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FINAL REPORT

National Study of BRT Development Outcomes

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Transportation Insight for Vibrant Communities

NATIONAL STUDY OF BRT DEVELOPMENT OUTCOMES

Final Report

NITC-RR-650

by

Arthur C. Nelson
Joanna Ganning

University of Utah

for

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

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16. Abstract

Bus rapid transit (BRT) is poised to become the "next big thing" in public transit. From virtually no systems a generation ago, there are now 19 lines operating with at least seven under construction and more than 20 in the planning stages. BRT is gaining popularity because of its combination of low capital cost and potential for high levels of benefits. But are BRT systems effective in attracting development?

To answer this and many more trending BRT questions, the Metropolitan Research Center (MRC) reviewed multiple studies using data from the United States Census Bureau, Longitudinal Employer-Household Dynamics, and CoStar data in a quasi-experimental, compare-and-contrast research design to compare jobs, population and households, and housing units before and after BRT station construction relative to control stations and the stations' metropolitan context. Our units of analysis will be 2010 census blocks and their assemblages as data allow within 0.25 mile buffers.

The final products of the MRC's research include case studies of each BRT and meta-assessments of whether and to what extent BRT systems attract development. Some of the studies answer the following questions: What are the effects of BRT on sectoral employment change in the United States? How does BRT affect housing location affordability? What is the relationship between BRT and its surrounding area's wage-related job change? These answers can provide MPOs with information to aid in the decision-making process in terms of economic development and transportation planning options.

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Additionally, we acknowledge and thank the anonymous peer reviewers who provided immensely helpful insights and corrections to this report.

DISCLAIMER

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EXECUTIVE SUMMARY

Figure A. The MAX is a BRT run by the Utah Transit Authority

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 observing the extent of economic development potential between BRT types remains nascent. So, are BRT systems effective in attracting development?

To answer this and many more trending BRT questions, the Metropolitan Research Center has reviewed multiple studies using data from the United States Census Bureau, Longitudinal Employer-Household Dynamics, and CoStar data in a quasi-experimental, compare-and-contrast research design to compare jobs, population and households, and housing units before and after BRT station construction relative to control stations and the stations’ metropolitan context. Our units of analysis are the 2010 census blocks and their assemblages into block groups as data allow within 0.25-mile buffers.

Our research was designed to gather information and data about a number of relevant questions related to BRT and economic development. The evaluation sought to answer the following questions:

- How does BRT influence development patterns?
- What are the effects of BRT on sectoral employment change in the United States?
- How does BRT affect housing location affordability?
- What is the relationship between BRT and its surrounding area’s wage-related job change?
- Does the type of BRT system technology make a difference in economic development outcomes?

This report includes case studies of each BRT and meta-assessments of whether and to what extent BRT systems attract development. We summarize our research in eight areas as follows, first with economic development outcomes and then with respect to social well-being outcomes.

Development Patterns

We analyzed new development patterns within 0.50 mile of BRT corridors between the periods 2000 and 2007, before the Great Recession, and 2008 to 2015 covering the recession and recovery. We find that for metropolitan counties with BRT systems, transit corridors increased their share of new office space by a third, from 11.4 percent to 15.2 percent. We also find that although new multifamily apartment construction within 0.50 mile of BRT was small, its share has more than doubled since 2008. We observe that BRT corridors appear to be gaining share of new offices and multifamily apartments.

Profiles in Bus Rapid Transit and Economic Development with Special Reference to BRT Technology

We use shift-share analysis to compare pre-recession (2002/2004-2007) and recovery (2008-2011) periods for the BRT station areas compared to their central county. As in other studies, we controlled for the counter-factual. For most but not all systems, we find the 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. We further find circumstantial evidence suggesting that more technologically advanced BRT systems may contribute to positive economic development outcomes.

Sectoral Employment Change

We studied 0.25-mile buffer areas around BRT stations on nine lines opened in the mid-2000s across the U.S., and equally sized areas around control points, to estimate the effects of BRT stations on employment growth for sectors. We find that while our model adequately predicts overall employment change regardless of BRT, BRT is found to influence employment change in only one sector—manufacturing. We believe this finding should be encouraging to economic development planners, as manufacturing provides an employment base for a broad spectrum of income levels and represents a significant share of industrial recruitment activity.

Bus Rapid Transit and Office Rents

Using a commercial real estate service, we evaluate the association between office properties located within 0.50 mile of a BRT line and asking rents. We find evidence of an office rent premium for location within a BRT corridor for most metropolitan areas studied.

Express Busways and Economic Development: Case Study of the South Miami-Dade Busway

A growing body of literature is showing important associations between several forms of fixed-guideway public transit systems and economic development; yet, there exists no assessment of the economic development contributions of express bus service. To help close this gap in literature, we evaluate the change in jobs and share of jobs within 0.50 mile of the express bus stations comprising the South Miami-Dade Busway over the period 2002 through 2011. As for the BRT and wage-related job change analysis, we controlled for the counter-factual. We again used shift-share analysis to assess development outcomes before and after the recession with respect to these counter-factual locations and compared outcomes to Express Bus stations. We find important economic development outcomes with respect to the South Miami-Dade Busway.

Bus Rapid Transit and Location Affordability

Literature shows transportation costs as a share of household income increase with respect to distance from downtowns and freeway interchanges, but it is silent on the relationship with proximity to BRT stations. Using ordinary least squares regression analysis, we evaluate block-group data for all 12 BRT lines operating in the U.S. in 2010. We use the quadratic transformation of the central business district (CBD) and BRT distance variables to estimate the extent to which distance effects are found. We find that 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.

Bus Rapid Transit and Wage-Related Job Change

Literature suggests fixed-guideway transit systems attract more lower-wage jobs near transit stations. We evaluate this proposition in the context BRT. To help control for the counter-factual—that is, the shift in jobs by wage group would have occurred anyway—we devised an algorithm to identify 10 alternative locations having comparable attributes to each existing station at the beginning of our study period. We used shift-share analysis to assess the shift in jobs based on wage categories before and after the Great Recession with respect to these counter-factual locations and compared outcomes to BRT station areas. We find that before the recession, the shift in jobs for all wage groups was about the same between BRT station areas and counter-factual locations. During the recovery, however, BRT station areas saw larger shifts compared to counter-factual locations for lower-wage and upper-wage jobs. However, BRT station areas were associated with the largest positive shift in the share of upper-wage jobs during economic recovery while the share of lower-wage jobs in BRT station areas fell, both compared to their central counties and counter-factual locations.

The Relationship between Bus Rapid Transit and the Location of People and Housing

Because of their novelty, little research has addressed whether and the extent to which BRT systems influences the location of people and housing. We help close this gap in research. We find little difference in BRT study area performance compared to their metropolitan areas in terms of influencing population and residential patterns. However, we 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.

1.0 INTRODUCTION

1.1 PURPOSE OF THE REPORT

Bus rapid transit (BRT) is poised to become the “next big thing” in public transit. From virtually no systems a generation ago, there are now more than 20 true BRT lines operating in more than a dozen metropolitan areas with dozens more lines planned or under construction. BRT is gaining popularity because of its combination of low capital cost and potential for high levels of benefits. But are they effective in attracting development? And, given the variation in design between systems, do development outcomes along BRT corridors and at stations vary by type of system? To answer these questions, we conducted a national study of all 13 BRT systems in place as of 2011 and operating since at least 2009. Our research methods, findings and implications are presented in this report.

We are motivated in this report to provide the systematic evidence decision-makers and the general public need to understand the nature of development outcomes associated with BRT investments. To the extent data allow, we aim also to indicate differences in outcomes to different levels of BRT quality. Unlike rail transit, BRT systems can vary in design considerably, as we will note later in this introduction.

Our central interest is learning the extent to which BRT lines and stations attract jobs and associated nonresidential development, as well as people and associated residential development. At the time we started our research, the Transportation Research International Documentation (TRID) database reported only seven relevant publications since 2009. Only one study reported statistical analysis associating BRT stations with jobs and that is ours (Nelson et al., 2013). It showed that, for certain sectors, Eugene-Springfield’s BRT system attracted jobs yet repelled jobs in others. Their research was limited to just one BRT flavor (Bronze—described later in the introduction) in just one metropolitan area.

A 2012 study by the U.S. General Accountability Office (GAO) provided descriptive information about ridership and a combination of descriptive and anecdotal information on new jobs and development activity for some BRT systems. It provided no statistically rigorous assessment, however, nor did it offer evidence on the extent to which jobs and development vary by type of BRT system.

We also found that two published studies used hedonic analysis to show that single-family residential property values rise with respect to BRT station proximity in Pittsburgh (Perk et al., 2010) and in Boston (Perk et al., 2012). Neither reported hedonic analysis of nonresidential and apartment residential development.

We found three other works reported in TRID worth noting. Davis (2013) offered general observations of the growth and prospects of BRT to shape metropolitan development patterns, and he includes planning implications. Panero et al. (2012) reported peer-to-peer observations about the planning, design, implementation and management of existing and new BRT systems.

The National Bus Rapid Transit Institute (NBRTI, 2009) provided an overview of planning, design and implementation issues. In 2013, the Institute for Transportation and Development Policy (ITDP) issued a report providing background information for BRT, light rail and streetcar systems nationally (Hook, Lotshaw and Weinstock, 2013). Except for two case studies, it did not evaluate development outcomes with respect to transit investments, however. Its two BRT case studies – Cleveland and Pittsburgh – described development that has occurred along the BRT lines, but neither offered statistical evidence that BRT made a difference relative to controls. Moreover, neither case study provided the kind of rigorous statistical analysis we used for the research presented in this report.

In short, previous research does not comprehensively address whether and the extent to which BRT lines and stations are associated with residential and job change along with residential development. And, if so, whether variations in development outcomes are associated with differences in BRT features. This is the purpose of our national study.

1.2 THEORETICAL OVERVIEW

Public transit systems are often promoted as offering many social, economic and environmental benefits to urban populations, in part by transforming urban forms from auto-centric designs into more sustainable, transit-accessible ones. There is a sound theoretical foundation for this.

Fixed-guideway transit systems include heavy or "fifth" rail, such as the New York subway; light rail, such as provided in Charlotte and San Diego; non-tourist-related streetcar, such as seen in Portland and Tampa; and bus rapid transit, such as the world's second-oldest system operated in Pittsburgh. Fixed-guideway systems reinvent the idea of agglomeration economies, which is a cornerstone of urban economic development. In this section, we review the role of agglomeration economies in economic development, assess how the advantages of agglomeration economies are undermined by automobile dependency, and summarize the role of fixed-guideway transit systems in recreating those economies.

Cities are formed and grow in large part by creating agglomeration economies (Glaeser, 2011). Annas, Arnott and Small (1998) define the term as "the decline in average cost as more production occurs within a specified geographical area" (p. 1,427). They arise specific to certain economic sectors, however. As more firms in a related sector cluster together, costs of production fall as productivity increases. These economies can spill over into complementary sectors (Holmes, 1999). Cities can become ever larger as economies of agglomeration are exploited (Ciccone and Hall, 1996). If cities get too large, however, congestion occurs, which leads to diseconomies of scale. The result may be relocation of firms, but this can weaken economies of scale (Bogart, 1998). Highways connecting the city to outlying areas can induce firms to relocate, thereby reducing agglomeration diseconomies of scale through sacrificing some economies, though overall economic improvement is debatable (Boarnet, 1997). Cities thus spread out, and although the urban area may contain more people and jobs, the advantages of agglomeration economies are weakened.

One way to preserve agglomeration economies and reduce diseconomies is to improve transportation systems; this is a role of fixed-guideway transit systems. Within about 0.25 to 0.50

miles from transit stations accessing these systems, firms maximize the benefits of agglomeration economies (Cervero et al., 2004). Moreover, some firms can also benefit from expanded access to the labor force residing within walking distance of transit stations, wherever they are located (Belzer, Srivastava and Austin, 2011).

There is another aspect of agglomeration economies identified by Chapman and Noland (2011). Although transit systems can lead to higher-density development by shifting new jobs and population to station areas, it could lead, instead, to the redistribution of existing development even in the absence of growth.

In part because of their role in facilitating agglomeration economies, there is a growing body of research showing that rail-based public transit facilitates underlying agglomeration economies and thereby enhances economic development (see Nelson et al., 2009). Those economies are facilitated when they improve accessibility between people and their destinations (Littman, 2009) by reducing travel time and the risk of failing to arrive at a destination (Weisbrod and Reno, 2009). At the metropolitan scale, adding rail transit corridors in built-up urban areas increases aggregate economic activity (Graham, 2007). But do these theories and findings apply as well to bus rapid transit systems?

1.3 BRIEF ORIENTATION TO BUS RAPID TRANSIT SYSTEMS

BRT systems are described as bus services with advanced operational features distinct from other local bus services (Levinson et al., 2003). BRTs typically include separate priority lanes, faster passenger boarding, off-vehicle fare collection, and branding. Branding provides a BRT identity and style (GAO, 2012; Thole and Samus, 2009; Hook et.al, 2013; Urban Land Institute, 2011). Such features provide BRT a sense of permanence, which fixed-rail investments typically signify (Polzin and Baltes, 2002; Graham, 2007; Cervero and Dai, 2014). These features are illustrated in Figure 1.1. Although we address some details of BRT system design and technology in individual chapters, we provide an overall orientation here.

Kittelson & Associates (2007) pose an ideal set of features that differentiate BRT systems from regular bus service, if not rail transit options. They are:

1. Physically separated, exclusive BRT-use lanes or roadways;
2. Distinctive lines with frequent, reliable service and regular headways at all daily hours;
3. Distinctive, protected and closely-spaced (300-600 meters) stops;
4. Specially designed buses with large door-to-capacity ratios, low floors and/or high platforms;
5. Signalized intersection priority; and
6. Use of intelligent transportation technology to maximize vehicle movements, passenger information, and fare collection.

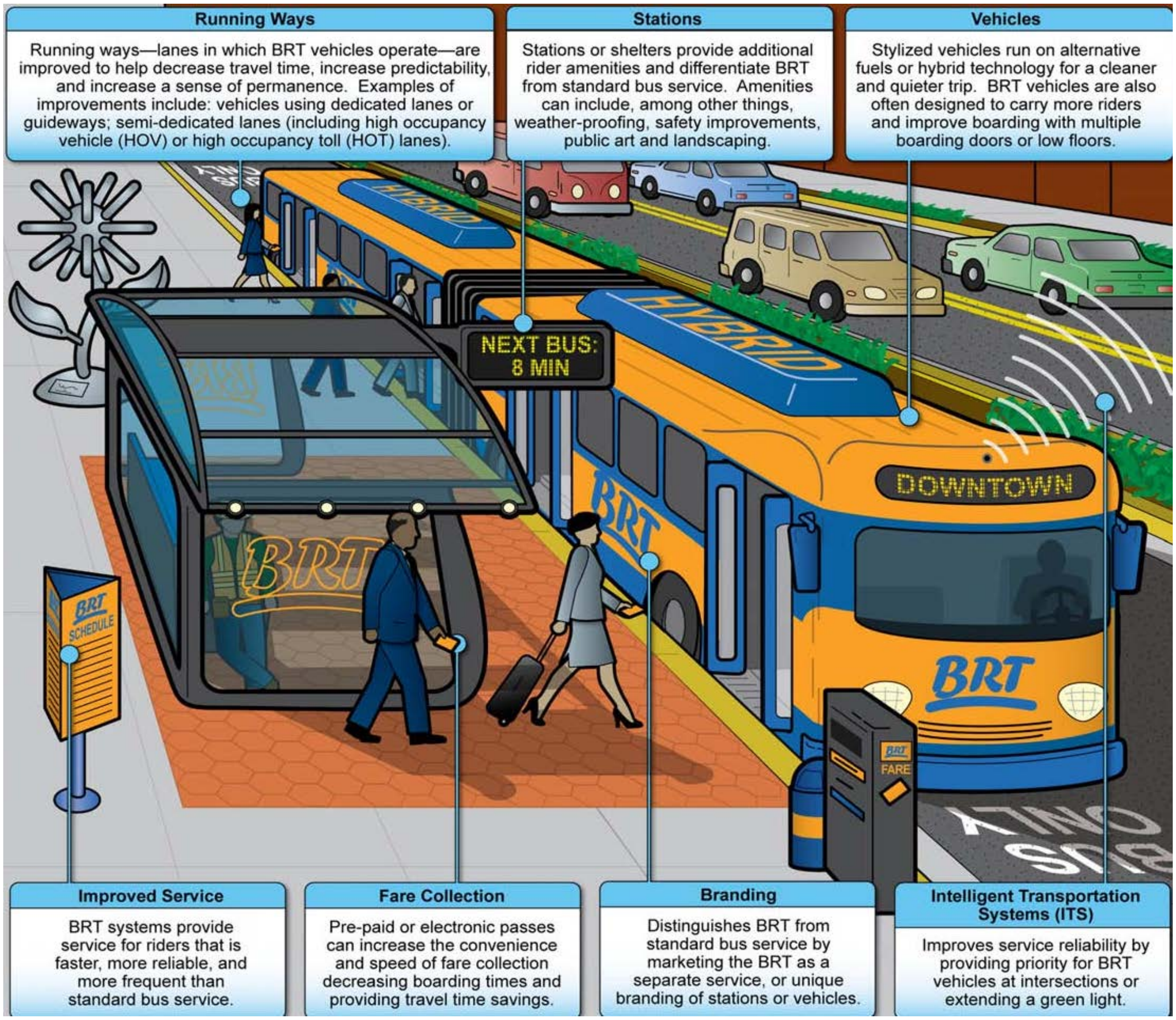

Figure 1.1 Characteristics of Bus Rapid Transit
***Source*: United States Government Accountability Office (2012). BUS RAPID TRANSIT: Projects Improve Transit Service and Can Contribute to Economic Development.**

Vuchic, Stanger and Bruun (2012) note, however, that no BRT system in the world includes all those elements. In their view, BRT systems should have most of them. They also note the most important element is for a BRT system to be comparable in as many ways as possible to light rail transit (LRT) systems, especially in terms of dedicated right-of-way and operating speed. This is not an inexpensive proposition according to Hoffman (2008). Indeed, it is possible that along any given segment, BRT capital costs can be more than LRT costs. We adapt Vuchic, Stanger and Bruun's comparison of BRT and LRT planning, design, operational and cost features (p. 1,881) as follows:

1. Separate ROW (B or A) for LRT is easier to achieve because LRT uses rail tracks instead of roadway lanes, and due to its different technology requires no physical protection and police enforcement, as do busways.
2. LRT has better vehicle performance than BRT because of its electric traction.
3. LRT produces no exhaust along the line and much lower noise than BRT.
4. LRT is often designed to serve as the central element for access and image of pedestrian areas in central cities; BRT with high-frequency services is much less compatible with "pedestrianized" areas.
5. LRT can use tunnels while BRT cannot.
6. LRT vehicles are more spacious and comfortable than BRT buses.
7. LRT has a stronger brand leading it to attract more riders.
8. LRT has a stronger positive impact on urban development than BRT—though we note that research has yet to support this conclusively.
9. Investment costs for LRT are higher, often far higher, than those for BRT.

Several tables synthesize insights offered by Vuchic, Stanger and Bruun which compare regular bus (RB), BRT and LRT systems. To some extent, streetcar systems can be considered a form of LRT for purposes of comparing rail to BRT options. Table 1.1 compares RB, BRT and LRT systems in terms of system components, operational features of service lines, and overall system characteristics. For the most part, it is easy to see that BRT functions essentially in the middle between RB and LRT services.

Table 1.2 compares RB, BRT, LRT and rapid rail transit services. Rapid rail transit is sometimes called "heavy" rail since its cars hold more passengers and its travel speeds are higher than LRT, and also sometimes called "third rail" since many rapid rail systems are powered by an electrified track closely paralleling one of the two main load-bearing tracks. Comparisons are made based on observed data from Los Angeles, which has examples of all these systems; the BRT example is explicitly the Orange Lin, which is also among the highest rated BRT lines in the nation (this will be discussed later). Here we see that for the most part BRT, or at least Los Angeles' Orange Line BRT, has the greater cost-effectiveness outcomes.

Table 1.3, also adapted from Vuchic, Stanger and Bruun, attempts to compare RB, BRT and LRT systems in terms of costs, environmental implications and effects on urban form. For the most part, LRT appears to be the preferred choice, but this assumes implicitly that planning, design and cost features are the same between the options. Of course they are not. Moreover, the implicit assumption is that LRT per se will influence development outcomes to a greater extent than LRT. Although we do not make many direct comparisons in our report, we believe we make enough to warrant reconsideration of this assumption.

