(14,469)	(19,090)	(18,300)	(5,578)	(3,158)	(31,845)
Retail-Lodging-Food	89,364	11,078	12,739	31,350	6,221	4,467	(9,243)
Knowledge	71,050	5,969	3,354	1,387	919	(129)	40,655
Office	52,957	(3,040)	(7,163)	(8,039)	(2,559)	(1,445)	34,291
Education	(61,299)	(4,166)	4,372	3,925	(910)	999	70,350
Health	(136,845)	8,831	(2,596)	(2,124)	(1,219)	(340)	194,081
Arts-Ent-Rec	(7,525)	(262)	(7,175)	(4,584)	63	(231)	6,694
Total Jobs	(231,657)	(10,389)	(18,159)	785	(4,650)	(48)	159,946

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-94.7%	-97.9%	-80.4%	-73.8%	-89.0%	-41.9%	-62.2%
Light Industry	-86.7%	-96.5%	-85.0%	-98.4%	-96.3%	-97.3%	-76.6%
Retail-Lodging-Food	2009.1%	3914%	1551%	3441.3%	2374.4%	1272.6%	153.0%
Knowledge	234.6%	921.1%	209.6%	113.0%	320.2%	-59.4%	79.0%
Office	67.8%	-30.1%	-65.3%	-64.8%	-61.9%	-57.3%	34.0%
Education	-79.5%	-78.7%	114.0%	200.4%	-79.0%	745.5%	-18.3%
Health	-81.0%	123.7%	-56.6%	-52.3%	-58.5%	-47.5%	-33.2%
Arts-Ent-Rec	-38.7%	-38.8%	-94.2%	-94.7%	18.5%	-89.5%	-76.2%

Total Jobs	-35.9%	-19.3%	-33.0%	1.6%	-29.4%	-0.6%	-25.2%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	0.16	0.05	0.58	0.51	0.03	0.31	0.01	1.16
Light Industry	0.66	0.14	0.71	0.05	0.25	0.17	0.05	0.09
Retail-Lodging-Food	9.73	14.71	7.29	10.30	10.19	10.36	11.73	4.08
Knowledge	2.18	5.29	1.93	0.88	1.13	2.49	0.93	0.17
Office	1.46	0.48	0.29	0.19	0.29	0.30	0.24	0.24
Education	0.29	0.24	2.92	2.71	4.90	0.27	0.51	7.79
Health	0.33	3.11	0.73	0.53	1.75	0.66	16.34	0.59
Arts-Ent-Rec	3.00	2.38	0.27	0.16	0.24	5.27	0.99	0.33
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.14 CRT High MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	1	3	4	5	12	14	41,703
Urban Square Miles – Cum.	1	3	7	12	24	38	41,703
Manufacturing	1,297	87	575	625	491	144	1,247,240
Light Industry	5,204	2,346	5,543	2,469	864	627	1,699,290
Retail-Lodging-Food	15,941	6,992	16,225	12,051	6,361	9,170	3,752,570
Knowledge	32,909	6,551	24,816	18,391	961	8,410	2,451,350
Office	26,550	17,445	24,941	18,569	2,323	12,851	4,147,638
Education	10,864	700	946	587	616	644	1,603,407
Health	2,913	1,484	12,160	9,410	9,509	2,474	2,261,704
Arts-Ent-Rec	1,733	1,874	983	558	760	2,519	386,885
Total Jobs	97,418	37,486	86,196	62,667	21,892	36,846	17,550,084

Economic Change 2010-2016

Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	629	(57)	37	243	(140)	(199)	957,803
Light Industry	(241)	1,642	(1,332)	703	373	(476)	4,446,116
Retail-Lodging-Food	4,636	1,191	2,129	1,775	1,012	2,099	2,813,637
Knowledge	8,123	400	6,603	(220)	194	(338)	1,806,586
Office	(16,772)	(2,649)	(5,559)	(6,046)	(551)	247	3,176,861
Education	(1,135)	63	350	(40)	(15)	(301)	1,224,061
Health	(90)	(248)	3,152	1,795	593	520	1,565,297
Arts-Ent-Rec	(132)	1,111	(142)	122	305	2,208	570,440
Total Jobs	(4,982)	1,453	5,238	(1,668)	1,771	3,760	16,560,801