Because BRT systems vary considerably in their planning, design, operational and cost features, the next section reviews a way in which these different systems can be compared based on their differences.

Table 1.1 Bus, BRT and Light Rail Transit Systems Compared

Mode	Regular Bus (RB)	Bus Rapid Transit	Light Rail Transit
System Components			
Travel Lane	Road	Road	Rail
Guidance	Steered	Steered	Guided
Propulsion	ICE	ICE	Electric
Transit unit (TU) control	Driver/Visual	Driver/Visual	Driver/Signal
Vehicle capacity (spaces)	80-120	80-120	100-250
Maximum transit unit size	Single Vehicle	Single Vehicle	1-4 car trains
Maximum TU capacity	80-120	80-120	4 x 180 = 720
Lines/Operational Elements			
Lines	Many	Few	Few
Headways	Long/Medium/Short	Long/Medium/Short	Medium/Short
Urban Stop Spacing (meters)	80-250	200-400	250-600
Transfers	Few	Some/Many	Many
System Characteristics			
Investment cost/km	Low	High	Very High
Operating cost/space	Medium	Medium	Low
System brand	Variable	Good	Excellent
Passenger attraction	Limited	Good	Strong
Impacts on land use and livability	Least	Moderate	Strongest
Note: ICE means internal combustion engine			

Source: Adapted from Vuchic, Stanger and Bruun (2012).

Table 1.2 Bus, BRT and Light Rail Transit Operating Features and Costs Compared

Mode	Regular Bus	Orange Line BRT	Light Rail Transit	Rapid Rail Transit
Feature				
Ave. peak hour speed km/hour	20.6	29.3	41.4	51.8
Ave. trip length	5.7	9.4	11.3	8.0
Daily riders: Observed	30,000	25,000	84,000	140,000
Daily riders: Capacity	30,000	35,000	100,000	300,000
Capital cost/km (millions)	na	$17.3 (2005)	$38.9 (2003)	$130 (2000)
Operating costs per passenger km	$0.60	$0.30	$0.31	$0.27
Operating subsidy per passenger km	$0.47	$0.22	$0.25	$0.20

Source: Adapted from Vuchic, Stanger and Bruun (2012).

Table 1.3 Bus, BRT and Light Rail Transit Service Quality, Economic, Environmental and Planning Aspects Compared

Mode	Regular Bus	Bus Rapid Transit	Light Rail Transit	Preference
Feature				
Investment cost	Medium	High	Very High	RB
Implementation complexity/time	Short	Medium	Long	RB
Operating cost	Lower for low volumes	Lower for low volumes	Lower for high volumes	No Clear Choice
Operating speed	Medium	High	High	No Clear Choice
Flexibility for operating options	Low	Some with 4-lane stops	Low except with 4-track stops	BRT
Capacity	Low	Medium	High	LRT
Energy & traction	ICE	ICE	Electric	LRT
Vehicle performance	Good	Good	Excellent	LRT
Air pollution	Poor	Poor	No local pollution	LRT
Noise	Poor	Poor	Some	LRT
System brand, attraction	Fair	Good	Excellent	LRT
Potential to influence development	Limited	Fair	Very good	LRT
Contribution to livability	Some	Limited	Excellent	LRT

Source: Adapted from Vuchic, Stanger and Bruun (2012).

1.4 RATING BUS RAPID TRANSIT SYSTEMS

Our study includes all 13 BRT systems operating (one being technically a regional express bus service—Miami-Dade—that we will discuss later) as of 2011 for which data are available no later than 2009. Key features of those systems are reviewed in Table 1.4. We remind readers that technologies used for BRT systems vary much more than other fixed-guideway transit systems. Rail and streetcar transit systems, for instance, operate on rails with specially designed platforms serving riders. Conventional buses involve buses using regular travel lanes with few specially designed platforms serving riders. According to Nikitas and Karlsson (2015), BRT systems have several uniquely varying features such as the following (adapting from their work):

- ***Unique buses*** that contribute significantly to BRT's image and identity;
- ***Stops, stations, terminals and corridors*** that clearly define the BRT operating area;
- ***Variety of rights-of-way*** such as intersection signalization priority, dedicated lanes, and potentially separation from other surface street traffic;
- ***Pre-board fare collection*** that economizes on boarding time;
- ***Information and communication technologies*** that improve the rider experience both at the platform and on the bus;
- ***Substantial service during the day*** ideally being no less than 16 hours per day with peak frequencies of no more than 10 minutes; and
- ***Brand identity*** that distinguishes BRT from all other forms of transit.

To help in differentiating BRT systems based on their differences, Weinstock et al. (2011) devised an objective rating scheme to classify them. It was adapted by the Institute for Transportation and Development Policy (2013). For its part, the ITDP rates BRT systems worldwide as Gold, Silver, Bronze, Basic or "Unrated" (which is our term). Based on this rating scheme, technically, unrated systems are not defined as true BRT systems. Semantics aside, we consider all BRT systems in the U.S. that transit authorities say are BRT systems to be such. Whether economic development performance differs by overall rating of BRT systems is unknown, however. We report the ITDP ratings for U.S. BRT systems in Table 1.5. Systems not on this table are considered "unrated" for our purposes.

Using information provided in tables 1.4 and 1.5 we are able to estimate the differential capital costs per BRT system mile between BRT levels. They are:

Silver	$23.7 million per mile
Bronze	$22.9 million per mile
Basic	$28.5 million per mile
Unrated	$3.0 million per mile

In other words, while there is not much difference in the cost per system-mile of BRT systems that are rated, those that are unrated are about a full magnitude (one-tenth) less costly. We will use this finding in our overall assessment of how BRT systems affect development outcomes with special reference to overall system quality.

Table 1.4 General Features of U.S. BRT Systems Evaluated

Place	Line	Year	Miles	Stations	Buses	Corridor Cost (millions 2015$)	Corridor Cost/Mile (millions 2015$)	Average Weekday Ridership
Cleveland OH	HealthLine	2008	9.4	58	24	$222.0	$23.7	10,500
Eugene-Springfield OR	Emerald Express	2007	4.0	10	6	$25.3	$6.3	6,000
Kansas City MO	Main Street	2005	6.0	47	14	$28.1	$4.7	4,800
Las Vegas NV	Strip and Downtown (SDX)	2010	9.0	na	na	$51.6	$5.7	14,000
Los Angeles	901 Metro Orange Line	2005	14.4	28	23	na	na	23,156
Los Angeles	910 Silver Line	2009	26.7	38	16	na	na	7,269
Miami-Dade FL	South Miami-Dade Busway	1996	20.0	30	57	$81.2	$4.1	25,000
New York City - Bronx NY	Fordham Rd/ Pelham Parkway	2008	9.0	18	25	$11.7	$1.3	35,000
Phoenix AZ	Main Street LINK	2009	13.0	15	8	$22.2	$1.7	1,174
Pittsburgh PA	MLK East Busway	1983	9.1	10	na	$274.9	$30.2	25,000
Pittsburgh PA	West Busway	2000	8.1	6	na	$451.3	$55.7	na
Pittsburgh PA	South Busway	1977	4.3	10	na	$106.1	$24.7	13,000
Salt Lake County UT	3500 South BRT (MAX)	2008	10.0	12	10	$7.8	$0.8	4,400

Source: Data from National Bus Rapid Transit Institute. Corridor costs adjusted by authors.

Table 1.5 Ratings of U.S. Bus Rapid Transit Systems, 2013

		Cleveland OH HealthLine	Eugene OR EmX Green Line	Pittsburgh PA Martin Luther King Jr. East Busway	Pittsburgh PA West Busway	Pittsburgh PA South Busway	Las Vegas Strip & Downtown Express	Los Angeles Orange Line
Corridor length, km		***15.0***	***12.5***	***14.6***	***8.2***	***6.9***	***2.0***	***23.0***
Metric	**Points**							
BRT Basics - Minimum score of 18 points needed	**33**	**29**	**20**	**20**	**20**	**20**	**23**	**25**
Busway alignment	7	7	4	7	7	7	6	7
Dedicated right-of-way	7	7	4	7	7	7	6	7
Off-board fare collection	7	6	6	0	0	0	3	6
Intersection treatments	6	3	0	6	6	6	3	5
Platform-level boarding	6	6	6	0	0	0	5	0
Service Planning	**24**	**16**	**11**	**13**	**12**	**11**	**12**	**13**
Multiple routes	4	4	0	4	4	4	4	0
Peak frequency	3	1	0	2	1	0	0	3
Off-peak frequency	2	0	2	0	0	0	0	2
Express, limited, and local services	3	0	0	2	2	2	0	0
Control center	3	3	3	0	0	0	2	3
Located In top ten corridors	2	2	2	2	2	2	2	0
Demand Profile	3	3	3	0	0	0	0	3
Hours of operations	2	2	1	2	2	2	2	2
Multi-corridor network	2	1	0	1	1	1	2	0
Infrastructure	**14**	**8**	**5**	**11**	**10**	**10**	**5**	**9**
Passing lanes at stations	4	2	0	4	4	4	0	4
Minimizing bus emissions	3	2	2	2	1	1	3	3
Stations set back from intersections	3	1	1	3	3	3	1	0
Center stations	2	1	0	0	0	0	0	0
Pavement quality	2	2	2	2	2	2	1	2

Table 1.5 Ratings of U.S. Bus Rapid Transit Systems, 2013 – continued

Metric		Cleveland OH HealthLine	Eugene OR EmX Green Line	Pittsburgh PA Martin Luther King Jr. East Busway	Pittsburgh PA West Busway	Pittsburgh PA South Busway	Las Vegas Strip & Downtown Express	Los Angeles Orange Line
Station Design and Station-bus Interface	**10**	**9**	**7**	**5**	**7**	**7**	**6**	**5**
Distances between stations	2	2	2	0	2	2	2	0
Safe and comfortable stations	3	3	2	1	1	1	1	1
Number of doors on bus	3	3	3	3	3	3	3	3
Docking bays and sub-stops	1	1	0	1	1	1	0	1
Sliding doors in BRT stations	1	0	0	0	0	0	0	0
Quality of Service & Passenger Information Systems	5	5	5	0	0	0	4	5
Branding	3	3	3	0	0	0	3	3
Passenger information	2	2	2	0	0	0	1	2
Integration and Access	**14**	**9**	**10**	**7**	**2**	**2**	**7**	**8**
Universal access	3	3	3	2	1	1	3	3
Integration with other public transport	3	1	3	2	0	0	1	0
Pedestrian access	3	3	2	2	1	1	2	1
Secure bicycle parking	2	1	1	1	0	0	0	2
Bicycle lanes	2	1	1	0	0	0	1	2
Bicycle-sharing integration	1	0	0	0	0	0	0	0
TOTAL 100	**100**	**76**	**58**	**56**	**51**	**50**	**57**	**65**
BRT BASICS (MINIMUM NEEDED 18)	**33**	**29**	**20**	**20**	**20**	**20**	**23**	**25**

Table 1.5 Ratings of U.S. Bus Rapid Transit Systems, 2013 – continued

		Cleveland OH HealthLine	**Eugene OR EmX Green Line**	**Pittsburgh PA Martin Luther King Jr. East Busway**	**Pittsburgh PA West Busway**	**Pittsburgh PA South Busway**	**Las Vegas Strip & Downtown Express**	**Los Angeles Orange Line**
Point Deductions	**-36**	**0**	**-3**	**0**	**0**	**0**	**-3**	**0**
Commercial Speeds	-10	0	-3	0	0	0	0	0
Peak passengers per hour per direction (pphpd) below 1,000	-5	0	0	0	0	0	0	0
Lack of enforcement of right-of-way	-5	0	0	0	0	0	0	0
Significant gap between bus floor and station platform	-5	0	0	0	0	0	-3	0
Overcrowding	-3	0	0	0	0	0	0	0
Poorly-maintained Busway, Buses, Stations and Technology Systems	-8	0	0	0	0	0	0	0
Total Score:	**100**	**76**	**55**	**56**	**51**	**50**	**54**	**65**
Gold	***85-100***							
Silver	***72-84***	***Silver***						
Bronze	***55-71***		***Bronze***	***Bronze***				***Bronze***
Basic	***18-54***				***Basic***	***Basic***	***Basic***	

Source: Adapted from Institute for Transportation and Development Policy (2014)

1.5 RESEARCH OBJECTIVES

The overall objective of this research is to evaluate the type and extent of economic impacts of BRT stations in the United States. This research examines 12 BRT systems located in 10 areas: Pittsburgh, PA; Las Vegas, NV; Los Angeles, CA; Kansas City, MO; Eugene-Springfield, OR; Cleveland, OH; Bronx, NY; Phoenix, AZ; Miami, FL; and West Valley City, UT. Each of the BRTs observed in this research possess different technologies and quality rankings, and are set in diverse cultural contexts.

Our research was designed to gather information and data about a number of relevant questions related to BRT and economic development. The evaluation sought to answer the following questions:

- How does BRT influence development patterns?
- What are the effects of BRT on sectoral employment change in the United States?
- How does BRT affect housing location affordability?
- What is the relationship between BRT and its surrounding area's wage-related job change?
- Does the type of BRT system technology make a difference in economic development outcomes?

These questions are addressed in eight chapters.

Figure 1.2 The Eugene-Springfield Emerald Express (EmX) BRT system

1.6 BRT SYSTEMS EVALUATED

Here we profile the BRT systems operating in the 10 metropolitan areas that are evaluated in this report. We review them chronologically from the metropolitan areas with the oldest system, including its subsequent systems.

1.6.1 Pittsburgh, Pennsylvania

Pittsburgh launched the South Line (earning a Basic rating) in 1977, just three years after the world's first system in Curitiba, Brazil, to be the U.S.'s first BRT system. The South Line's 4.3 miles of exclusive bus lanes encompass previously underserved areas from the western suburbs to the downtown area. Funding for the system came from U.S. DOT, the State of Pennsylvania, and Allegheny County. The Port Authority of Allegheny County operates the system. By 1983, Pittsburgh started the East Line (rated Bronze with 6.8 miles) connecting eastern suburbs to downtown. In 2000, the West Line (rated Basic) was initiated.

1.6.2 Las Vegas, Nevada

In 2004, the BRT system called MAX launched to operate on a northeasterly radial corridor (7.5 miles) between downtown Las Vegas and Nellis Air Force Base. The BRT service is intertwined with regular bus service. Much of the BRT system serves areas already substantially developed as low to modest intensities, and is an important connector between the City of North Las Vegas and Nellis AFB. The line is owned by the Regional Transportation Commission of Southern Nevada and operated by Veolia Transportation.

1.6.3 Los Angeles, California

During the study period, Los Angeles opened two BRT systems: the Orange Line (in 2005—rated Bronze) serving the San Fernando Valley north of the City of Los Angeles and the Silver Line serving areas south of the city (2009 – unrated). The Orange Line is 18 miles of exclusive right-of-way, and the Silver Line is 26 miles but does not operate exclusively in a right-of-way. Both are operated by the Los Angeles County Metropolitan Transportation Authority.

1.6.4 Kansas City, Missouri

Kansas City began operating its Main Street Line in 2005. It connects downtown to the Crown Center Plaza along a six-mile route, nearly four miles of which are dedicated lanes. It has proven to be moderately successful in attracting economic development within a slow-growing metropolitan area. The BRT currently hosts 87 stations and is operated by the Kansas City Area Transportation Authority, which is planning for more routes to expand the line.

1.6.5 Eugene-Springfield, Oregon

The Emerald Express (EmX) BRT system serving the Eugene-Springfield metropolitan area was put into service in 2007. It connects downtown Springfield to downtown Eugene with stops at the University of Oregon. One unique feature affecting this metropolitan area is the presence of an urban growth boundary designed to steer jobs away from lower-density areas into more central ones especially served by transit. EmX was extended in 2011 to connect northward from the east to the Gateway Mall and Sacred Heart Medical Center at RiverBend.

1.6.6 Cleveland, Ohio

Cleveland's HealthLine BRT system, the nation's highest-rated BRT system according to the Institute for Transportation and Development Policy, started operations in 2008. The HealthLine connects downtown Cleveland to the medical centers to the east. Features of the HealthLine include 24 hybrid-electric vehicles, doors on both sides, bike lanes, landscaping/hardscape treatment with 1,500 irrigated trees, and integrated/stand-alone public art. The 36-station, 9.2-mile BRT corridor is operated by the Greater Cleveland Regional Transit Authority.

1.6.7 The Bronx, New York

New York City initiated the Pelham Parkway BRT Line in 2008, substantially serving Bronx County which is also the central county used in our analysis. The Fordham Road-Pelham Parkway BRT offers transfer opportunities to subway lines and to the Metro-North Commuter Railroad lines. The BRT is operated by the New York City Department of Transportation.

1.6.8 Phoenix, Arizona

In 2008, the Valley Metro Transit serving Maricopa County, the central county of the Phoenix metropolitan area, opened its Main Street Line. The 11-mile, 25-station Main Street Line has since connected to include several other BRTs, including the Arizona Avenue BRT.

1.6.9 West Valley City, Utah

Yet another BRT system initiated in 2008, the MAX runs along the Wasatch Front in suburban West Valley City in Salt Lake County. The Max is run by the Utah Transit Authority to operate in a dedicated guideway separate from regular traffic. Future routes are being planned along 5600 West in Salt Lake County and along University Parkway in Utah County.

1.6.10 Miami-Dade, Florida

The South Miami-Dade Busway began in 1997 and is an eight-mile, two-lane roadway designed for use by buses and emergency vehicles along a former railroad right-of-way running parallel from US-1. Now, the busway is a 20-mile, dedicated bus-only facility operating 24 hours a day, seven days a week. Currently six local and limited-stop bus routes operate on the busway.

1.7 ORGANIZATION OF REPORT

We report our results in eight chapters. A final chapter synthesizes our findings and offers implications for transit and land use planning.

In the first part of our research findings, we report physical and economic development outcomes. We start in **Chapter 2** with a review of BRT and physical development patterns. In this chapter we report the limited academic literature on physical development outcomes associated with BRT. **Chapter 3** goes into considerable detail comparing the share and shift in share of jobs within BRT corridors before the recession and since. It also addresses the extent to which differences in BRT technology help explain the magnitudes of share changes seen between those periods. In **Chapter 4** we note that while there would seem to be a positive relationship between BRT and economic development there is little research on it. One way to measure BRT outcomes is to assess the extent to which market-based office rents respond to being within BRT corridors; this is done in **Chapter 5**. In **Chapter 6** we report a separate analysis of the South Miami-Dade Busway, which may not technically be considered a true BRT system. We include it because its results are remarkably similar to those we found for BRT systems, suggesting both versions of non-traditional bus investments can have positive economic development outcomes.

The second part of our report addresses relationships between BRT and population settlement patterns. We devote two chapters to the association between BRT and social outcomes. In **Chapter 4** we address the association between BRT and location affordability, while in **Chapter 5** we explore the relationship between BRT and the change in the distribution of jobs based on low-, middle- and upper-wage categories. Last but not least, we report in **Chapter 9** the extent to which BRT may influence the shifting of people and housing. We synthesize our research findings and offer implications for BRT system planning in **Chapter 10**.

2.0 BRT AND PHYSICAL DEVELOPMENT

In this chapter we identify overall changes in physical development associated with bus rapid transit system corridors. We note that there is a small literature on the physical development outcomes associated with BRT systems. Notably, Higgins, Ferguson and Kanaroglou's 2014 review of the academic literature reveals what seems to be sparse analysis of land use changes around LRT stations and virtually none around BRT stations or corridors.

The most sweeping assessment of BRT-, LRT-, and SCT-related development is offered by the Institute for Transportation and Development Policy (Hook, Lotshaw and Weinstock, 2013). Table 2.1 summarizes its findings. Its key findings are (p. 7):

> Bus Rapid Transit leverages more transit-oriented development investment than Light Rail Transit or streetcars: Cleveland's HealthLine BRT and Portland's MAX Blue Line LRT leveraged the most overall TOD investment of all the corridors we studied — $5.8 billion and $6.6 billion, respectively. Yet, because the HealthLine BRT cost significantly less to build than the MAX Blue Line LRT, Cleveland's HealthLine BRT leveraged approximately 31 times more TOD investment per dollar spent on transit than Portland's MAX Blue Line LRT.
>
> Both BRT and LRT can leverage many times more TOD investment than they cost. Of the 21 corridors we studied, 14 leveraged greater than $1 of TOD investment per $1 of transit (funds) spent. Five of them were BRT, four of them were LRT, two were streetcars, and three were improved bus (non-BRT) corridors.

To some extent, these results may be spurious as they depend on the economic health of the corridor to begin with. Cleveland's HealthLine, for instance, connects downtown to the medical centers east of downtown and is one of the healthiest (pun intended) corridors in the metropolitan area. Because Hook, Lotshaw and Weinstock did not employ controls, there is no way of knowing whether the investment occurred would have happened anyway. We thus caution that these are not cause-and-effect outcomes. Some, most or even all investment near transit stations may have occurred anyway, or may have merely located near stations rather than elsewhere in the metropolitan area, resulting in no net development gain. This is an area of future research.

Moreover, the differences in investment outcomes are based substantially on where transit goes, and how it is aligned. In the U.S., streetcar systems are found only in downtowns; they run relatively short stretches in existing travel lanes in high-value real estate environments so their costs are low while collateral development is high. Whether modern streetcars will be successful modes serving the vast distances BRT and LRT cover has not been tested. For its part, BRT has the advantage of also being built in existing travel lanes at relatively low cost. LRT systems are not only the most expensive to construct but if they are co-located within freight rail corridors or along freeways or freeway/expressway medians, their opportunities to stimulate collateral private investment will be diminished.

Table 2.1 TOD Investment and Development per Dollar Invested

System	Public TOD Investment (millions)	Investments in TOD Areas (millions)	Development per TOD Dollar Invested
Bus Rapid Transit			
Cleveland HealthLine	$51	$5,800	$114.54
Kansas City Main Street Metro Area Express	$51	$5,200	$101.96
Las Vegas Strip & Downtown Express (SDX)	$47	$2,000	$42.28
Boston Washington Street Silver Line	$31	$650	$20.97
Eugene Emerald Express Green Line (EmX)	$25	$100	$3.96
Pittsburgh Martin Luther King, Jr. East Busway	$252	$900	$3.59
Ottawa Transitway	$585	$1,000	$1.71
Boston Waterfront Silver Line	$719	$1,000	$1.39
BRT Summary	***$1,761***	***$16,650***	***$9.46***
Light Rail Transit			
Denver Central Corridor	$171	$2,550	$14.88
Portland MAX Blue Line	$1,765	$6,600	$3.74
Phoenix Metro	$1,418	$2,820	$1.99
Charlotte Lynx	$488	$810	$1.66
Los Angeles Orange Line	$361	$300	$0.83
Denver Southwest Corridor	$225	$160	$0.71
LRT Summary	***$6,189***	***$29,890***	***$4.83***

Source: Adapted from Institute for Transportation and Development Policy (2013)

2.1 DISTRIBUTION OF NEW OFFICE SPACE, 2000-2007 AND 2008-2015

We advance physical development outcomes associated with BRT systems as follows. We use CoStar data to gather a general impression of the relationship between BRT and the distribution of office development—measured in square feet— between 2000 and 2015 within 0.50 mile of BRT corridors. We compare changes in share of development between the pre-recession period of 2000-2007 and recession/recovery, 2008-2015. Both are eight years. Results are reported in Table 2.2. We find that for those metropolitan areas that have BRT systems, new office development has been gravitating toward BRT corridors substantially (increasing by a third) and significantly.

Table 2.1 Distribution of Office Development 2000-2007 and 2008-2015

Metric	BRT Metros
2000-2007	
New Office Square Feet	39,292,786
<=0.50 mile Transit	4,487,390
Share	11.4%
2007-2015	
New Office Square Feet	13,682,472
<=0.50 mile Transit	2,081,209
Share	15.2%
Change in Share of New Office Development	***33.2%***

Note: Difference in share have z-scores resulting in p <0.01.
<= means less than or equal to.

To be sure, the largest share of new office development still occurs outside 0.50 mile of transit corridors. Moreover, we cannot extrapolate the change in share of new office space. Nonetheless, there is some evidence suggesting that transit corridors are attractive to an increasing share of new office buildings.

2.2 DISTRIBUTION OF NEW MULTIFAMILY APARTMENT UNITS, 2000-2007 AND 2008-2015

Another way to assess physical development outcomes is to evaluate the change in multifamily apartment construction. Similar to our analysis of new office development, we use CoStar data to estimate new multifamily apartment units over the same time frame in Table 2.3. We find that although new multifamily apartment construction within 0.50 mile of BRT is small, their share has grown substantially since 2008, more than doubling. We caution that these are not cause-and-effect outcomes. Some, most or even all investment near transit stations may have occurred anyway, or may have merely located near stations rather than elsewhere in the metropolitan area, resulting in no net development gain. This is an area of future research.

Table 2.2 Distribution of Multifamily Apartment Development 2000-2007 and 2008-2015

Metric	BRT Metros
2000-2007	
New MF Square Feet	25,271,580
<0.50 mile Transit	546,325
Share	2.2%
2007-2015	
New MF Square Feet	6,746,189
<0.50 mile Transit	349,177
Share	5.2%
Change in Share of New Multifamily Units	139.4%

In the next chapter we profile the economic development outcomes to individual BRT systems, with special reference to BRT system rating.

3.0 PROFILES IN BUS RAPID TRANSIT AND ECONOMIC DEVELOPMENT WITH SPECIAL REFERENCE TO BRT TECHNOLOGY

3.1 INTRODUCTION

In this article, we evaluate the relationship between bus rapid transit (BRT) systems and economic development before and after the Great Recession of 2008-09. Because BRT technology differs more so than other fixed-guideway transit systems, we consider differences in outcomes based on type of BRT technology used.

That public transit generally (Nelson, Anderson, Bartholomew, Perlich, Sanchez and Ewing, 2009), and BRT specifically, can and even should advance economic development is well known (Thole and Samus, 2009; GAO, 2012). Unfortunately, there is only one study that comprehensively evaluates the change in jobs with respect to transit station proximity across several transit modes and its study period extended only from 2002 to 2008, or before the Great Recession (Belzer, Srivastava and Austin, 2011). Furthermore, there is only one case study on economic development outcomes associated with BRT – Eugene-Springfield's Emerald Express (EmX) – but it does not differentiate effects before the recession and during recovery (Nelson, Appleyard, Kannan, Ewing, Miller and Eskic, 2013).

There is another consideration: Technologies used for BRT systems vary much more than other fixed-guideway transit systems. Rail and streetcar transit systems, for instance, operate on rails with specially designed platforms serving riders. Conventional buses involve buses using regular travel lanes with few specially designed platforms serving riders. According to Nikitas and Karlsson (2015), however, BRT has several unique and varying features, which we adapt here:

- ***Unique buses*** that contribute significantly to BRT's image and identity;
- ***Stops, stations, terminals and corridors*** that clearly define the BRT operating area;
- ***Variety of rights-of-way*** such as intersection signalization priority, dedicated lanes, and potentially separation from other surface street traffic;
- ***Pre-board fare collection*** that economizes on boarding time;
- ***Information and communication technologies*** that improve the rider experience both at the platform and on the bus;
- ***Substantial service during the day*** ideally being no less than 16 hours per day with peak frequencies of no more than 10 minutes; and
- ***Brand identity*** that distinguishes BRT from all other forms of transit.

Weinstock et al. (2011) devised an objective rating scheme to classify BRT systems that was adapted by the Institute for Transportation and Development Policy (2013). The ITDP rates BRT systems worldwide as Gold, Silver, Bronze, Basic or "Unrated," which is our term. Based on this rating scheme, technically, unrated systems are not defined as true BRT systems. Semantics aside, we consider all BRT systems in the U.S. that transit authorities say are BRT systems to be such. Whether economic development performance differs by overall rating of BRT systems is unknown, however.

The study we report here helps close the gap in BRT economic development research by addressing these questions:

- Is there an association between BRT and economic development generally, and does this association differ before and after the Great Recession?
- Does classification of BRT make a difference in economic development outcomes?

We apply these questions to each of the BRT systems initiated in the U.S. before 2010. Our article thus includes 13 profiles. Brief characteristics of each system will be offered in each profile.

3.2 DATA AND METHODS

Our data are the Longitudinal Employer-Household Dynamics (LEHD) for 17 of the 20 two-digit North American Industrial Classification Scheme economic sectors. We exclude agriculture, mining and construction because those workers do not normally occupy building spaces in urban areas. We use LEHD data for the period 2002 (when the data first became available) or 2004 (the first year data were available for Phoenix) through 2011. Though LEHD data are available at the census-block level, we aggregate to the block group. We compare change between the central county (CC) and the block groups whose centroids are within 0.50 mile of BRT stations along each BRT system line.

For our analysis, we combine the 17 urban-related, space-occupying sectors into eight categories in the manner shown in Table 8.1. This is similar to the combinations used by others (Belzer, Srivastava and Austin, 2011).

We use shift-share analysis because it assigns the change or shift in the share or concentration of jobs with respect to the region, other economic sectors, and the local area. The "region" can be any level of geography and is often the nation or the state. In our case, where we want to see whether there are intra-metropolitan shifts in the share of jobs by sector, our region is the central county of the metropolitan area. The "local" area is often a city or county or even state, but it can be any geographic unit that is smaller than the region. Our local areas are block groups within 0.50 mile of the nearest BRT station; we call this the BRT Station Area. As shifts in the share of jobs may vary by sector over time because of changes in economic sector mixes, there is also an "industry mix" adjustment that we call the Sector Mix. Using notations by the Carnegie Mellon Center for Economic Development (undated), the shift-share formula is:

$$\mathbf{SS_i = CC_i + SM_i + Busway_i}$$

(3.1)

Where,

SSi = Shift-Share

CCi = Central County share

SMi = Sector Mix

Buswayi = Busway Station Area shift

The CC share measures by how much total employment in a BRT station area changed because of change in the metropolitan area economy during the period of analysis. If metropolitan area employment grew by 10 percent during the analysis period, then employment in the BRT station area would have also grown by 10 percent if there is no BRT effect. The Sector Mix (SM) identifies fast-growing or slow-growing economic sectors in a BRT station area based on the CC growth rates for the individual economic sectors. For instance, a BRT station area with an above-average share of the metropolitan area's high-growth sectors would have grown faster than a BRT station area with a high share of low-growth sectors. The BRT station area shift, also called the "competitive effect," is the most relevant component; it identifies a BRT station area's leading and lagging sectors. The competitive effect compares a BRT station area's growth rate in a given economic sector with the growth rate for that same sector at the metropolitan area. A leading sector is one where that sector's BRT station area growth rate is greater than its metropolitan area growth rate. A lagging sector is one where the sector's BRT station area growth rate is less than its CC growth rate.

The equations for each component of the shift-share analysis are:

$$\mathbf{CC} = ({}_i\text{BRT station area}^{t-1} \bullet CC^t / CC^t\text{-}1)$$
$$\mathbf{SM} = [({}_i\text{BRT station area}^{t-1} \bullet {}_iCC_t / {}_iCC^{t-1}) - CC]$$
$$\mathbf{Busway} = [{}_i\text{BRT station area}^{t-1} \bullet ({}_i\text{BRT station area}^t / {}_i\text{BRT station area}^{t-1} - {}_iCC^t / {}_iCC^{t-1})]$$

(3.2)

Where:

iBRT station area^{t-1} = number of jobs in the BRT station area sector (i) at the beginning of the analysis period (t-1)

iBRT station area^{t} = number of jobs in the BRT station area in sector (i) at the end of the analysis period (t)

CC^{t-1} = total number of jobs in the central county at the beginning of the analysis period (t-1) CC^{t} = total number of jobs in the central county at the end of the analysis period (t)

iCC^{t-1} = number of jobs in the central county in sector (i) at the beginning of the analysis period (t-1)

iCC^t = number of jobs in the central county in sector (i) at the end of the analysis period (t)

We apply shift-share analysis to each of the 12 BRT profiles for the period before the Great Recession, 2002-2007 – or in the case of Phoenix from 2004-20-07 because of data reporting limitations – and during recovery from the Great Recession in 2008 to 2011, the latest year for which data were available for our analysis. Because there are usually more counter-factual block groups than BRT station area block groups, shift-share results between the CC and counter-factual block groups will be skewed relative to BRT results. We normalized this by taking the means of block groups for all three geographic units. Results for the pre-recession period are reported in the top half of the respective tables.

However, shift-share analysis by itself does not necessarily ascribe a causal relationship, merely an associative one. In addition, to control for the counter-factual – that is, that development (or lack thereof) would have occurred anyway – we devised an algorithm in ArcGIS to identify 10 alternative locations having comparable attributes to each existing station at the beginning of our study period – 2002 for all systems except Phoenix which is 2004. We adjust the notation above by substituting "CF," our counter-factual block groups, for "BRT." Results are reported in the bottom half of respective tables. We caution that though this improves causal inference, we are conservative in concluding only associative ones.

We do not evaluate BRT systems put into service after 2009. The reason is that the market needs at least three years to respond to the BRT investment. After reporting results for all 12 profiles we offer a qualitative assessment of whether the class of BRT system appears to make a difference, at least in terms of economic development outcomes.

3.2.1 Profiles

We now profile present results for the 12 BRT systems, grouped by the metropolitan areas they serve. We report several numbers. They include jobs by category for the beginning and end period for each geography, and then percent change in jobs followed by shift-share results. Our discussion focuses on the key shift-share result being total shift of jobs to or away from BRT stations or counter-factual locations, which are highlighted in bold. Space does not allow us to explore sector-specific insights, so these we leave to the reader to explore.

3.2.1.1 Pittsburgh

We report results for these three BRT lines in Tables 3.1, 3.2 and 3.3, respectively.

Results for the South Line BRT system (Table 3.1) indicate it has no positive effect on economic development during either the pre-recession and recovery periods. Indeed, jobs seem to have shifted away from the South Line station areas. While both the BRT line and the counter-factual locations lost share of jobs during both periods, the BRT line lost greater share. We surmise that, like many BRT systems, the South Line was designed principally to transport people efficiently from residential areas to downtown or other existing activity centers.

In contrast, the East Line BRT system (Table 3.2) went from having a modest but favorable shift in jobs during the pre-recession period, being somewhat higher than counter-factual locations, to gaining substantial share during recovery while counter-factual locations lost share. Unlike the South Line, the East Line connects several established smaller and moderately sized activity centers with neighborhoods as well as downtown. Information available to us does not indicate a conscientious effort to have jobs attracted to the BRT line, but that appears to have been the case. We also observe that the East Line is rated Bronze, making it one of the most highly rated BRT systems in the U.S.

The West Line BRT system (Table 3.3) saw the most dramatic change of all systems. It lost share of jobs relative to the CC at a much larger rate than counter-factual locations, which also lost share. But during recovery, while the counter-factual locations continued to lose share, the West BRT system gained the most of all Pittsburgh lines in our study. In addition to serving downtown, it also appears to serve the largest number of employment centers.

3.2.1.2 Las Vegas

Table 8.4 reports shift-share results for the Las Vegas MAX line that connects downtown with Nellis Air Force Base.

Before the recession, both the BRT station areas and the counter-factual locations lost share of jobs relative to Clark County, the CC, with the BRT block groups losing the greatest share. During recovery, however, the counter-factual locations gained share while the BRT areas lost only a small share.

Figure 3.1 Las Vegas's BRT MAX Operated by Regional Transportation Commission of Southern Nevada

Table 3.1 Pittsburgh South Line (1977—Basic) Shift-Share Results

PRE-RECESSION 2002-2007

BRT Block Groups

Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	56.7	37.2	47.5	38.5	-34%	28%	54.9	-9.0	-8.7
Industrial	54.2	55.2	57.3	52.9	2%	4%	52.5	-2.5	5.2
Retail-Lodging-Food	73.8	68.3	121.7	120.7	-8%	78%	71.5	1.7	-4.9
Knowledge	205.1	151.2	65.4	64.5	-26%	-57%	198.6	3.7	-51.2
Office	311.4	278.5	141.4	142.6	-11%	-49%	301.6	12.4	-35.5
Education	46.2	93.4	53.2	59.1	102%	-43%	44.8	6.6	42.0
Health Care	74.7	89.0	84.5	112.0	19%	-5%	72.4	26.6	-9.9
Arts-Entertain-Recreation	4.0	4.0	9.8	9.6	1%	142%	3.9	0.1	0.1
Total	826.2	776.8	580.9	599.8	-6%	-25%	800.2	39.5	**-62.9**

Counter-Factual Block Groups

Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	22.8	15.0	47.5	38.5	-34%	216%	22.1	-3.6	-3.4
Industrial	17.1	15.4	57.3	52.9	-10%	273%	16.5	-0.8	-0.4
Retail-Lodging-Food	93.9	72.7	121.7	120.7	-23%	68%	90.9	2.1	-20.4
Knowledge	25.6	21.8	65.4	64.5	-15%	199%	24.8	0.5	-3.5
Office	43.6	48.8	141.4	142.6	12%	190%	42.2	1.7	4.9
Education	24.2	42.1	53.2	59.1	74%	26%	23.5	3.5	15.2
Health Care	23.7	24.1	84.5	112.0	2%	251%	22.9	8.4	-7.2
Arts-Entertain-Recreation	1.7	2.0	9.8	9.6	21%	377%	1.6	0.0	0.4
Total	252.5	242.0	580.9	599.8	-4%	140%	244.6	11.8	**-14.4**

RECOVERY 2008-2011

Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	40.5	29.8	37.8	34.3	-26.4%	-9.4%	39.1	-2.4	-6.9
Industrial	42.1	26.5	49.4	49.3	-37.1%	-0.3%	40.6	1.4	-15.5
Retail-Lodging-Food	73.1	83.7	116.9	116.7	14.5%	-0.1%	70.5	2.5	10.7
Knowledge	153.4	148.5	65.2	64.8	-3.2%	-0.6%	148.0	4.5	-4.0
Office	284.0	270.6	141.4	154.6	-4.7%	9.3%	274.0	36.5	-39.9
Education	101.3	77.4	59.7	63.6	-23.5%	6.6%	97.7	10.3	-30.5
Health Care	90.0	75.5	109.8	116.6	-16.1%	6.2%	86.9	8.7	-20.1
Arts-Entertain-Recreation	6.0	4.5	10.0	11.8	-24.5%	17.5%	5.8	1.3	-2.5
Total	790.4	716.5	590.2	611.7	-9.3%	3.6%	762.7	62.7	**-108.8**

Counter-Factual Block Groups

Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	15.3	14.1	37.8	34.3	-7.3%	-9.4%	14.7	-0.9	0.3
Industrial	16.2	17.3	49.4	49.3	6.7%	-0.3%	15.6	0.5	1.1
Retail-Lodging-Food	74.4	65.2	116.9	116.7	-12.4%	-0.1%	71.8	2.5	-9.1
Knowledge	24.1	23.7	65.2	64.8	-1.7%	-0.6%	23.3	0.7	-0.3
Office	49.4	57.9	141.4	154.6	17.3%	9.3%	47.7	6.3	3.9
Education	43.1	43.5	59.7	63.6	1.0%	6.6%	41.6	4.4	-2.4
Health Care	26.2	26.4	109.8	116.6	0.7%	6.2%	25.3	2.5	-1.5
Arts-Entertain-Recreation	2.3	0.6	10.0	11.8	-72.6%	17.5%	2.3	0.5	-2.1
Total	251.0	248.8	590.2	611.7	-0.9%	3.6%	242.2	16.6	**-10.0**