Percent Economic Change 2010-2016

Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	94.0%	-39.3%	6.9%	63.4%	-22.2%	-57.8%	8.9%
Light Industry	-4.4%	232%	-19.4%	39.8%	75.8%	-43.1%	22.8%
Retail-Lodging-Food	41.0%	20.5%	15.1%	17.3%	18.9%	29.7%	21.7%
Knowledge	32.8%	6.5%	36.3%	-1.2%	25.3%	-3.9%	24.0%
Office	-38.7%	-13.2%	-18.2%	-24.6%	-19.2%	2.0%	3.5%
Education	-9.5%	9.9%	58.6%	-6.4%	-2.4%	-31.8%	7.3%
Health	-3.0%	-14.3%	35.0%	23.6%	6.7%	26.6%	16.4%
Arts-Ent-Rec	-7.1%	145%	-12.6%	27.9%	66.9%	707%	12.4%
Total Jobs	-4.9%	4.0%	6.5%	-2.6%	8.8%	11.4%	14.1%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	2.14	0.61	1.05	1.76	0.45	0.75	1.49	0.40
Light Industry	0.93	2.97	0.70	1.33	1.02	1.50	1.96	0.47
Retail-Lodging-Food	1.39	1.09	1.01	1.13	2.15	1.03	0.91	1.09
Knowledge	1.28	0.94	1.18	0.93	1.01	1.06	1.01	0.79
Office	0.71	0.92	0.85	0.85	0.57	0.82	0.98	1.01
Education	1.01	1.12	1.59	1.02	1.02	0.95	1.00	0.65
Health	1.00	0.81	1.24	1.24	1.00	0.96	1.04	1.11
Arts-Ent-Rec	0.99	2.40	0.83	1.33	1.22	1.56	0.44	7.36
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.15 LRT High MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	124	19	56	173	116	17	*29,669*
Urban Square Miles – Cum.	124	143	199	372	488	504	*29,669*
Manufacturing	11,094	370	842	2,704	380	115	1,504,975
Light Industry	34,099	564	8,268	5,168	367	298	1,842,851
Retail-Lodging-Food	105,545	14,973	38,251	19,669	9,839	8,616	3,800,602
Knowledge	134,855	7,456	13,258	7,070	1,464	1,692	2,242,526
Office	218,912	26,014	26,314	16,104	2,817	6,468	4,609,558
Education	32,000	11,428	2,332	2,968	532	1,519	1,608,044
Health	59,060	6,969	16,947	12,297	2,627	6,408	2,630,962
Arts-Ent-Rec	18,500	2,009	1,129	572	1,341	556	353,302
Total Jobs	614,072	69,790	107,348	66,559	19,374	25,679	18,592,820
Economic Change 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(659)	(14)	71	42	(110)	(993)	(247,069)
Light Industry	(5,376)	(29)	5,707	1,578	(153)	(75)	(26,098)
Retail-Lodging-Food	20,438	4,850	22,856	4,626	2,570	2,379	64,894
Knowledge	27,572	3,095	5,630	(737)	(10)	935	104,140
Office	(47,363)	6,018	8,996	(220)	(1,579)	3,278	152,352
Education	(15,499)	655	507	894	197	683	137,537
Health	8,709	654	2,786	3,617	104	790	378,107
Arts-Ent-Rec	5,266	1,095	102	84	152	541	25,271
Total Jobs	(6,912)	16,324	46,655	9,884	1,171	7,538	589,134
Percent Economic Change 2010-2016							
Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-5.6%	-3.6%	9.2%	1.6%	-22.4%	-89.5%	8.6%
Light Industry	-13.6%	-4.9%	222.8%	43.9%	-29.4%	-20.1%	17.8%
Retail-Lodging-Food	24.0%	47.9%	148.5%	30.7%	35.4%	38.1%	23.0%
Knowledge	25.7%	71.0%	73.8%	-9.4%	-0.7%	123.4%	26.0%
Office	-17.8%	30.1%	51.9%	-1.3%	-35.9%	102.7%	14.2%
Education	-32.6%	6.1%	27.8%	43.1%	58.6%	81.6%	5.2%
Health	17.3%	10.4%	19.7%	41.7%	4.1%	14.1%	22.3%
Arts-Ent-Rec	39.8%	119.7%	9.9%	17.2%	12.8%	3381.3%	22.3%
Total Jobs	-1.1%	30.5%	76.9%	17.4%	6.4%	41.5%	17.5%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	1.03	0.80	0.67	0.94	0.61	0.79	2.17	0.08
Light Industry	0.87	0.73	1.82	1.22	0.69	0.66	1.14	0.56
Retail-Lodging-Food	1.20	1.08	1.34	1.06	1.08	1.21	1.06	0.93
Knowledge	1.19	1.22	0.92	0.72	0.98	0.87	1.22	1.47
Office	0.86	1.03	0.88	0.86	0.77	0.62	0.97	1.47
Education	0.76	0.91	0.81	1.36	1.20	1.66	0.68	1.43
Health	1.14	0.81	0.65	1.16	1.23	0.94	0.60	0.77
Arts-Ent-Rec	1.36	1.62	0.60	0.96	2.03	1.02	1.15	23.62
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3A.16 SCT High MA Transit Station Type Job Dynamics by Economic Group 2010-2016