Table 3.2 Pittsburgh East Line (1983—Bronze) Shift-Share Results

PRE-RECESSION 2002-2007									
BRT Block Groups									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	31.7	24.7	95.1	77.0	-22.0%	-19.0%	30.7	-5.0	-0.9
Industrial	42.3	36.0	114.6	105.8	-14.8%	-7.7%	41.0	-1.9	-3.0
Retail-Lodging-Food	93.5	91.1	243.5	241.3	-2.6%	-0.9%	90.6	2.1	-1.6
Knowledge	39.7	39.8	130.7	129.0	0.3%	-1.3%	38.5	0.7	0.7
Office	81.0	67.8	282.8	285.1	-16.3%	0.8%	78.4	3.2	13.8
Education	32.9	34.1	106.3	118.2	3.6%	11.1%	31.9	4.7	-2.5
Health Care	76.0	143.2	169.1	223.9	88.4%	32.4%	73.6	27.0	42.5
Arts-Entertain-Recreation	12.1	10.3	19.5	19.3	-15.1%	-1.3%	11.7	0.2	-1.7
Total	409.2	447.0	1161.7	1199.6	9.2%	3.3%	396.3	31.1	**19.6**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	37.7	32.3	95.1	77.0	-14.4%	-19.0%	36.5	-6.0	1.7
Industrial	28.5	21.0	114.6	105.8	-26.3%	-7.7%	27.6	-1.3	-5.3
Retail-Lodging-Food	81.1	74.5	243.5	241.3	-8.0%	-0.9%	78.5	1.8	-5.8
Knowledge	30.4	22.4	130.7	129.0	-26.2%	-1.3%	29.4	0.6	-7.6
Office	82.9	75.8	282.8	285.1	-8.6%	0.8%	80.2	3.3	-7.8
Education	28.6	27.8	106.3	118.2	-2.7%	11.1%	27.7	4.1	-3.9
Health Care	101.0	172.3	169.1	223.9	70.7%	32.4%	97.8	35.9	38.6
Arts-Entertain-Recreation	3.3	5.3	19.5	19.3	61.8%	-1.3%	3.2	0.1	2.1
Total	393.3	431.4	1161.7	1199.6	9.7%	3.3%	380.9	38.4	**12.1**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	24.0	19.6	75.7	68.5	-18.4%	-9.4%	23.2	-1.4	-2.2
Industrial	32.8	34.6	98.9	98.6	5.7%	-0.3%	31.6	1.1	2.0
Retail-Lodging-Food	82.0	96.8	233.8	233.5	18.0%	-0.1%	79.1	2.8	14.9
Knowledge	44.1	46.4	130.3	129.6	5.1%	-0.6%	42.5	1.3	2.5
Office	68.5	65.0	282.7	309.1	-5.1%	9.3%	66.1	8.8	-9.9
Education	31.1	22.6	119.4	127.3	-27.3%	6.6%	30.0	3.2	-10.6
Health Care	132.0	172.9	219.6	233.2	31.0%	6.2%	127.3	12.8	32.7
Arts-Entertain-Recreation	11.3	11.0	20.1	23.6	-2.7%	17.5%	10.9	2.4	-2.3
Total	425.7	468.8	1180.5	1223.4	10.1%	3.6%	410.8	30.8	**27.2**
Counter-Factual Block Groups									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	34.3	29.5	75.7	68.5	-14.1%	-9.4%	33.1	-2.0	-1.6
Industrial	23.6	21.2	98.9	98.6	-10.1%	-0.3%	22.8	0.8	-2.3
Retail-Lodging-Food	86.1	85.6	233.8	233.5	-0.5%	-0.1%	83.1	2.9	-0.4
Knowledge	27.6	27.4	130.3	129.6	-0.7%	-0.6%	26.6	0.8	-0.0
Office	85.0	97.9	282.7	309.1	15.2%	9.3%	82.0	10.9	5.0
Education	32.1	35.4	119.4	127.3	10.2%	6.6%	31.0	3.3	1.1
Health Care	209.4	219.5	219.6	233.2	4.8%	6.2%	202.1	20.3	-2.9
Arts-Entertain-Recreation	6.1	5.6	20.1	23.6	-8.5%	17.5%	5.9	1.3	-1.6
Total	504.3	522.2	1180.5	1223.4	3.5%	3.6%	486.6	38.2	**-2.7**

Table 3.3 Pittsburgh West Line (2000—Basic) Shift-Share Results

BRT Block Groups									
PRE-RECESSION 2002-2007									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	43.5	36.8	47.5	38.5	-15.4%	-19.0%	42.1	-6.9	1.6
Industrial	66.5	41.6	57.3	52.9	-37.4%	-7.7%	64.4	-3.0	-19.7
Retail-Lodging-Food	134.9	146.4	121.7	120.7	8.5%	-0.9%	130.7	3.1	12.6
Knowledge	232.8	211.3	65.4	64.5	-9.2%	-1.3%	225.4	4.2	-18.4
Office	739.8	694.5	141.4	142.6	-6.1%	0.8%	716.4	29.4	-51.3
Education	45.1	53.8	53.2	59.1	19.4%	11.1%	43.7	6.4	3.7
Health Care	72.6	45.6	84.5	112.0	-37.2%	32.4%	70.3	25.8	-50.6
Arts-Entertain-Recreation	37.2	25.5	9.8	9.6	-31.5%	-1.3%	36.0	0.7	-11.3
Total	1372.4	1255.4	580.9	599.8	-8.5%	3.3%	1329.1	59.7	**-133.3**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	59.7	42.8	47.5	38.5	-28.3%	-19.0%	57.8	-9.5	-5.5
Industrial	51.3	52.0	57.3	52.9	1.4%	-7.7%	49.7	-2.4	4.7
Retail-Lodging-Food	97.2	91.7	121.7	120.7	-5.7%	-0.9%	94.1	2.2	-4.6
Knowledge	52.3	60.5	65.4	64.5	15.8%	-1.3%	50.6	1.0	9.0
Office	160.5	129.7	141.4	142.6	-19.2%	0.8%	155.5	6.4	-32.1
Education	46.5	39.0	53.2	59.1	-16.1%	11.1%	45.0	6.6	-12.7
Health Care	106.9	156.6	84.5	112.0	46.5%	32.4%	103.6	38.0	15.1
Arts-Entertain-Recreation	9.0	11.5	9.8	9.6	28.0%	-1.3%	8.7	0.2	2.6
Total	583.4	583.9	580.9	599.8	0.1%	3.3%	565.0	42.5	**-23.6**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	35.9	26.2	37.8	34.3	-26.9%	-9.4%	34.6	-2.1	-6.3
Industrial	37.7	43.4	49.4	49.3	15.2%	-0.3%	36.4	1.2	5.8
Retail-Lodging-Food	152.6	166.0	116.9	116.7	8.8%	-0.1%	147.2	5.2	13.6
Knowledge	220.8	198.6	65.2	64.8	-10.0%	-0.6%	213.1	6.5	-20.9
Office	671.5	786.0	141.4	154.6	17.0%	9.3%	647.9	86.3	51.8
Education	61.3	85.1	59.7	63.6	38.9%	6.6%	59.1	6.2	19.8
Health Care	42.5	50.3	109.8	116.6	18.3%	6.2%	41.0	4.1	5.1
Arts-Entertain-Recreation	29.5	52.1	10.0	11.8	76.4%	17.5%	28.5	6.2	17.4
Total	1251.8	1407.8	590.2	611.7	12.5%	3.6%	1207.8	113.5	**86.4**
Counter-Factual Block Groups									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	40.6	35.0	37.8	34.3	-13.8%	-9.4%	39.2	-2.4	-1.7
Industrial	54.2	50.4	49.4	49.3	-7.0%	-0.3%	52.3	1.8	-3.7
Retail-Lodging-Food	88.2	89.6	116.9	116.7	1.6%	-0.1%	85.1	3.0	1.5
Knowledge	59.7	65.5	65.2	64.8	9.8%	-0.6%	57.6	1.7	6.2
Office	145.5	173.8	141.4	154.6	19.5%	9.3%	140.4	18.7	14.7
Education	39.3	43.8	59.7	63.6	11.4%	6.6%	37.9	4.0	1.9
Health Care	125.8	115.4	109.8	116.6	-8.3%	6.2%	121.4	12.2	-18.3
Arts-Entertain-Recreation	12.4	10.6	10.0	11.8	-14.4%	17.5%	11.9	2.6	-3.9
Total	565.7	584.1	590.2	611.7	3.3%	3.6%	545.9	41.6	**-3.3**

Table 3.4 Las Vegas MAX Line (2004—Bronze) Shift-Share Results

BRT Block Groups

PRE-RECESSION 2008-2011

Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	9.3	18.0	16.1	21.1	94.0%	31.0%	7.4	4.8	5.8
Industrial	23.2	18.2	37.6	47.9	-21.6%	27.6%	18.5	11.2	-11.4
Retail-Lodging-Food	355.8	342.0	223.4	271.7	-3.9%	21.6%	283.0	149.7	-90.8
Knowledge	56.2	59.2	32.6	41.6	5.2%	27.7%	44.7	27.0	-12.6
Office	178.9	234.8	108.1	138.9	31.3%	28.5%	142.3	87.6	4.9
Education	53.4	1.2	31.4	43.2	-97.8%	37.9%	42.5	31.2	-72.4
Health Care	44.7	36.8	37.6	48.8	-17.5%	29.9%	35.5	22.5	-21.2
Arts-Entertain-Recreation	30.6	29.1	13.2	15.1	-4.7%	14.3%	24.3	10.6	-5.8
Total	752.1	739.3	499.9	628.4	-1.7%	25.7%	598.3	344.6	**-203.5**

Counter-Factual Block Groups

Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	16.3	14.0	16.1	21.1	-14.1%	31.0%	13.0	8.4	-7.4
Industrial	55.0	69.9	37.6	47.9	27.1%	27.6%	43.8	26.4	-0.3
Retail-Lodging-Food	666.4	777.5	223.4	271.7	16.7%	21.6%	530.1	280.3	-32.9
Knowledge	42.2	43.7	32.6	41.6	3.4%	27.7%	33.6	20.3	-10.2
Office	238.6	245.9	108.1	138.9	3.1%	28.5%	189.8	116.9	-60.8
Education	29.6	36.0	31.4	43.2	21.5%	37.9%	23.6	17.3	-4.9
Health Care	91.8	97.6	37.6	48.8	6.3%	29.9%	73.0	46.3	-21.7
Arts-Entertain-Recreation	22.7	23.2	13.2	15.1	2.0%	14.3%	18.1	7.9	-2.8
Total	1162.6	1307.8	499.9	628.4	12.5%	25.7%	924.8	523.8	**-140.8**

RECOVERY 2008-2011

Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	16.8	11.7	20.3	15.3	-30.7%	-24.3%	17.4	-4.6	-1.1
Industrial	20.5	19.3	47.7	44.1	-5.9%	-7.5%	21.2	-2.2	0.3
Retail-Lodging-Food	334.3	263.2	265.9	263.8	-21.3%	-0.8%	345.4	-13.8	-68.5
Knowledge	59.6	52.8	40.9	35.7	-11.5%	-12.6%	61.6	-9.5	0.6
Office	242.2	276.8	138.8	130.2	14.3%	-6.2%	250.3	-23.0	49.5
Education	2.0	2.3	43.9	44.3	13.3%	1.0%	2.1	-0.0	0.2
Health Care	36.6	34.4	51.2	56.4	-6.0%	10.2%	37.9	2.5	-5.9
Arts-Entertain-Recreation	24.5	33.9	14.7	13.3	38.2%	-9.3%	25.3	-3.1	11.7
Total	736.7	694.3	623.2	603.1	-5.8%	-3.2%	761.2	-53.8	**-13.1**

Counter-Factual Block Groups

Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	11.6	9.5	20.3	15.3	-17.6%	-24.3%	11.9	-3.2	0.8
Industrial	70.8	65.4	47.7	44.1	-7.6%	-7.5%	73.1	-7.7	-0.0
Retail-Lodging-Food	743.6	805.1	265.9	263.8	8.3%	-0.8%	768.3	-30.6	67.4
Knowledge	39.4	40.3	40.9	35.7	2.2%	-12.6%	40.7	-6.3	5.8
Office	259.9	210.0	138.8	130.2	-19.2%	-6.2%	268.5	-24.7	-33.8
Education	36.6	222.5	43.9	44.3	507.3%	1.0%	37.9	-0.9	185.5
Health Care	98.4	105.8	51.2	56.4	7.5%	10.2%	101.7	6.8	-2.6
Arts-Entertain-Recreation	21.9	20.3	14.7	13.3	-7.2%	-9.3%	22.6	-2.8	0.5
Total	1282.2	1479.0	623.2	603.1	15.4%	-3.2%	1324.8	-69.3	**223.5**

3.2.1.3 Los Angeles

Results for the newer BRT system, the Silver Line, are reported in Table 3.6. Before the recession, this BRT corridor lost a large share of jobs relative to the CC while the counter-factual locations gained. During the recovery, which is when the Silver Line BRT system began operating, it gained the largest share of jobs per block group of all BRT systems we evaluated. At 26 miles, it is also the longest we evaluated. The Silver Line connects downtown to major employment centers southward. It provides intermodal transit connections in downtown and Harbor Gateway in South Los Angeles. Substantial redevelopment of older buildings and less intensely developed parcels occurred along this system since the late 2000s.

3.2.1.4 Kansas City

Kansas City began operating its Main Street Line in 2005, connecting downtown to the Crown Center Plaza along a six-mile route. It has proven to be moderately successful in attracting economic development within a slow-growing metropolitan area. As seen in Table 3.7, before the recession, the BRT station areas lost share of jobs relative to Jackson County, while the counter-factual locations gained share. The relationship reversed during the recovery, as the BRT station areas gained share of jobs relative to the county as the counter-factual locations lost share. To be sure, all geographic areas lost jobs between 2008 and 2011, but the BRT station areas lost fewer jobs as a percent while gaining overall share of jobs compared to the county.

3.2.1.5 Eugene-Springfield

The Emerald Express BRT system connects downtown Springfield to downtown Eugene with stops at the University of Oregon. Prior work using data from InfoGroup USA showed a positive association between the BRT system and economic development (Nelson et al., 2013). Using different time frames and LEHD data, we find similar results (Table 3.8). Before the recession, the BRT station areas gained a small share of jobs compared to the county while the counter-factual locations lost a small share. But during the recovery, the BRT station areas gained a larger share as the counter-factual areas lost more share. While economic development outcomes in Eugene-Springfield are comparable to other metropolitan areas, planning that encourages development at or near BRT stations may be a key reason.

Table 3.5 Los Angeles Orange Line (2005—Bronze) Shift-Share Results

BRT Block Groups									
PRE-RECESSION 2002-2007									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	52.3	76.9	81.4	69.6	46.9%	-14.5%	49.4	-4.6	32.1
Industrial	48.8	42.4	64.1	66.4	-13.1%	3.5%	46.0	4.4	-8.1
Retail-Lodging-Food	182.6	202.1	109.7	121.1	10.6%	10.4%	172.4	29.3	0.4
Knowledge	91.9	86.8	75.5	81.2	-5.6%	7.5%	86.7	12.0	-12.0
Office	280.1	310.4	134.8	147.9	10.8%	9.7%	264.3	42.8	3.3
Education	34.4	31.3	46.0	52.1	-9.0%	13.2%	32.4	6.5	-7.6
Health Care	47.5	109.1	55.4	62.3	129.7%	12.4%	44.8	8.6	55.7
Arts-Entertain-Recreation	11.5	11.9	12.0	13.0	3.4%	8.4%	10.8	1.6	-0.6
Total	749.0	870.8	579.0	613.5	16.3%	6.0%	706.9	100.6	**63.3**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	73.4	81.7	81.4	69.6	11.3%	-14.5%	69.3	-6.5	18.9
Industrial	64.3	66.3	64.1	66.4	3.2%	3.5%	60.7	5.9	-0.2
Retail-Lodging-Food	221.9	264.0	109.7	121.1	19.0%	10.4%	209.4	35.6	19.0
Knowledge	295.7	260.9	75.5	81.2	-11.8%	7.5%	279.1	38.8	-56.9
Office	254.4	262.4	134.8	147.9	3.1%	9.7%	240.1	38.9	-16.6
Education	146.9	185.1	46.0	52.1	26.0%	13.2%	138.6	27.6	18.8
Health Care	83.1	110.5	55.4	62.3	32.9%	12.4%	78.5	15.0	17.0
Arts-Entertain-Recreation	19.2	26.5	12.0	13.0	38.3%	8.4%	18.1	2.7	5.7
Total	1158.9	1257.4	579.0	613.5	8.5%	6.0%	1093.7	157.9	**5.8**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	73.7	61.3	68.0	59.0	-16.9%	-13.3%	72.5	-8.6	-2.6
Industrial	39.5	39.5	66.8	64.8	0.0%	-3.0%	38.8	-0.5	1.2
Retail-Lodging-Food	199.4	180.5	121.4	116.9	-9.5%	-3.7%	196.2	-4.2	-11.5
Knowledge	90.4	88.2	87.1	88.3	-2.4%	1.4%	88.9	2.7	-3.5
Office	276.2	266.3	148.1	157.6	-3.6%	6.4%	271.7	22.2	-27.6
Education	41.6	96.2	50.8	57.9	131.0%	13.9%	41.0	6.5	48.7
Health Care	111.8	63.8	66.2	74.4	-42.9%	12.4%	110.0	15.7	-61.9
Arts-Entertain-Recreation	9.0	10.5	13.1	12.8	17.0%	-2.2%	8.8	-0.1	1.7
Total	841.5	806.2	621.6	631.8	-4.2%	1.6%	827.9	33.6	**-55.4**
Counter-Factual Block Groups									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	83.2	78.6	68.0	59.0	-5.5%	-13.3%	81.9	-9.7	6.5
Industrial	65.5	60.7	66.8	64.8	-7.4%	-3.0%	64.5	-0.9	-2.9
Retail-Lodging-Food	265.5	253.4	121.4	116.9	-4.6%	-3.7%	261.2	-5.6	-2.2
Knowledge	288.8	273.6	87.1	88.3	-5.2%	1.4%	284.1	8.6	-19.1
Office	264.0	259.5	148.1	157.6	-1.7%	6.4%	259.8	21.2	-21.5
Education	196.5	211.7	50.8	57.9	7.8%	13.9%	193.3	30.5	-12.1
Health Care	113.8	111.9	66.2	74.4	-1.7%	12.4%	112.0	16.0	-16.0
Arts-Entertain-Recreation	23.9	23.5	13.1	12.8	-1.7%	-2.2%	23.5	-0.1	0.1
Total	1301.1	1272.9	621.6	631.8	-2.2%	1.6%	1280.2	60.0	**-67.2**

Table3.6 Los Angeles Silver Line (2009—Unrated) Shift-Share

BRT Block Groups									
PRE-RECESSION 2002-2007									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	231.8	142.9	81.4	69.6	-38.4%	-14.5%	218.8	-20.6	-55.3
Industrial	398.8	402.6	64.1	66.4	0.9%	3.5%	376.4	36.3	-10.1
Retail-Lodging-Food	310.5	355.5	109.7	121.1	14.5%	10.4%	293.1	49.8	12.6
Knowledge	426.8	434.2	75.5	81.2	1.7%	7.5%	402.8	55.9	-24.5
Office	1198.4	1188.1	134.8	147.9	-0.9%	9.7%	1131.0	183.3	-126.2
Education	203.3	263.6	46.0	52.1	29.7%	13.2%	191.9	38.2	33.5
Health Care	178.9	238.7	55.4	62.3	33.4%	12.4%	168.8	32.3	37.6
Arts-Entertain-Recreation	153.7	161.3	12.0	13.0	4.9%	8.4%	145.1	21.6	-5.4
Total	3102.2	3186.7	579.0	613.5	2.7%	6.0%	2927.7	396.9	**-137.8**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	96.6	86.3	81.4	69.6	-10.7%	-14.5%	91.2	-8.6	3.7
Industrial	80.0	91.2	64.1	66.4	14.0%	3.5%	75.5	7.3	8.4
Retail-Lodging-Food	119.1	137.5	109.7	121.1	15.4%	10.4%	112.4	19.1	5.9
Knowledge	70.1	74.0	75.5	81.2	5.5%	7.5%	66.2	9.2	-1.4
Office	144.8	163.2	134.8	147.9	12.7%	9.7%	136.6	22.1	4.4
Education	93.3	115.8	46.0	52.1	24.1%	13.2%	88.1	17.5	10.2
Health Care	73.8	80.0	55.4	62.3	8.5%	12.4%	69.7	13.3	-2.9
Arts-Entertain-Recreation	8.7	10.5	12.0	13.0	20.5%	8.4%	8.2	1.2	1.1
Total	686.5	758.6	579.0	613.5	10.5%	6.0%	647.9	81.2	**29.4**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	131.9	94.1	68.0	59.0	-28.6%	-13.3%	129.8	-15.4	-20.3
Industrial	265.1	442.8	66.8	64.8	67.0%	-3.0%	260.8	-3.7	185.6
Retail-Lodging-Food	330.1	383.7	121.4	116.9	16.2%	-3.7%	324.8	-7.0	65.8
Knowledge	459.6	462.0	87.1	88.3	0.5%	1.4%	452.2	13.8	(4.0)
Office	1,317.2	2,034.4	148.1	157.6	54.5%	6.4%	1,296.0	105.8	632.6
Education	292.5	539.2	50.8	57.9	84.3%	13.9%	287.8	45.4	206.0
Health Care	256.8	258.3	66.2	74.4	0.6%	12.4%	252.6	36.1	-30.4
Arts-Entertain-Recreation	169.1	165.5	13.1	12.8	-2.2%	-2.2%	166.4	-1.0	0.1
Total	3,222.3	4,380.0	621.6	631.8	35.9%	1.6%	3,170.4	174.0	**1,035.5**
Counter-Factual Block Groups									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	89.6	76.5	68.0	59.0	-14.6%	-13.3%	88.2	-10.5	-1.2
Industrial	91.0	85.9	66.8	64.8	-5.5%	-3.0%	89.5	-1.3	-2.3
Retail-Lodging-Food	141.7	129.6	121.4	116.9	-8.5%	-3.7%	139.4	-3.0	-6.8
Knowledge	74.2	84.6	87.1	88.3	14.1%	1.4%	73.0	2.2	9.4
Office	163.9	169.0	148.1	157.6	3.1%	6.4%	161.2	13.2	-5.4
Education	83.6	61.1	50.8	57.9	-26.9%	13.9%	82.3	13.0	-34.2
Health Care	85.8	105.2	66.2	74.4	22.7%	12.4%	84.4	12.1	8.8
Arts-Entertain-Recreation	10.7	9.4	13.1	12.8	-12.8%	-2.2%	10.6	-0.1	-1.1
Total	740.4	721.3	621.6	631.8	-2.6%	1.6%	728.5	25.6	**-32.9**

Table 3.7 Kansas City Main Street Line (2005—Unrated) Shift-Share

BRT Block Groups

PRE-RECESSION 2002-2007

Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	24.1	21.9	57.0	48.7	-9.1%	-14.6%	24.2	-3.6	1.3
Industrial	34.3	32.7	50.6	55.4	-4.7%	9.4%	34.4	3.1	-4.8
Retail-Lodging-Food	95.2	90.1	120.8	119.2	-5.4%	-1.3%	95.6	-1.6	-3.9
Knowledge	86.7	89.9	64.6	64.6	3.7%	-0.1%	87.0	-0.4	3.3
Office	124.7	123.6	133.1	132.7	-0.9%	-0.3%	125.2	-0.9	-0.7
Education	40.2	38.8	48.1	46.5	-3.6%	-3.3%	40.4	-1.5	-0.1
Health Care	60.7	57.7	68.9	71.9	-5.0%	4.3%	60.9	2.4	-5.6
Arts-Entertain-Recreation	10.6	13.3	12.4	14.4	26.1%	16.2%	10.6	1.7	1.0
Total	476.4	467.9	555.5	553.3	-1.8%	-0.4%	478.3	-0.9	-9.6

Counter-Factual Block Groups

Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	31.2	23.1	57.0	48.7	-26.1%	-14.6%	31.3	-4.7	-3.6
Industrial	34.1	38.8	50.6	55.4	13.9%	9.4%	34.2	3.1	1.5
Retail-Lodging-Food	92.4	90.4	120.8	119.2	-2.2%	-1.3%	92.8	-1.6	-0.8
Knowledge	79.9	82.9	64.6	64.6	3.7%	-0.1%	80.2	-0.4	3.0
Office	120.0	120.7	133.1	132.7	0.6%	-0.3%	120.5	-0.8	1.1
Education	35.6	37.8	48.1	46.5	6.2%	-3.3%	35.7	-1.3	3.4
Health Care	56.1	59.3	68.9	71.9	5.7%	4.3%	56.3	2.2	0.8
Arts-Entertain-Recreation	10.9	14.1	12.4	14.4	29.4%	16.2%	10.9	1.7	1.4
Total	460.1	467.0	555.5	553.3	1.5%	-0.4%	462.0	-1.8	6.8

RECOVERY 2008-2011

Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	21.1	20.4	48.8	41.1	-3.0%	-15.7%	21.9	-4.2	2.7
Industrial	31.4	32.4	56.5	51.9	2.9%	-8.1%	32.7	-3.8	3.5
Retail-Lodging-Food	91.6	88.4	120.3	112.9	-3.5%	-6.1%	95.3	-9.3	2.4
Knowledge	85.7	76.0	62.1	52.3	-11.3%	-15.8%	89.1	-17.0	3.9
Office	130.1	129.6	134.7	139.2	-0.4%	3.3%	135.3	-0.9	(4.8)
Education	41.6	41.6	47.5	44.3	0.0%	-6.6%	43.2	-4.4	2.8
Health Care	60.8	66.0	76.5	85.8	8.5%	12.2%	63.3	5.0	(2.3)
Arts-Entertain-Recreation	13.6	12.3	13.3	10.3	-9.2%	-22.6%	14.1	-3.6	1.8
Total	475.8	466.6	559.6	537.9	-1.9%	-3.9%	495.0	-38.3	9.9

Counter-Factual Block Groups

Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	24.5	17.5	48.8	41.1	-28.6%	-15.7%	25.5	-4.8	-3.2
Industrial	36.7	24.2	56.5	51.9	-34.1%	-8.1%	38.2	-4.4	-9.6
Retail-Lodging-Food	92.8	78.3	120.3	112.9	-15.6%	-6.1%	96.6	-9.4	-8.8
Knowledge	73.6	63.1	62.1	52.3	-14.3%	-15.8%	76.6	-14.6	1.1
Office	114.7	108.9	134.7	139.2	-5.0%	3.3%	119.3	-0.8	-9.5
Education	39.6	37.1	47.5	44.3	-6.4%	-6.6%	41.2	-4.2	0.1
Health Care	62.9	52.7	76.5	85.8	-16.3%	12.2%	65.5	5.1	-17.9
Arts-Entertain-Recreation	13.7	10.8	13.3	10.3	-21.0%	-22.6%	14.2	-3.6	0.2
Total	458.5	392.5	559.6	537.9	-14.4%	-3.9%	477.0	-36.9	-47.6

Table 3.8 Eugene-Springfield Emerald Express (2007—Bronze) Shift-Share

BRT Block Groups

PRE-RECESSION 2002-2007

Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	86.9	76.1	73.8	75.4	-12.4%	2.2%	79.2	9.7	-12.8
Industrial	120.3	124.4	36.5	43.0	3.4%	17.8%	109.7	32.1	-17.3
Retail-Lodging-Food	387.8	414.3	111.0	120.6	6.8%	8.7%	353.4	68.0	-7.1
Knowledge	246.9	239.6	37.1	37.2	-3.0%	0.2%	225.0	22.5	-7.9
Office	434.3	534.5	101.5	112.6	23.1%	10.9%	395.8	86.1	52.7
Education	64.7	73.7	56.5	63.0	13.9%	11.6%	58.9	13.2	1.5
Health Care	398.7	448.5	70.0	78.9	12.5%	12.7%	363.3	86.1	-0.9
Arts-Entertain-Recreation	23.2	31.1	7.7	11.4	34.2%	48.1%	21.1	13.2	-3.2
Total	1762.7	1942.2	494.1	542.2	10.2%	9.7%	1606.4	330.8	**5.0**

Counter-Factual Block Groups

Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	253.0	263.7	73.8	75.4	4.2%	2.2%	230.6	28.1	5.1
Industrial	94.7	118.4	36.5	43.0	25.0%	17.8%	86.3	25.2	6.8
Retail-Lodging-Food	276.9	303.7	111.0	120.6	9.7%	8.7%	252.3	48.5	2.9
Knowledge	47.1	50.4	37.1	37.2	6.9%	0.2%	43.0	4.3	3.2
Office	222.5	226.9	101.5	112.6	2.0%	10.9%	202.7	44.1	-19.9
Education	193.4	214.8	56.5	63.0	11.0%	11.6%	176.3	39.5	-1.1
Health Care	114.8	129.3	70.0	78.9	12.6%	12.7%	104.6	24.8	-0.1
Arts-Entertain-Recreation	19.4	30.3	7.7	11.4	56.1%	48.1%	17.7	11.1	1.6
Total	1221.9	1337.5	494.1	542.2	9.5%	9.7%	1113.5	225.6	**-1.6**

RECOVERY 2008-2011

Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	74.3	63.7	71.4	48.6	-14.2%	-32.0%	79.1	-28.6	13.2
Industrial	100.0	114.3	42.7	36.6	14.3%	-14.4%	106.5	-20.9	28.7
Retail-Lodging-Food	429.8	406.3	122.4	116.5	-5.5%	-4.8%	457.5	-48.5	-2.8
Knowledge	241.1	220.4	38.0	35.2	-8.6%	-7.5%	256.6	-33.5	-2.7
Office	522.9	501.7	109.1	102.6	-4.1%	-5.9%	556.6	-64.7	9.8
Education	75.3	77.0	64.2	68.0	2.2%	5.8%	80.2	-0.5	-2.7
Health Care	461.0	504.6	81.2	90.5	9.5%	11.5%	490.7	23.4	-9.5
Arts-Entertain-Recreation	29.6	26.2	10.7	9.2	-11.4%	-13.9%	31.5	-6.0	0.7
Total	1,934.0	1,914.2	539.8	507.1	-1.0%	-6.1%	2,058.6	-179.2	**34.8**

Counter-Factual Block Groups

Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	248.9	164.0	71.4	48.6	-34.1%	-32.0%	264.9	-95.7	-5.2
Industrial	117.4	97.2	42.7	36.6	-17.2%	-14.4%	125.0	-24.5	-3.3
Retail-Lodging-Food	304.4	290.6	122.4	116.5	-4.5%	-4.8%	324.0	-34.3	0.9
Knowledge	52.7	49.9	38.0	35.2	-5.3%	-7.5%	56.1	-7.3	1.1
Office	218.0	201.2	109.1	102.6	-7.7%	-5.9%	232.0	-27.0	-3.9
Education	218.9	232.7	64.2	68.0	6.3%	5.8%	233.0	-1.4	1.1
Health Care	133.5	152.3	81.2	90.5	14.1%	11.5%	142.1	6.8	3.5
Arts-Entertain-Recreation	28.6	23.9	10.7	9.2	-16.3%	-13.9%	30.4	-5.8	-0.7
Total	1,322.4	1,211.8	539.8	507.1	-8.4%	-6.1%	1,407.6	-189.3	**-6.5**

3.2.1.6 Cleveland

Cleveland's HeathLine BRT system started operations in 2008. It connects downtown to the medical centers to the east. The HealthLine is the nation's highest-rated BRT system, according to the Institute for Transportation and Development Policy (ITDP, 2015). Table 3.9 shows shift-share results. Before the recession, the BRT station areas lost job share relative to the CC (Cuyahoga), as did the counter-factual locations although at a higher rate. During the recovery, the situation reversed somewhat as BRT station areas still lost job share but the counter-factual locations lost even more share. We also note that the ITDP reports the HealthLine gained more real estate investment per dollar of transportation investment than any other BRT system it evaluated (ITDP, 2013).

3.2.1.7 New York City—Bronx

New York City initiated the Pelham Parkway BRT Line in 2008, substantially serving Bronx County which is also the CC used in our analysis. Shift-share results are reported in Table 3.10. Before the recession, the BRT station areas lost job share with respect to the CC at a faster rate than for the counter-factual locations. During the recovery, however, it gained share substantially while the counter-factual locations lost even more share.

3.2.1.8 Phoenix

In 2008, Valley Metro Transit serving Maricopa County, the CC of the Phoenix metropolitan area, opened its Main Street Line. As seen in Table 3.11, the BRT station areas lost job share relative to the CC to a greater extent than the counter-factual locations. During the recovery, although the BRT station areas lost even more share to the CC, so did the counter-factual locations. As Phoenix is well-known for its decades of sprawl, we are not surprised to see BRT station areas lose job share.

3.2.1.9 Salt Lake City

Yet another BRT system was initiated in 2008—MAX operated by the Utah Transit Authority located in suburban West Valley City in Salt Lake County, the CC for the Salt Lake City metropolitan area. Table 3.12 shows that it has been effective in shifting jobs to BRT station areas. Before the recession, the BRT station areas lost share of jobs compared to the CC, but so did the counter-factual locations though at a lower rate. During the recovery, the BRT station areas gained considerable share compared to the CC while the counter-factual locations lost share at about the same rate as before the recession. We know from personal knowledge that West Valley City has encouraged economic development

Table 3.9 Cleveland HealthLine (2008—Silver) Shift-Share

BRT Block Groups									
PRE-RECESSION 2002-2007									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	32.9	27.7	61.6	57.7	-15.9%	-6.3%	33.8	-2.9	-3.2
Industrial	29.3	25.0	48.3	47.7	-14.8%	-1.4%	30.0	-1.1	-3.9
Retail-Lodging-Food	73.9	70.1	100.1	95.0	-5.2%	-5.1%	75.8	-5.6	-0.0
Knowledge	30.3	29.1	44.5	43.9	-4.0%	-1.3%	31.1	-1.1	-0.8
Office	99.1	89.3	124.3	117.9	-10.0%	-5.2%	101.6	-7.6	-4.8
Education	37.6	31.3	43.9	42.4	-16.8%	-3.3%	38.6	-2.2	-5.1
Health Care	73.7	70.4	82.9	88.4	-4.5%	6.6%	75.5	3.0	-8.2
Arts-Entertain-Recreation	8.1	9.7	8.8	8.9	20.2%	0.5%	8.3	-0.2	1.6
Total	385.0	352.5	514.4	501.9	-8.4%	-2.4%	394.7	-17.8	**-24.4**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	42.6	37.4	61.6	57.7	-12.2%	-6.3%	43.6	-3.7	-2.5
Industrial	28.1	26.5	48.3	47.7	-5.7%	-1.4%	28.8	-1.1	-1.2
Retail-Lodging-Food	67.5	62.6	100.1	95.0	-7.2%	-5.1%	69.2	-5.1	-1.4
Knowledge	23.0	21.6	44.5	43.9	-5.7%	-1.3%	23.5	-0.9	-1.0
Office	84.3	74.6	124.3	117.9	-11.6%	-5.2%	86.4	-6.5	-5.4
Education	26.3	23.1	43.9	42.4	-12.4%	-3.3%	27.0	-1.5	-2.4
Health Care	59.0	59.4	82.9	88.4	0.8%	6.6%	60.5	2.4	-3.4
Arts-Entertain-Recreation	5.9	6.2	8.8	8.9	4.6%	0.5%	6.1	-0.1	0.2
Total	336.7	311.5	514.4	501.9	-7.5%	-2.4%	345.2	-16.6	**-17.1**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	27.2	19.8	55.6	45.9	-27.2%	-17.4%	28.4	-5.9	-2.7
Industrial	24.6	21.0	47.6	40.0	-14.6%	-16.1%	25.7	-5.0	0.4
Retail-Lodging-Food	70.6	63.3	93.6	87.3	-10.3%	-6.7%	73.5	-7.7	-2.5
Knowledge	29.9	21.3	45.2	38.3	-28.8%	-15.3%	31.1	-5.8	-4.0
Office	87.3	71.5	117.3	109.2	-18.1%	-6.9%	91.0	-9.7	-9.8
Education	30.8	23.1	41.1	40.5	-24.9%	-1.3%	32.1	-1.7	-7.3
Health Care	63.3	79.9	75.3	95.5	26.2%	26.9%	66.0	14.3	-0.4
Arts-Entertain-Recreation	9.1	5.5	8.6	7.9	-39.0%	-8.0%	9.4	-1.1	-2.8
Total	342.7	305.4	484.3	464.7	-10.9%	-4.1%	357.2	-22.7	**-29.1**
Counter-Factual Block Group									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	35.1	23.8	55.6	45.9	-32.3%	-17.4%	36.6	-7.6	-5.2
Industrial	27.2	17.9	47.6	40.0	-34.3%	-16.1%	28.4	-5.5	-5.0
Retail-Lodging-Food	63.3	47.7	93.6	87.3	-24.8%	-6.7%	66.0	-7.0	-11.4
Knowledge	21.5	13.0	45.2	38.3	-39.4%	-15.3%	22.4	-4.2	-5.2
Office	72.0	58.9	117.3	109.2	-18.3%	-6.9%	75.1	-8.0	-8.2
Education	22.5	16.4	41.1	40.5	-27.2%	-1.3%	23.5	-1.2	-5.8
Health Care	50.8	61.0	75.3	95.5	20.1%	26.9%	52.9	11.5	-3.4
Arts-Entertain-Recreation	5.9	4.0	8.6	7.9	-33.4%	-8.0%	6.2	-0.7	-1.5
Total	298.5	242.6	484.3	464.7	-18.7%	-4.1%	311.1	-22.8	**-45.8**

Table 3.10 New York, Bronx, Pelham Parkway (2008—Unrated) Shift-Share

BRT Block Groups									
PRE-RECESSION 2002-2007									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	2.1	1.4	9.3	7.8	-33.6%	-15.8%	2.1	-0.3	-0.4
Industrial	17.8	19.1	16.1	16.2	7.6%	0.3%	17.3	0.5	1.3
Retail-Lodging-Food	51.8	54.9	29.8	31.4	6.0%	5.6%	50.6	4.1	0.2
Knowledge	7.0	6.9	5.5	7.5	-1.5%	37.3%	6.8	2.8	-2.7
Office	26.3	29.6	29.3	27.3	12.8%	-6.7%	25.7	-1.1	5.1
Education	14.1	24.1	7.2	12.1	70.9%	68.5%	13.7	10.0	0.3
Health Care	96.7	84.6	72.7	71.5	-12.5%	-1.7%	94.5	0.6	-10.4
Arts-Entertain-Recreation	0.5	0.8	2.4	2.5	76.3%	2.9%	0.4	0.0	0.3
Total	216.2	221.4	172.2	176.3	2.4%	2.4%	211.2	16.5	**-6.2**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	9.2	7.7	9.3	7.8	-16.3%	-15.8%	9.0	-1.2	-0.0
Industrial	12.3	11.7	16.1	16.2	-4.3%	0.3%	12.0	0.3	-0.6
Retail-Lodging-Food	25.8	26.6	29.8	31.4	2.8%	5.6%	25.2	2.0	-0.7
Knowledge	5.2	7.1	5.5	7.5	36.2%	37.3%	5.1	2.1	-0.1
Office	29.7	25.7	29.3	27.3	-13.6%	-6.7%	29.0	-1.3	-2.1
Education	4.0	7.8	7.2	12.1	95.7%	68.5%	3.9	2.8	1.1
Health Care	67.5	67.7	72.7	71.5	0.3%	-1.7%	65.9	0.4	1.4
Arts-Entertain-Recreation	2.2	2.3	2.4	2.5	5.4%	2.9%	2.1	0.1	0.1
Total	155.9	156.6	172.2	176.3	0.5%	2.4%	152.3	5.2	**-0.9**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	1.4	1.5	7.5	5.8	8.6%	-23.1%	1.2	-0.1	0.4
Industrial	6.3	16.9	16.0	17.5	169.3%	9.3%	5.4	1.5	10.0
Retail-Lodging-Food	56.1	62.2	32.0	36.7	10.8%	14.5%	48.3	16.0	-2.0
Knowledge	6.9	6.2	7.3	7.5	-9.6%	2.7%	5.9	1.1	-0.8
Office	29.5	27.6	29.2	31.5	-6.6%	8.2%	25.4	6.5	-4.4
Education	24.3	27.4	12.6	14.3	13.1%	14.0%	20.9	6.8	-0.2
Health Care	56.1	109.9	68.6	88.4	95.8%	28.9%	48.3	24.0	37.6
Arts-Entertain-Recreation	0.7	1.0	2.6	2.6	30.8%	-0.7%	0.6	0.1	0.2
Total	181.3	252.6	175.8	204.3	39.4%	16.2%	155.9	55.9	**40.8**
Counter-Factual Block Groups									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	7.3	5.6	7.5	5.8	-23.7%	-23.1%	6.3	-0.7	0.0
Industrial	11.8	13.2	16.0	17.5	11.7%	9.3%	10.2	2.7	0.3
Retail-Lodging-Food	27.1	31.4	32.0	36.7	15.7%	14.5%	23.3	7.7	0.3
Knowledge	6.8	7.3	7.3	7.5	7.2%	2.7%	5.9	1.1	0.3
Office	28.0	31.0	29.2	31.5	10.7%	8.2%	24.1	6.2	0.7
Education	8.4	9.6	12.6	14.3	15.1%	14.0%	7.2	2.3	0.1
Health Care	69.7	83.9	68.6	88.4	20.5%	28.9%	59.9	29.8	-5.8
Arts-Entertain-Recreation	2.5	2.4	2.6	2.6	-4.1%	-0.7%	2.1	0.3	-0.1
Total	161.5	184.4	175.8	204.3	14.1%	16.2%	139.0	49.6	**-4.2**