Station Share of Shift 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County Sum 2016*
Urban Square Miles – Increm.	19	4	10	24	18	3	12,770
Urban Square Miles – Cum.	19	23	33	58	75	79	12,770
Manufacturing	3,446	1,392	125	1,355	492	39	524,288
Light Industry	18,911	2,645	392	3,000	405	49	825,910
Retail-Lodging-Food	66,304	10,444	26,442	6,359	1,658	3,561	1,597,042
Knowledge	87,348	14,051	3,075	3,114	991	673	1,101,103
Office	107,562	18,331	2,837	5,798	822	1,715	1,981,603
Education	14,962	1,034	435	253	258	332	689,431
Health	33,059	10,618	1,897	6,126	268	762	1,035,329
Arts-Ent-Rec	9,063	1,062	1,080	1,648	27	113	185,019
Total Jobs	340,662	59,584	36,290	27,660	4,928	7,251	7,939,725

Economic Change 2010-2016							
Sector Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	(78)	193	(78)	766	47	11	(76,872)
Light Industry	(1,060)	(444)	(27)	36	194	(61)	(30,086)
Retail-Lodging-Food	9,750	842	18,103	2,363	617	(828)	(16,664)
Knowledge	21,873	(1,775)	145	(397)	155	(324)	34,442
Office	(35,890)	(6,759)	218	53	75	89	(35,118)
Education	(7,035)	(71)	3	(208)	97	25	46,586
Health	5,186	(264)	139	1,497	(27)	(412)	105,773
Arts-Ent-Rec	2,869	142	483	299	(31)	4	3,632
Total Jobs	(4,385)	(8,136)	18,986	4,409	1,127	(1,496)	31,693

Percent Economic Change 2010-2016							
Income Groups	*0.125*	*0.25*	*0.375*	*0.5*	*0.75*	*1*	*Transit County*
Manufacturing	-2.2%	16.1%	-38.2%	129.8%	10.5%	37.9%	7.5%
Light Industry	-5.3%	-14.4%	-6.4%	1.2%	91.5%	-55.0%	19.9%
Retail-Lodging-Food	17.2%	8.8%	217.1%	59.1%	59.2%	-18.9%	21.0%
Knowledge	33.4%	-11.2%	4.9%	-11.3%	18.5%	-32.5%	17.1%
Office	-25.0%	-26.9%	8.3%	0.9%	10.0%	5.5%	0.1%
Education	-32.0%	-6.4%	0.7%	-45.0%	59.9%	8.1%	13.7%
Health	18.6%	-2.4%	7.9%	32.3%	-9.1%	-35.1%	8.3%

Arts-Ent-Rec	46.3%	15.4%	80.8%	22.1%	-52.5%	3.6%	39.9%
Total Jobs	-1.3%	-12.0%	109.7%	19.0%	29.6%	-17.1%	11.7%

LQ Trend 2010-2016 (LQ 2016 / LQ 2010)

Sector Groups	*0.125*	*0.25*	*0.375*	*0.50*	*0.625*	*0.75*	*0.875*	*1.00*
Manufacturing	0.87	0.66	2.94	0.45	2.67	1.02	1.72	0.52
Light Industry	0.99	0.98	2.14	1.12	1.61	0.65	0.68	1.76
Retail-Lodging-Food	0.83	0.79	0.65	0.73	0.79	0.80	0.53	1.00
Knowledge	0.77	1.03	2.08	1.39	1.15	1.14	0.93	1.28
Office	1.28	1.17	1.89	1.15	1.32	1.15	1.68	0.77
Education	1.58	1.03	2.27	2.36	1.33	0.88	8.78	0.84
Health	0.95	1.03	2.22	1.02	0.80	1.63	1.34	1.46
Arts-Ent-Rec	0.69	0.78	1.19	1.00	1.75	2.80	0.82	0.82
Total Jobs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00