Table 3.11 Phoenix, Main Street (2008—Unrated) Shift-Share

BRT Block Groups

PRE-RECESSION 2002-2007

Sector	**BRT 2004**	**BRT 2007**	**CC 2004**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	28.5	36.5	51.6	56.4	28.0%	9.2%	25.6	5.5	5.3
Industrial	30.9	23.0	56.1	64.4	-25.7%	14.8%	27.8	7.7	-12.5
Retail-Lodging-Food	263.1	237.2	132.7	149.9	-9.9%	13.0%	236.2	61.0	-60.0
Knowledge	65.1	57.0	49.0	53.6	-12.4%	9.3%	58.5	12.7	-14.1
Office	216.5	194.9	171.8	194.5	-10.0%	13.2%	194.4	50.7	-50.2
Education	245.0	309.0	46.2	48.1	26.1%	4.1%	220.0	35.0	54.0
Health Care	83.7	125.8	58.8	63.2	50.4%	7.5%	75.1	14.8	35.9
Arts-Entertain-Recreation	12.8	12.3	12.1	13.9	-4.0%	15.3%	11.5	3.3	-2.5
Total	945.5	995.6	578.4	644.2	5.3%	11.4%	849.0	190.8	**-44.2**

Counter-Factual Block Groups

Sector	**CF 2004**	**CF 2007**	**CC 2004**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	47.4	44.4	51.6	56.4	-6.3%	9.2%	42.6	9.2	-7.4
Industrial	55.9	53.9	56.1	64.4	-3.6%	14.8%	50.2	14.0	-10.3
Retail-Lodging-Food	199.4	209.4	132.7	149.9	5.1%	13.0%	179.0	46.2	-15.8
Knowledge	91.0	100.9	49.0	53.6	11.0%	9.3%	81.7	17.8	1.5
Office	204.9	252.8	171.8	194.5	23.4%	13.2%	184.0	48.0	20.8
Education	36.2	40.7	46.2	48.1	12.5%	4.1%	32.5	5.2	3.1
Health Care	124.3	128.6	58.8	63.2	3.5%	7.5%	111.6	22.0	-5.0
Arts-Entertain-Recreation	12.7	17.2	12.1	13.9	35.6%	15.3%	11.4	3.2	2.6
Total	771.6	848.0	578.4	644.2	9.9%	11.4%	692.9	165.6	**-10.5**

RECOVERY 2008-2011

Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	33.9	20.7	50.8	45.9	-38.9%	-9.8%	34.8	-4.3	-9.9
Industrial	30.7	25.9	65.3	61.0	-15.8%	-6.7%	31.6	-2.9	-2.8
Retail-Lodging-Food	213.7	191.7	147.6	138.9	-10.3%	-5.9%	219.9	-18.8	-9.4
Knowledge	52.5	27.4	54.4	50.0	-47.8%	-8.1%	54.1	-5.8	-20.9
Office	221.5	198.6	189.8	177.4	-10.3%	-6.5%	227.9	-20.8	-8.4
Education	301.1	278.4	55.4	56.4	-7.5%	1.7%	309.8	-3.6	-27.7
Health Care	121.1	150.7	69.7	84.1	24.4%	20.6%	124.7	21.5	4.5
Arts-Entertain-Recreation	13.6	16.7	12.4	13.7	22.9%	10.3%	14.0	1.0	1.7
Total	988.1	910.1	645.5	627.3	-7.9%	-2.8%	1,016.8	-33.8	**-72.9**

Counter-Factual Block Groups

Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	39.8	36.3	50.8	45.9	-8.9%	-9.8%	40.9	-5.0	0.4
Industrial	68.1	57.0	65.3	61.0	-16.4%	-6.7%	70.1	-6.5	-6.6
Retail-Lodging-Food	202.9	165.7	147.6	138.9	-18.3%	-5.9%	208.8	-17.9	-25.2
Knowledge	100.6	81.8	54.4	50.0	-18.7%	-8.1%	103.5	-11.0	-10.7
Office	240.7	236.6	189.8	177.4	-1.7%	-6.5%	247.6	-22.7	11.6
Education	43.5	51.5	55.4	56.4	18.3%	1.7%	44.8	-0.5	7.2
Health Care	130.3	162.7	69.7	84.1	24.8%	20.6%	134.1	23.1	5.5
Arts-Entertain-Recreation	13.3	12.2	12.4	13.7	-7.7%	10.3%	13.6	1.0	-2.4
Total	839.2	803.7	645.5	627.3	-4.2%	-2.8%	863.6	-39.6	**-20.3**

Table 3.12 Salt Lake City, MAX—West Valley City (2008—Unrated) Shift-Share

BRT Block Groups									
PRE-RECESSION 2002-2007									
Sector	**BRT 2002**	**BRT 2007**	**CC 2002**	**CC 2007**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	59.4	59.9	76.2	81.2	0.8%	6.6%	53.9	9.4	-3.4
Industrial	82.4	86.6	83.0	90.6	5.1%	9.1%	74.8	15.1	-3.3
Retail-Lodging-Food	216.8	197.8	162.6	175.4	-8.8%	7.8%	196.8	37.1	-36.1
Knowledge	36.8	30.3	70.0	82.3	-17.6%	17.5%	33.4	9.9	-12.9
Office	156.0	182.9	207.7	226.0	17.3%	8.8%	141.5	28.1	13.3
Education	54.2	60.7	66.3	72.7	12.0%	9.8%	49.2	10.3	1.2
Health Care	44.1	49.7	71.0	84.0	12.7%	18.4%	40.0	12.2	-2.5
Arts-Entertain-Recreation	13.7	14.1	17.5	19.0	3.4%	8.5%	12.4	2.4	-0.7
Total	663.4	682.1	754.3	831.2	2.8%	10.2%	602.1	124.5	**-44.5**
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2007**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	79.3	81.2	76.2	81.2	2.4%	6.6%	71.9	12.5	-3.3
Industrial	109.2	110.1	83.0	90.6	0.8%	9.1%	99.1	20.1	-9.1
Retail-Lodging-Food	235.7	236.4	162.6	175.4	0.3%	7.8%	213.9	40.3	-17.8
Knowledge	106.8	112.4	70.0	82.3	5.2%	17.5%	96.9	28.6	-13.1
Office	290.7	309.3	207.7	226.0	6.4%	8.8%	263.8	52.5	-7.0
Education	66.0	65.4	66.3	72.7	-0.8%	9.8%	59.9	12.5	-7.0
Health Care	84.8	91.1	71.0	84.0	7.4%	18.4%	77.0	23.4	-9.3
Arts-Entertain-Recreation	15.4	16.0	17.5	19.0	3.7%	8.5%	14.0	2.7	-0.7
Total	987.9	1021.9	754.3	831.2	3.4%	10.2%	896.6	192.7	**-67.4**
RECOVERY 2008-2011									
Sector	**BRT 2008**	**BRT 2011**	**CC 2008**	**CC 2011**	**BRT Change**	**CC Change**	**CC Share**	**SM Share**	**BRT Shift**
Manufacturing	58.4	64.3	84.3	77.9	10.1%	-7.6%	58.7	-4.7	10.3
Industrial	92.5	91.9	93.1	91.2	-0.7%	-2.1%	93.0	-2.4	1.3
Retail-Lodging-Food	203.3	191.9	181.3	170.7	-5.6%	-5.8%	204.3	-12.9	0.5
Knowledge	33.3	31.4	85.2	84.5	-5.5%	-0.8%	33.4	-0.4	-1.5
Office	186.2	258.0	228.6	228.2	38.5%	-0.1%	187.2	-1.2	72.1
Education	62.4	69.6	73.6	76.1	11.6%	3.4%	62.7	1.8	5.1
Health Care	42.2	52.2	85.0	98.2	23.6%	15.6%	42.4	6.4	3.4
Arts-Entertain-Recreation	15.6	19.3	18.3	18.2	23.8%	-0.6%	15.7	-0.2	3.8
Total	693.8	778.6	849.4	845.1	12.2%	-0.5%	697.3	-13.7	**95.0**
Counter-Factual Block Groups									
Sector	**CF 2008**	**CF 2011**	**CC 2008**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	77.8	64.3	84.3	77.9	-17.4%	-7.6%	78.2	-6.3	-7.7
Industrial	110.3	97.1	93.1	91.2	-12.0%	-2.1%	110.8	-2.8	-10.9
Retail-Lodging-Food	237.6	205.6	181.3	170.7	-13.5%	-5.8%	238.8	-15.1	-18.1
Knowledge	115.3	112.1	85.2	84.5	-2.8%	-0.8%	115.9	-1.5	-2.2
Office	306.9	296.9	228.6	228.2	-3.3%	-0.1%	308.5	-2.0	-9.6
Education	66.7	58.4	73.6	76.1	-12.4%	3.4%	67.0	1.9	-10.6
Health Care	92.3	109.2	85.0	98.2	18.3%	15.6%	92.8	13.9	2.5
Arts-Entertain-Recreation	15.8	15.2	18.3	18.2	-3.8%	-0.6%	15.9	-0.2	-0.5
Total	1,022.7	958.7	849.4	845.1	-6.3%	-0.5%	1,027.9	-12.1	**-57.1**

3.3 SUMMARY AND IMPLICATIONS

Using shift-share analysis we find during economic recovery that, for the most part, BRT systems are associated with improved economic development when compared to the central counties within which they operate and when compared to the counter-factual. Table 3.13 summarizes our findings with respect to the shift in jobs per block group before the recession and during the recovery. Of the 12 BRT systems evaluated, only three gained share of jobs relative to the central county before the recession, as did only four counter-factual sets of locations. On the whole, the counter-factual locations lost half the job share as BRT station areas.

See further that only four BRT station areas lost job share relative to their central counties from before the recession into the recovery. One of those was in a metropolitan area well-known for sprawl and associated policies that appear to do little to contain it (Phoenix); two were in economically stagnating metropolitan areas (Pittsburgh South Line and Cleveland); and one was serving a small part of one of the nation's largest metropolitan areas that mostly connects residential areas to major job centers outside the corridor (Los Angeles Orange Line).

Equally interesting is that during the recovery, BRT station areas gained more share (or lost less share) compared to counter-factual locations for all but three systems: Pittsburgh South Line, Las Vegas, and Phoenix (also noted above). Indeed, more than half (seven) of the BRT station areas gained share while only one counter-factual set of locations did.

Figure 3.2 Eugene-Springfield Emerald Express (EmX) BRT Station and Vehicle

Table 3.13 also shows the unweighted (summed) means of shift in block group share of total jobs. (The Los Angeles Silver Line is excluded as it appears to be an outlier in positive performance.) While counter-factual locations lost about half the jobs BRT station areas did before the recession, the BRT station areas as a whole gained total job share while counter-factual locations lost share.

We believe there is circumstantial, though not conclusive. evidence that quality of a BRT system contributes to economic development. Three of the four systems rated Bronze or better showed chief changes in job share compared to their central counties and counter-factual locations with the fourth (Las Vegas) decidedly designed more to connect residential areas to downtown and Nellis AFB than to facilitate economic development along its route. On the other hand, some of the most dramatic changes are associated with unrated or Basic systems, notably the Pittsburgh West Line, Los Angeles Silver Line, Bronx Pelham Parkway and Salt Lake City MAX.

We surmise that, on the whole, BRT systems contribute to economic development with both respect to their central counties and the counter-factual; that is, economic development may not have happened without BRT systems anyway. To an important extent, the market appears to respond to BRT investments. Where they improve access to employment centers along routes and where there are opportunities for redevelopment, BRT systems appear to facilitate economic development. We also surmise that planning and economic development incentives are needed to facilitate market response to BRT investments (Nelson, 2014). Planning is needed to assure market-feasible development opportunities while incentives are needed to help offset additional costs of redeveloping otherwise problematic sites lest new development is lured to lower-cost land elsewhere that may impose higher social, environmental and economic costs on metropolitan areas (Nelson, 2013).

Table 3.13 Mean Block Group Shift-Share Summary of BRT Station Area and Counter-Factual Locations before Recession (2002/2004-2007) and during Recovery (2008-2011)

	Pre-Recession Shift-Share		Recovery Shift-Share	
BRT Line	**Counter-Factual**	**BRT**	**Counter-Factual**	**BRT**
Pittsburgh South—1977 – Basic	-14.4	-62.9	-10.0	-108.8
Pittsburgh East—1983 – Bronze	49.4	5.7	-5.0	34.1
Pittsburgh West— 2000 – Basic	-23.6	-133.3	-3.3	86.4
Las Vegas MAX—2004 - Unrated	-140.8	-203.5	223.5	-13.1
Los Angeles Orange—2005 - Bronze	5.8	63.3	-67.2	-55.4
Los Angeles Silver—2009 - Unrated	29.4	-137.8	-32.9	1,035.5
Kansas City Main Street—2005 - Unrated	6.8	-9.6	-47.6	9.9
Eugene-Springfield Emerald Express—2007 - Bronze	-1.6	5.0	-6.5	34.8
Cleveland Health Line—2008 - Silver	-17.1	-24.4	-45.8	-29.1
Bronx Pelham Parkway—2008 - Unrated	-0.9	-6.2	-4.2	40.8
Phoenix Main Street—2008 - Unrated	-10.5	-44.2	-20.3	-72.9
Salt Lake City MAX—2008 - Unrated	-67.4	-44.5	-57.1	95.0
Positive Shift in Share	4	3	1	7
Unweighted (summed) means*	(214.3)	(454.6)	(43.5)	21.8

*Excludes Los Angeles Silver Line

Note: Coefficients are the sum of the "industry share" of the shift in mean jobs per block group from shift-share analysis comparing change in share of total jobs between BRT station areas and counter-factual locations with respect to their central county over pre-recession (2002-2007; Phoenix is 2004-2007) and recovery (2008-2011) periods.

4.0 THE EFFECTS OF BUS RAPID TRANSIT ON SECTORAL EMPLOYMENT CHANGE IN THE U.S., 2000-2010

4.1 INTRODUCTION

Over the past two decades, various public transportation systems have been developed to provide people with better accessibility to their destinations while also changing car-dependent urban forms and improving environmental quality (Cervero & Dai, 2014). As one of the promising and sustainable public transportation alternatives, bus rapid transit (BRT) systems have gradually gained in popularity because they can provide better accessibility from origins to destinations while also yielding lower capital costs than rail-based transit options such as light rapid transit (LRT) and commuter rail (U.S. GAO, 2012) Additionally, cities which have installed transit systems have seen economic activity in the form of retail, office and residential developments along routes and around stations (Glaeser, Rosenthal and Strange, 2010; De Bok and Bliemer, 2006; Banister and Berechman, 2001; Thole and Samus, 2009), though these studies use aggregated employment data and do not focus specifically on BRT. Recent urban economics and public transit literature question how the provision of rapid transit systems in a city can affect employment or overall industrial mix around transit corridors or stations. Identifying potential sectoral employment impacts of BRT can help planners and decision-makers justify transit investments in BRT through economic development (Chatman and Noland, 2013; Chatman and Noland, 2011). Understanding sector-specific impacts can also assist planners in approaching the integration of transportation and land use planning near stations, where transit-oriented development (TOD) is a possibility.

However, few studies analyze the impact of BRT corridors on total employment change, and fewer still on individual sectors. This study addresses this literature gap by comparing sector-specific employment change near BRT stations along nine corridors with control points from 2002-2010. We use a series of regression analyses to argue that BRT systems have demonstrable employment effects on a single sector: manufacturing. Given the ongoing prominence of manufacturing in many states' economic development agendas, and the importance of connecting low-skill workers to jobs in this diverse sector, we believe our findings offer new opportunities for economic development planning around transportation.

4.2 LITERATURE REVIEW

4.2.1 Background: What is BRT and How Does it Compare to LRT?

Public transit systems are often promoted as offering a range of social, economic and environmental benefits to urban populations (Dunn, 2010; Kang, 2010; Polzin and Baltes, 2002). BRT systems are the latest trend in the fields of public transit and transportation planning. Part of this recent popularity in BRT stems from its more affordable cost of system development when compared to light rail transit (LRT) (Cervero and Dai, 2014; Levinson et al., 2003; Polzin and Baltes, 2002). In addition to saving dollars in initial capital investments, a municipality can use BRT as an economic development tool (Levinson et al., 2003), though research comparing the economic development potential of BRT relative to other transit types remains nascent.

Figure 4.1 Eugene-Springfield Emerald (EmX)

LRT systems have long been considered by users as preferable to bus systems. How are they different? Simply, BRTs are abstractly defined as bus services with advanced operational features that are uniquely branded from other local bus services (Levinson et al., 2003). BRT systems typically include separate priority lanes, faster passenger boarding and fare collection (typically off of the vehicle and on a platform), and a distinct, recognizable branding image. Branding provides a BRT system with a neighborhood identity and style (Hook et al., 2013; Thole and Samus, 2009; U.S. GAO, 2012; Urban Land Institute, 2011). Such physical features provide community members and developers with a sense of permanence, which the fixed-rail investment of an LRT typically signifies (Cervero and Dai, 2014; Davis et al., 2007; Polzin and Baltes, 2002; Polzin, 1999). BRT systems are easier to construct with gradual investment to include different routes and operational features (Cervero and Dai, 2014; Hook et al., 2013; Kang, 2010; Polzin and Baltes, 2002). Through case studies of six cities (Pittsburgh, Los Angeles, New York, etc.), Thole and Samus (2009) argue that there are no apparent differences between the land use incentives offered by cities for BRT versus LRT projects. In other qualitative case studies of BRT development practices in both developing and developed countries, BRT can be as influential as rail systems in encouraging urban redevelopment (Cervero, 2013; Cervero and Dai, 2014).

4.2.2 BRT and Economic Development

Considering the economic motivations often cited in the development of transit systems, it is vital to understand how BRT can be used as more than a mobility investment (Cervero and Dai, 2014), but also as a catalyst for economic development. As expanded upon below, global cities have described significant development occurring along BRT lines and adjacent to installed BRT stations (Cervero and Dai, 2014; Levinson et al., 2003). Moreover, cities have experienced land value increases surrounding BRT stations (Cervero and Dai, 2014; Cervero and Kang, 2011; Levinson et al., 2003).

However, there are limits to the economic development potential of BRT systems. Several studies have shown transit alone cannot induce economic development in a weak real estate market (Cervero and Dai, 2014; Cervero and Landis, 1997). BRT might also not produce desired economic development benefits if installed without appropriate planning processes. To produce effective BRT systems, municipal planning agencies must recognize a BRT investment should be integrated holistically into all economic development, transportation and land use plans. With such plans and policies, a BRT can serve as a focal point, or “backbone” (Cervero and Dai, 2014), to guide urban growth in a more transit-oriented fashion. Literature outlines the theoretical possibilities for economic growth around BRT corridors or stations to be strengthened when BRTs couple with zoning incentives, density bonuses, higher floor area ratio (FAR), street-facing orientation for buildings, specified setbacks, mixed-use and TOD, and pedestrian-oriented design standards (Cervero and Dai, 2014; Levinson et al., 2003; U.S. GAO, 2012). This manuscript argues that in the U.S., BRT specifically benefits one sector—manufacturing. As such, the zoning and land use considerations to foster economic development around corridors and stations should focus on development that will facilitate growth in this sector.

While, as described, existing studies show a relationship between economic development and BRT, we currently have a limited understanding of how BRT impacts the location choice of specific industries (Graham, 2007; Kang, 2010). Other studies that intersect transit and economic development often focus on rail transit (Bollinger and Ihlanfeldt, 1997; Graham, 2007; Nelson et al., 2013; Polzin, 1999). One exception to this is a study of creative industries near BRT stations in Seoul, South Korea, which found a positive relationship between BRT and employment densities. We add to this previous work through the study of nine BRT corridors in eight U.S. counties, and through the lens of employment change in disaggregated, two-digit NAICS code sectors. This manuscript also uses a before-and-after analysis, which has also been called for in the literature (Kang, 2010).

Although exceptionally little literature exists from which we can form *a priori* hypotheses regarding impacts for specific sectors, we are able to form some hypotheses based on existing knowledge of the physical characteristics of our sample of BRT corridors. Among our sample of nine BRT corridors, four have segments built near industrial areas, suggesting that we might see employment impacts to industrial sectors. Two other systems were developed to connect residential areas to downtowns, suggesting that BRT might impact employment in downtown industries, such as retail, finance, entertainment, etc. In total, our sample of corridors is built in a variety of settings, creating the opportunity to observe employment growth across a variety of sectors. In all cases, the BRT corridors studied herein are located in urban settings, and thus are more likely to influence sectors and sub-industries commonly found in urban settings, rather than sectors that are land-intensive or more mature in their product cycle, and thus more likely to locate away from centers of innovation.

4.3 METHODS

This manuscript investigates the impacts of BRT on employment changes of each sector between 2002 and 2010 by using Longitudinal Employer-Household Dynamics (LEHD) employment data. A BRT case in Arizona is an exception because the LEHD database provides Arizona employment data between 2004 and 2010. Throughout this manuscript, we use the term “sector” to refer to two-digit NAICS level establishments and employment, and “industry” to refer to the 3-digit or lower NAICS level. Our sample includes 226 BRT stations situated along the nine BRT corridors opened between 2002 and 2010 in eight U.S. counties (Table 4.1). We treat pairs of split platforms as single stations. The analysis evaluates changes that occur within a 0.25-mile buffer area around each point. While some transportation research uses a 0.50-mile buffer (Guerra, Cervero and Tischler, 2012; McDonnell and Madar, 2011), we chose the 0.25-mile buffer due to its common use in research on bus-related economic impacts specifically. Previous research has shown that the majority of economic impact occurs within this radius (American Public Transit Association, 2009). A secondary reason to choose a 0.25-mile buffer is to reduce the co-location of multiple stations within overlapping buffers.

Table 4.1 BRT Systems Included in BRT Industrial Sector Analysis

Name of Corridor	County	Host Metropolitan Statistical Area[1]	Year Corridor Opened
Main Street BRT	Maricopa County, Arizona	Phoenix	2008
Orange Line	Los Angeles County, California	Los Angeles	2005
Silver Line	Los Angeles County, California	Los Angeles	2009
Main Street BRT	Jackson County, Missouri	Kansas City	2005
MAX BRT	Clark County, Nevada	Las Vegas	2004
Bx12SBS	Bronx County, New York	New York City	2008
HealthLine BRT	Cuyahoga County, Ohio	Cleveland	2008
Emerald Express (EMX) BRT	Lane County, Oregon	Eugene	2007
3500 South MAX BRT	Salt Lake County, Utah	Salt Lake City	2008

We investigate the role of BRT station presence by comparison to intra-county control points. This method was chosen for a variety of reasons. Transit stations and corridors, BRT systems included, are not located randomly, but rather are situated to maximize ridership while navigating land ownership, zoning and other planning issues. Consequently, stations and corridors often run through areas enjoying urban densities, multiple types of transit networks, and significant other forms of investment, both public and private. In other words, transit and density benefit one another (Graham, 2007; Venables, 2007), and density also benefits urban economic development (Glaeser, 2011). Therefore, analyzing economic development, whether via job growth, productivity or other metrics, without controlling for the context, leaves analysis open to the likelihood of misattributing growth to transit, when transit and economic development occur endogenously.

Controlling for context might be accomplished in one of several ways. Initially, controlling for context via inclusion of variables for population density, rail transit provision, employment density, and other socioeconomic and infrastructure variables seems promising, but the problem of endogeneity remains. To overcome the endogeneity challenge, we instead created a pool of comparable points. These comparable points were selected based on similar initial-year characteristics; a dummy variable signifying BRT station status (dummy=1) or control point (dummy=0) was then introduced to our model, as specified below.

We selected by drawing a 0.25-mile buffer around each block-group centroid within the host county, then spatially apportioning data from Census geographies into the geographies created by drawing the buffers. Then, the buffered areas (henceforth “comparable points”) were ranked from most to least similar to each BRT station. To establish likeness, the quadrance distance was calculated using five variables in t=0 (2000): total population, total employment, median household income, total housing units and total households. Each variable i was converted to a z-

[1] Host Metropolitan Statistical Areas are given for reference purposes, but note that BRT systems exist in all case study cases within single counties.

score for BRT stations and all other census block groups within the county. The 10 points having the lowest quadrance value (Equation (4.1)) were selected as the control points for each BRT station.

$$Quadrance = \sum_{i=1}^{n} (Z_{BRT} - Z_{Comp})^2 \tag{4.1}$$

Where:
i = variable used to identify control points: population, employment, median household income, housing units, households
Z = z-score of each variable *i*
BRT = the 0.25-mile area surrounding the BRT station
Comp = the 0.25-mile area surrounding the block-group centroid of each non-BRT block group in the host county

In many cases, identical candidate points were identified as comparable points for multiple BRT stations. In these cases, the point was assigned as a comparable point for the station for which it had a lower quadrance value. After removing duplicate comparable points, a pool of 1,085 comparable points was identified for use in analysis.

Having established the pool of observations, consisting of 0.25-mile buffers around 226 BRT stations and 1,085 distinct comparable points, we constructed a series of regression models to test the impact of BRT stations on employment growth at the sectoral level. The models' dependent variable is employment change within the buffer area. The variation in the dependent variable is modeled as a function of initial year conditions and sectoral diversity within the 0.25-mile buffer area, state, and our key independent variable, BRT station presence. The Herfindahl-Hirschman Index (HHI) is a commonly used index to measure degree of market concentration in urban economics, but it can also be used to evaluate the degree of industrial mix (while we analyze sectors, we retain the term "industrial mix" to maintain consistency with how the HHI is referenced in literature) within an area. Table 4.2 summarizes the variables and data sources.

Table 4.2 Variables and Data Sources

Variable	Description	Data Source
EMPCH	Employment change between 2002 and 2010	LEHD 2002 and 2010
POPDEN00	Population density	Census 2000
HHINDEX00	Herfindahl-Hirschman Index	LEHD 2002
MEDINC00	Median household income, 2000	Census 2000
TOTEMP02	Total employment, 2002 (2004 for Arizona)	LEHD 2002, 2004
POP00	Total population, 2000	Census 2000
BRT	Presence of a BRT station	General Transit Feed Specification 2014, 2015
AZ	Dummy variable for Arizona	
CA	Dummy variable for California	
MO	Dummy variable for Missouri (used as referent)	
NV	Dummy variable for Nevada	
NY	Dummy variable for New York	
OH	Dummy variable for Ohio	
OR	Dummy variable for Oregon	

UT	Dummy variable for Utah	

To test overall model fit, we modeled overall employment change as a function of the variables given in Table 4. 2. Following the overall specification, we constructed a model for each of the 20 two-digit NAICS sectors given in the LEHD data. We conducted preliminary analyses to test our compliance with OLS assumptions, and make corrections where necessary. We identified two areas of concern: heteroscedasticity and the influence of outliers.

While our dependent variable was normally distributed, we found heteroscedastic error terms across models. To correct these, we calculated robust error terms for each model. The influence of outliers required an inspection of data. We discovered that, depending on the sector being modeled, between two and approximately five points could be considered outliers, and compromised the model fit and diagnostics. In virtually all cases, these points were control points near one station on the Bx12SBS corridor in the Bronx. Employment growth between 2002 and 2010 had been astronomical within the buffer areas of these control points, and as such, the points behaved unlike the control points on other corridors, or like the station areas themselves. After careful consideration, and analysis of residual plots and dispersion metrics, we decided to remove the control points with a Cook's distance of greater than 0.6 from the regressions. Removing these observations resulted in drastic improvements to the models' AIC values, and modest increases in R^2 values.

Following these series of regression models, we then rely on County Business Pattern data to provide more descriptive knowledge of the sectors that are significantly influenced by the presence of BRT. This information reveals whether change was concentrated in single three-digit NAICS industries within the larger two-digit sectors, and was distributed across multiple three-digit industries. This descriptive narrative focuses on number of firms and on employment.

4.4 RESULTS AND DISCUSSION

4.4.1 Results

While our research design calls for the specification of a regression model for each sector, we tested the specification's validity by first specifying a model of overall employment change. These results, given in Table 4.3, show an adjusted R2 of 0.31 and statistical significance for the intercept and for the control variable TOTEMP00. Table 4.3 suggests that the specification provides a reasonable amount of explanatory power for the dependent variable. The model does not show multicollinearity, and heteroscedasticity has been corrected through the use of a White corrected robust error.

Table 4.3 OLS Results of Total Employment Change

	Coefficient	White Std. Error	Significance
Intercept	-487.8068	211.1062	**
POPDEN00	-2509.8520	1687.8280	
HHINDEX00	0.0558	0.0952	
MEDINC00	0.0076	0.0054	
TOTEMP00	0.2765	0.0870	***
POP00	3195.7060	2148.9700	
BRT	-75.4365	195.5599	
AZ	-288.0192	221.8283	
CA	-403.4474	276.8615	
NV	-340.9106	244.4557	
NY	-191.2666	355.7224	
OH	6.1519	99.7816	
OR	-101.8161	157.8812	
UT	-65.4031	137.5000	

Adjusted R2 = 0.31

**** $p < 0.01$; ** $p < 0.05$*

The same methodological process was followed for each two-digit NAICS sector given in the LEHD data. In each case, the standard OLS was tested, observations with a Cook's distance of >0.6 were removed, the model was re-fitted and then corrected for heteroscedastic error terms, which was necessary for all models. Several sectors' regressions showed strong overall model fit, but an insignificant coefficient for the key independent variable, the BRT dummy. These models include health care and social assistance, management of companies and enterprises, public administration, and retail trade.

While the model itself predicts employment change reasonably well overall, it shows that BRT statistically significantly influences employment change for just one sector: manufacturing. Table 4.4 shows these results. As our key independent variable is not a significant predictor of employment change in other sectors, we have omitted those results.

Table 4.4 Regression Results for Employment Change in Manufacturing

	Coefficient	White Std. Error	Significance
Intercept	25.3499	18.4015	
POPDEN00	-108.7747	118.1543	
HHINDEX00	0.0129	0.0054	**
MEDINC00	-0.0012	0.0005	**
TOTEMP00	-0.0262	0.0069	***
POP00	138.4978	150.4391	
BRT	38.9773	12.8323	***
AZ	-9.7021	12.1985	
CA	-5.4440	16.3507	
NV	-6.5041	11.7218	
NY	-56.9105	38.5219	
OH	-40.4694	9.7416	***
OR	-15.3542	9.6197	
UT	-5.2817	7.0745	

As Table 4.4 shows, the presence of BRT positively and significantly influences employment in the manufacturing sector across our sample. Nationally, the manufacturing sector has changed dramatically in recent decades, which adds context to the interpretation of our results. Employment in the manufacturing sector peaked at 22 percent of the U.S. workforce in 1979, and then employment declined 40 percent by 2010 to possess only 9 percent of the U.S. workforce (27). From January 2000 through January 2010, the U.S. shed 582,200 or approximately 34 percent of manufacturing jobs (Bureau of Labor Statistics, Current Employment Statistics Survey). Our sample behaved similarly; collectively, our 1,311 observations (stations and controls) lost 50,440 manufacturing jobs (36 percent) between 2002 and 2010. The average buffer in our sample experienced an employment change of -27 manufacturing jobs.

This context alters the interpretation of our findings. If the average buffer area lost 27 jobs between 2002 and 2010, but the presence of BRT adds 39 jobs, it stands to reason that BRT can be utilized as a valuable asset in the retention of manufacturing jobs. It seems less likely that BRT systems will lead to a large-scale reorganization or growth of the manufacturing sector nationally. However, these findings suggest that planners working to integrate land use and transportation planning consider how certain zoning and land use characteristics around BRT stations can find efficiencies to benefit the manufacturing sector. In other words, if BRT acts as an external benefit of agglomeration for manufacturing, what other infrastructure or land use planning can public agencies direct in support of that industrial district? These decisions could guide planning and zoning for the areas around BRT stations to become TODs.

To better understand the dynamics at play in the manufacturing sector, we analyze data from the Census Bureau’s County Business Patterns database. Nationally, these data show a decline in the number of establishments and the number of paid employees across all sub-industries, with one exception: beverage and tobacco product manufacturing (Table 4.5), which as a whole gained establishment while declining in paid employment.

Table 4.5 Change in the Number of Paid Employees and Establishments in Sub-Industries of the Manufacturing Sector in the U.S., 2000 and 2010

	Establishments		Paid Employees	
	2000	**2010**	**2000**	**2010**
Food Manufacturing (311)	25,698	24,773	1,443,766	1,432,843
Beverage and Tobacco Product Manufacturing (312)	**3,232**	**4,646**	**163,395**	**139,525**
Textile Mills (313)	4,045	2,514	261,655	109,285
Textile Product Mills (314)	7,332	6,262	190,209	111,076
Apparel Manufacturing (315)	13,359	7,206	350,439	120,627
Leather and Allied Product Manufacturing (316)	1,549	1,191	47,795	27,356
Wood Product Manufacturing (321)	17,052	14,387	534,011	350,288
Paper Manufacturing (322)	5,546	4,602	495,990	365,099
Printing and Related Support Activities (323)	36,902	29,118	706,419	499,622
Petroleum and Coal Products Manufacturing (324)	2,296	2,246	100,403	99,690
Chemical Manufacturing (325)	13,096	12,923	827,430	722,485
Plastics and Rubber Products Manufacturing (326)	15,462	12,969	925,607	667,615
Nonmetallic Mineral Product Manufacturing (327)	16,674	15,864	475,476	343,954
Primary Metal Manufacturing (331)	6,229	4,667	501,038	352,280
Fabricated Metal Product Manufacturing (332)	61,652	55,946	1,582,399	1,275,777
Machinery Manufacturing (333)	27,941	24,255	1,166,221	928,673
Computer and Electronic Product Manufacturing (334)	15,883	13,270	1,300,411	878,349
Electrical Equipment, Appliance, & Component Manufacturing(335)	6,601	5,880	502,400	329,234
Transportation Equipment Manufacturing (336)	12,202	11,715	1,578,707	1,201,956
Furniture and Related Product Manufacturing (337)	22,083	17,468	575,128	348,715
Miscellaneous Manufacturing (339)	29,507	28,080	664,710	558,389
Total	344,341	299,982	14,393,609	10,862,838

A deeper inspection of the data reveals that the growth in the number of establishments in sub-industry 312 are in beverage manufacturing, and within that, in breweries, wineries and distilleries. Within these four-digit NAICS code industries, only wineries show a positive change in both the number of firms *and* the number of paid employees over the decade. All of the cities studied in this manuscript are located near wine producing areas, have local breweries or both. As such, this industry could represent an opportunity to connect BRT systems with employment growth, as well as bolstering manufacturing for both local consumption and export from the local market. The implications of this are discussed further in the Discussion section.

Of course, the composition of the manufacturing sector varies tremendously across the nation and likely across our sample of buffer areas, and the role of local context should be considered during local planning processes. For instance, Table 4.4 shows that Ohio has a statistically significant, negative coefficient in the model. This finding is unsurprising, as Cleveland (which hosts the BRT corridor studied) is a prototypical Rust Belt city. Additionally, beverage manufacturing is not the most prominent manufacturing sub-industry in 2010 in terms of employment or number of firms. On the contrary, it is among the smaller industries. Consequently, a balanced economic development strategy to connect BRT to manufacturing stability and growth will likely consider connections with multiple manufacturing sub-industries within any given city.

4.4.2 Discussion

The results presented here provide guidance to planners hoping to use BRT as an economic development tool. Our results suggest that BRT may be a valuable tool in retaining manufacturing employment at the local level. Further, we find that there is tremendous variation in performance within the manufacturing sector. While, on the whole, the sector performs in our buffers as it does nationally, some sub-industries have found particular success in some states. This suggests that planners should integrate our findings with a close evaluation of local strengths in manufacturing sub-industries, and should analyze those sub-industries' national trends during early stages of the planning process.

Within the manufacturing sector, it remains unclear by what mechanism BRT facilitates employment growth. A few potential mechanisms seem plausible. First, it is possible that BRT systems benefit manufacturing through the creation of thicker labor pools by making the industrial district more accessible to potential workers. In this case, BRT not only affords economic development, but also improves accessibility for the economically diverse labor force engaged in manufacturing employment, thus also provides a social equity argument for the transit system.

Second, it seems plausible that depending on the sub-industry benefitted, BRT systems might improve consumers' accessibility to manufacturers of goods. This seems especially likely in instances where manufacturing intersects with the tourism industry, such as is the case with chocolate manufacturing in Hershey, PA, or the Ford River Rouge Factory Tour. The national data presented in Table 4.5 suggests that alcoholic beverage manufacturing might present a growing industry that could connect tourism and manufacturing. Craft beer brewing, while showing weaker growth than the winery sub-industry, is a particularly dynamic industry. Craft brewing has grown from approximately 50 establishments in the 1970s to over 2,500 in 2014 (The Economist), with breweries that often market their products using local themes. In such cases, planners can focus on connecting tourism-oriented locations to manufacturing hubs rather than solely connecting places of residence with places of work for employees, though this would likely remain important as well.

Third, indirect mechanisms might also be at play. One might theorize that BRT systems allow households to reduce expenditures for commuting, thus permitting increased expenditures for household goods purchased through local manufacturers. However, this scenario is predicated upon the assumption that those households using the BRT system also then purchase locally produced goods. This assumption requires that it is either reduced expenditures among the employees of the manufacturing firms serviced by BRT corridors, or the employees of other industries that also exist within the buffer areas of the BRT stations. Alternately, BRT may represent a public good that benefits a range of firms, allowing them to increase demand for manufacturing products made hyper-locally, meaning within their 0.25-mile buffer area.

Finally, further research on the manufacturing sector could uncover a qualitative understanding of the perceived value of BRT infrastructure to local business leaders and their workforces. Such field work could also be used to trace any economic linkages between manufacturing firms and either residential or commercial demand for manufacturing products. Further quantitative work should also investigate the impact of BRT on manufacturing growth in terms of employment size of firms, and on the potential to incite new firms to join an industrial district. If, as the first hypothesis suggests, BRT systems encourage the development of a thicker local labor market, existing firms might capitalize on its presence through expansion. An expanding industrial district creates other benefits of agglomeration economies, which could lure new firms.

4.5 CONCLUSION

Through our series of regression analyses we find that the manufacturing sector experiences employment growth around BRT stations compared to employment change around our control points. While we cannot conclude anything about the composition of the manufacturing sector around the BRT stations specifically, we can look at the national trends to offer suggestions for coordination of land use and transportation planning around BRT. The national trends suggest that traditional industries are large in scale and deserve attention in these cities, but there may be a new opportunities found in the growing alcoholic beverage manufacturing sector. There may be related opportunities where BRT can provide connectivity for manufacturers and consumers, which has been stressed as an important component of agglomeration economies and productivity (Graham, 2007).

While we are encouraged by these findings, future analyses can supplement this study. More contextual analyses should be conducted around BRT and control points. This could be accomplished either through case study analyses or through analysis of more detailed datasets which at present are unavailable, although private data providers may have this become available in the near future. Analysis based on qualitative field work, case studies or improved data might also suggest revisions to our model specifications that will improve model fit.

5.0 BUS RAPID TRANSIT AND OFFICE RENTS

5.1 THEORETICAL PERSPECTIVE AND LITERATURE

Fixed-guideway transit systems include heavy or "fifth" rail, such as the New York subway; light rail, such as provided in Charlotte and San Diego; non-tourist-related streetcar, such as seen in Portland and Tampa; and bus rapid transit, such as the world's second-oldest such system that is operated in Pittsburgh. Fixed-guideway systems reinvent the idea of agglomeration economies, which is a cornerstone of urban economic development. In this section, we review the role of agglomeration economies in economic development, assess how the advantages of agglomeration economies are undermined by automobile dependency, and summarize the role of fixed-guideway transit systems in recreating those economies.

Cities are formed and grow in large part by creating agglomeration economies (Glaeser, 2011). Annas, Arnott and Small (1998) define the term as "the decline in average cost as more production occurs within a specified geographical area" (p. 1427). They arise specific to certain economic sectors, however. As more firms in a related sector cluster together, costs of production fall as productivity increases. These economies can spill over into complementary sectors (Holmes, 1999). Cities can become ever larger as economies of agglomeration are exploited (Ciccone and Hall, 1996). If cities get too large, however, congestion occurs, which leads to diseconomies of scale. The result may be relocation of firms, but this can weaken economies of scale (Bogart, 1998). Highways connecting the city to outlying areas can induce firms to relocate, thereby reducing agglomeration diseconomies of scale through sacrificing some economies, though overall economic improvement is debatable (Boarnet, 1997). Cities thus spread out, and although the urban area may contain more people and jobs, the advantages of agglomeration economies are weakened.

One way to preserve agglomeration economies and reduce diseconomies is to improve transportation systems; this is a role of fixed-guideway transit systems. Within about 0.25 to 0.50 miles from transit stations accessing these systems, firms maximize the benefits of agglomeration economies (Cervero et al., 2004). Moreover, some firms can also benefit from expanded access to the labor force residing within walking distance of transit stations, wherever they are located (Belzer, Srivastava and Austin, 2011).

There is another aspect of agglomeration economies identified by Chapman and Noland (2011). Although transit systems can lead to higher-density development by shifting new jobs and population to station areas, it could lead, instead, to the redistribution of existing development even in the absence of growth.

In part because of their role in facilitating agglomeration economies, there is a growing body of research showing that rail-based public transit enhances economic development (see Nelson et al., 2009). Those economies are facilitated when they improve accessibility between people and their destinations (Littman, 2009) by reducing travel time and the risk of failing to arrive at a destination (Weisbrod and Reno, 2009). At the metropolitan scale, adding transit modes in built-up urban areas increases aggregate economic activity (Graham, 2007).

Economic development can be measured in many ways. One is by evaluating how the market responds to the presence of transportation investments, such as rail stations. Higher values closer to stations imply market capitalization of economic benefits, which can occur only when economic activity increases. Although there is a large literature assessing the association between transit proximity and market values (see Higgins and Kanaroglou, 2015), the literature with respect to BRT systems is very small and limited mostly to residential properties and then mostly to countries outside the U.S.

5.2 BUS RAPID TRANSIT PROPERTY VALUE EFFECTS

We find only eight studies associating BRT proximity with property values, with only two in the U.S. Three studies of the BRT system in Bogotá, Columbia, find that (1) residential rents increased by 6.8 percent to 9.3 percent for every five minutes walking time to the nearest BRT station (Rodíguez and Targa, 2004); (2) the asking price of properties within BRT catchment areas were 7-14 percent higher than that in control areas (Rodríguez and Mojica, 2009); and (3) some price premium was found with respect to middle-income residential property and distance from the nearest BRT station, but not for low-income residential property (Munoz-Raskin, 2010).

There are two studies of the BRT system operating in Seoul, South Korea. The first is by Cervero and Kang (2011), who find that within 300 meters of BRT stations residential land values increase from 5-10 percent, while within 150 meters non-residential land values increase from 3-26 percent (Jun, 2012). A study of the Quebec City Métrobus by Dubé, Thériault and Dib (2011) found that proximity to the nearest BRT station increased housing prices from 2.9 percent to 6.9 percent.

Two students of systems in the U.S. evaluated price premiums of residential and both residential and commercial properties with respect to BRT proximity in Pittsburgh and Los Angeles, respectively. In their study of the Pittsburgh East Line, Perk and Catalá (2009) found that a single-family residential property 100 feet away from a BRT station realized a premium of $9,745 compared to the same property located 1,000 feet away. The second study of the Los Angeles BRT line a year after it opened in 2000 by Cervero and Duncan (2002) found that the BRT system conferred a small negative premium on residential property, but a positive premium on commercial property. The researchers cautioned that the absence of dedicated travel lanes, the newness of service and underlying distress may have accounted for lower property value (see also Loukaitou-Sideris and Banerjee, 2000).

In sum, assessments of BRT-related value premiums are limited mostly to residential property and mostly outside the U.S.

5.3 THE ASSOCIATION BETWEEN OFFICE RENTS AND PROXIMITY TO BRT CORRIDORS

Econometric analysis can be used to estimate the extent to which benefits of transit accessibility are capitalized by property. Usually, the observed sales price of property, or sometimes the assessed value of property, is used for these studies. Asking rents have also been used as they reflect current market conditions and thus do not suffer from the lag in reporting sales or appraisals. Where available, asking rents may be more efficiently assembled for cross-section analysis than using reported sales or appraisals of property (which can suffer from reporting inconsistencies between states and even among county assessors in the same state). As we are interested in understanding differences in capitalized values with respect to different transit systems in different states, and given data availability, we choose to employ hedonic analysis of asking rents for privately-owned rental property reported by CoStar during the first quarter of 2015.

By permission as it is used for research, we have access to CoStar's asking rent database for all the metropolitan counties noted earlier. To our knowledge, it is the largest database of its kind assembled to analyze the association between transit accessibility and market rents. In all, the database is comprised of more than 50,000 structures with more than 3 billion square feet of space in these metropolitan counties offered for rent in the first quarter of 2015. We use these data to estimate the association between location within 0.50 mile of a BRT corridor and office rents.

From literature, the standard hedonic model is generalized as:

$$\mathbf{R}_{\boldsymbol{i}} = \mathbf{f}(\mathbf{S}_{\mathbf{i}}, \mathbf{SES}_{\mathbf{i}}, \mathbf{P}_{\mathbf{i}}, \mathbf{U}_{\mathbf{i}}, \mathbf{L}_{\mathbf{i},}) \tag{5.1}$$

where:

R is the asking rent per square foot for property *i*;

S is the set of structural attributes of property *i* including its architecture, mass, height, age and effective age, interior amenities, flow efficiencies and so forth;

SES is the set of socioeconomic characteristics of the vicinity of property *i* such as population features, income, education;

P is a set of planning, zoning and other development restrictions applicable to property *i*;

U is a set of measures of urban form of the vicinity of property *i* such as the nature of surrounding land uses, terrain, physical amenities (such as parks), street characteristics and related; and

L is a set of location attributes of property *i* such as distance to downtown and other activity centers, distance to nearest major highways including freeway/expressway ramps, and distance to different public transit options.

Where these data can be assembled, ordinary least squares hedonic (regression) analysis can explain between one and three quarters of the variation in the observed rent for the properties in the sample. Because of resource constraints, our analysis necessarily excludes **SES**, **P** and **U** vectors, uses only indicators of **S** where reported in CoStar, and uses only some categorical measures of **L**. Nonetheless, an important feature of hedonic analysis is that despite missing attributes that could help explain more of the variation in market rents, the coefficients of reported variables used will nonetheless reveal an estimate of the willingness of the market to pay for them.

Resources, however, impose some analytic limitations. Notably, our budget did not provide for the considerable amount of time it would take to assemble details on individual buildings, census and socioeconomic data at the block-group level, planning decisions affecting individual properties, urban form measures, or distances of individual properties to the downtowns, freeway exits and other features. (See Nelson et al., 2015 for a sample of the data needed to evaluate just one metropolitan area—in their case Dallas.)

Our reduced model is comprised of these features:

R is the asking rent per square foot for property *i* reported by CoStar in the first quarter of 2015 for all properties in the metropolitan counties used in our study.

For **S**, and depending on CoStar data availability, our attributes for property *i* include (with predicted sign of association with rent)

Year the structure was built (+)
If the property was renovated (+)
Number of floors (+)
Vacancy rate (- as the higher the rate the less attractive the property may be)
Some regressions for specific real estate types will have additional structure attributes.

L is comprised of three attributes indicating whether property *i* is within one-half mile of any of the BRT, LRT and SCT corridor centerlines in our study.

In the individual metropolitan area analyses of office rents we include binary variables of major submarkets as defined by CoStar. As is customary, we do not predict the association between rent and location within these metropolitan county controls.

5.4 INDIVIDUAL METROPOLITAN AREA ANALYSIS

We apply our hedonic analysis of office rents to individual metropolitan areas with BRT systems. Because many metropolitan areas' BRT systems extend from downtown to suburban areas, we can estimate market premiums with respect to the metropolitan area as a whole, downtown and outside of downtown, much as we did above for office and retail rents. However, where a system just serves downtown—the case for the downtown Kansas City, MO, BRT system for instance—our analysis is limited to where service is provided. We report results for individual metropolitan areas in alphabetical order, offering key insights for each. We consider only metropolitan areas with just BRT systems. For instance, we do not include New York City, Chicago, Los Angeles, the San Francisco Bay Area or Phoenix because those metropolitan areas have multiple transit systems often intersecting with each other. We synthesize results at the end of this section.

5.4.1 Cleveland

For Cleveland, we test for the association between office rent and location within the BRT corridor of the HealthLine that extends from downtown to the medical centers east of downtown. Results are reported in Table 5.1. We find a substantial and significant rent premium amounting to about $2.44 per square foot, or about 18 percent of the mean asking rental price.

5.4.2 Eugene-Springfield

Table 5.2 reports results for the Eugene-Springfield Emerald Express (EmX) BRT system. We find the coefficient for location within 0.50 mile of a BRT corridor confers a positive rent premium of $1.93 per square foot, or about 12 percent of the mean office rent.

5.4.3 Kansas City

Kansas City has provided BRT service within downtown since the mid-2000s. Regression results, reported in Table 5.3, show an office rent premium of $2.67 per square foot, which is equivalent to about 18 percent of the mean office rent downtown.

5.4.4 Las Vegas

Las Vegas has been operating a BRT system connecting downtown to Nellis Air Force Base. Table 5.4 shows a positive office rent premium of $4.82 per square foot with respect to being within 0.50 mile of a BRT corridor for the metropolitan area as a whole—about 30 percent of the mean rent, and a similar premium of $4.85 per square foot for properties outside the downtown—about 31 percent of the mean rent. Although the coefficient for office rent downtown is positive, it is not significant. We note, however, that CoStar's downtown Las Vegas inventory is small (33 total), reflecting perhaps the dominance of owner-occupant tenants.

5.4.5 Pittsburgh

Pittsburgh has the world's second-oldest BRT system, with Curitiba, Brazil, being the first. It includes three lines serving the south, east and west parts of Allegheny County. Results are reported in Table 5.5. We see that for Allegheny County as a whole, office space within 0.50 mile of a BRT line enjoys a premium of $1.57 per square foot or about 9 percent of the mean. Outside downtown Pittsburgh, the premium rises to $2.30 per square foot, or about 14 percent of the mean. In the downtown area, however, there is no significant association between the BRT variable and office asking rent, though the sign is in the predicted direction.

Table 5.1 Office Rent Results for Downtown Cleveland, Ohio

Variable	Beta	Error	t-score	1-tailed p
Cleveland Downtown to Medical Center				
Constant	2.645	20.019	0.132	0.895
Class A	6.438	1.534	4.196	0
Class B	2.86	0.753	3.799	0
Floors	0.101	0.049	2.082	0.02
Year Built	0.003	0.01	0.286	0.388
Renovated	0.559	0.741	0.754	0.226
Vacant	-0.009	0.011	-0.839	0.202
Acres	0.183	0.198	0.921	0.18
BRT <=0.50 mile	2.438	1.141	2.137	0.018
N	113			
R2 adjusted	0.473			
F-ratio	13.567			

*p <0.10

Table 5.2 Office Rent Results for Eugene, Oregon

Variable	Beta	Error	t-score	1-tailed p	
Constant	-111.501	50.253	-2.219	0.033	
Class A	-4.549	3.736	-1.218	0.116	
Class B	-4.607	2.414	-1.908	0.033	*
Year Built	0.067	0.026	2.595	0.007	*
Renovated	2.47	4.209	0.587	0.281	
Vacant	-0.047	0.023	-2.056	0.024	*
Acres	0.133	0.119	1.119	0.136	
BRT <=0.50 mile	1.928	1.355	1.423	0.082	*
N	41				
R2 adjusted	0.248				
F-ratio	2.883				

*p <0.10

Table 5.3 Office Rent Results for Downtown Kansas City, Missouri

Variable	Beta	Error	t-score	1-tailed p	
Kansas City Downtown					
Constant	-12.073	37.039	-0.326	0.745	
Class A	5.099	2.017	2.528	0.007	*
Class B	0.44	1.276	0.345	0.366	
Floors	-0.045	0.065	-0.69	0.247	
Year Built	0.012	0.019	0.616	0.27	
Renovated	1.828	1.087	1.681	0.049	*
Vacant	0.006	0.014	0.387	0.35	
Acres	0	0.177	0.002	0.499	
BRT <= 0.50 mile	2.669	1.728	1.544	0.064	*
n	79				
R2 adjusted	0.168				
F-ratio	2.97				

*p <0.10

Table 5.4 Office Rent Results for Las Vegas, Nevada

Variable	Beta	Error	t-score	1-tailed p	
Metropolitan Las Vegas					
Constant	-194.665	34.952	-5.569	0	
Class A	5.697	1.054	5.404	0	*
Class B	0.536	0.515	1.04	0.149	
Floors	1.16	0.144	8.082	0	*
Year Built	0.104	0.018	5.878	0	*
Acres	0.077	0.036	2.151	0.016	*
Central East	0.736	2.562	0.287	0.774	
North LV	-2.547	2.675	-0.952	0.341	
Northwest	2.233	2.582	0.865	0.387	
Outlying NE	-4.183	3.12	-1.341	0.18	
LV-Henderson	-0.572	2.645	-0.216	0.829	
South LV	0.484	2.575	0.188	0.851	
SW LV	1.183	2.585	0.458	0.647	
West LV	-0.004	2.577	-0.002	0.999	
Downtown	0.725	3.057	0.237	0.813	
BRT <= 0.50 mile	4.806	1.534	3.133	0.001	*
n	955				
R2 adjusted	0.304				
F-ratio	28.721				
Las Vegas Downtown					
Constant	-365.804	195.542	-1.871	0.073	
Class A	4.367	10.778	0.405	0.345	
Class B	-5.104	4.113	-1.241	0.113	
Floors	0.208	1.32	0.158	0.438	
Year Built	0.192	0.1	1.928	0.033	*
Acres	0.147	5.118	0.029	0.489	
BRT <= 0.50 mile	6.554	7.779	0.843	0.204	
n	33				
R2 adjusted	0.174				
F-ratio	2.122				
Metropolitan Las Vegas Outside Downtown					
Constant	-205.807	36.305	-5.669	0	
Class A	5.658	1.047	5.407	0	*
Class B	0.689	0.514	1.339	0.091	*
Floors	1.295	0.15	8.618	0	*
Year Built	0.109	0.018	5.96	0	*
Acres	0.072	0.035	2.055	0.02	*
Central East	0.62	2.508	0.247	0.805	
North LV	-2.709	2.623	-1.033	0.302	
Northwest	2.041	2.53	0.807	0.42	
Outlying NE	-4.364	3.058	-1.427	0.154	
Henderson	-0.707	2.591	-0.273	0.785	
South LV	0.327	2.523	0.129	0.897	
SW LV	0.983	2.533	0.388	0.698	
West LV	-0.145	2.524	-0.058	0.954	
BRT <= 0.50 mile	4.849	1.576	3.077	0.001	*
n	922				
R2 adjusted	0.309				
F-ratio	30.406				

*p <0.10

Table 5.5 Office Rent Results for Pittsburgh, Pennsylvania

Variable	Beta	Error	t-score	1-tailed p	
Allegheny County					
Constant	-36.336	15.91	-2.284	0.023	
Class A	8.363	0.785	10.651	0	*
Class B	3.384	0.517	6.548	0	*
Floors	0.05	0.036	1.401	0.081	*
Year Built	0.026	0.008	3.216	0.001	*
Renovated	0.691	0.46	1.501	0.067	*
Vacant	-0.032	0.008	-4.033	0	*
Acres	0.072	0.052	1.379	0.085	*
CBD	-1.74	0.866	-2.008	0.045	
Monroeville	-1.979	1.139	-1.737	0.083	
North Pittsburgh	-2.527	0.807	-3.132	0.002	
NE Pittsburgh	-3.838	1.031	-3.724	0	
Parkway East	-3.156	0.759	-4.156	0	
Parkway West	-1.854	0.832	-2.229	0.026	
South Pittsburgh	-1.659	0.83	-1.997	0.046	
West Pittsburgh	-2.641	1.06	-2.492	0.013	
BRT <= 0.50 mile	1.571	0.736	2.135	0.017	*
n	423				
R2 adjusted	0.503				
F-ratio	27.657				
Pittsburgh Downtown					
Constant	-99.492	40.179	-2.476	0.019	
Class A	6.165	3.494	1.765	0.044	
Class B	3.04	1.714	1.774	0.043	
Year Built	0.059	0.02	2.872	0.004	*
Renovated	1.87	1.751	1.068	0.147	
Vacant	-0.009	0.028	-0.332	0.371	
Acres	0.074	0.135	0.551	0.293	
BRT <= 0.50 mile	0.349	1.548	0.226	0.412	
n	40				
R2 adjusted	0.293				
F-ratio	3.312				
Allegheny County Outside Downtown Pittsburgh					
Constant	-22.003	18.653	-1.18	0.239	
Class A	9.316	0.817	11.404	0	*
Class B	3.847	0.552	6.966	0	*
Floors	0.062	0.036	1.707	0.045	*
Year Built	0.018	0.009	1.849	0.033	*
Renovated	0.63	0.489	1.289	0.099	*
Acres	0.108	0.063	1.73	0.043	
Monroeville	-0.628	1.056	-0.595	0.553	
North Pittsburgh	-0.821	0.709	-1.158	0.248	
NE Pittsburgh	-2.289	0.934	-2.451	0.015	
Oakland	1.23	1.432	0.859	0.391	
Parkway East	-1.703	0.716	-2.379	0.018	
Parkway West	-0.377	0.751	-0.502	0.616	
West Pittsburgh	-1.246	0.962	-1.296	0.196	
Downtown	-1.382	1.232	-1.122	0.263	
BRT <= 0.50 mile	2.295	0.934	2.457	0.007	*
n	385				
R2 adjusted	0.5				
F-ratio	26.557				

*p <0.10

5.5 REVIEW AND IMPLICATIONS

BRT generally has important associations with office rents within 0.50 mile of BRT lines. Table 5.6 summarizes outcomes for each geographic area evaluated. The statistically significant coefficients indicate that being within 0.50 mile of a BRT line increases asking office rents from $1.57 to $4.85 per square foot, or about 14 percent to 31 percent of the mean.

Table 5.6 Summary of BRT Corridor Location and Office Rents

System	Central County	Downtown	Outside Downtown
Cleveland		$2.44	
Eugene-Springfield		$1.93	
Kansas City		$2.67	
Las Vegas	$4.81	+	$4.85
Pittsburgh	$1.57	+	$2.30

Note: “+” means predicted direction of association but statistically insignificant coefficient

We are moderately impressed with results for downtowns. Though the coefficients for downtown Las Vegas and Pittsburgh were not statistically significant, they had the predicted signs. The current popularity of building streetcars downtowns is dampened somewhat by its high cost of construction. In contrast, if BRT systems have comparable economic development outcomes but are less costly to build, they may be worth considering in future downtown transit planning.

6.0 EXPRESS BUSWAYS AND ECONOMIC DEVELOPMENT: CASE STUDY OF THE SOUTH MIAMI-DADE BUSWAY

6.1 INTRODUCTION

There is a considerable, growing literature on the association between numerous forms of fixed-guideway transit systems and economic development. Types of systems include heavy or fifth rail, light rail, streetcar, and bus rapid transit modes. We note a recent, exhaustive review of literature by Higgins and Kanaroglou (2015) pertaining to the contribution of rail transit to property values, which by implication includes economic development. Another recent work reports economic development outcomes to several types of fixed-guideway transit systems by the Institute for Transportation and Development Policy (2013). An earlier work by Belzer et al. (2011) assesses the change in jobs by economic sector for several types of fixed-guideway transit systems through the 2000s. None of those works address the role of express busways and economic development. We help close this gap in the literature.

6.2 WHAT EXPRESS BUSWAYS ARE AND ARE NOT

Unfortunately, some key literature confused types of bus-related services. Notably, TCRP Report (Levinson et al., 2003) offers these examples of bus rapid transit in the U.S. that we contend are better defined as express bus service (Levinson et al., 2003: 36):

- HOV busway
- Freeway HOV lanes have express bus service and stations
- Busway along abandoned railroad line
- Express buses use contra-flow bus lanes on freeway
- Peak-period freeway bus lane busway with stations along unused railroad

The last example is of the South Miami-Dade Busway. But are these really examples of BRT in current practice? Consider that in recent years, bus rapid transit has come to be characterized as comprising the following elements, adapting from work by Nikitas and Karlsson (2015: 2):

- **Unique buses** that contribute significantly to BRT's image and identity;
- **Stops, stations, terminals and corridors** that clearly define the BRT operating area;
- **Variety of rights-of-way** such as intersection signalization priority, dedicated lanes, and potentially separation from other surface street traffic;
- **Pre-board fare collection** that economizes on boarding time;
- **Information/communication technologies** to improve experience at platform and bus;
- **Substantial day time service** ideally >16 hours per day, peak frequencies <10 minutes;
- **Brand identity** that distinguishes BRT from all other forms of transit.

While many express bus services have the same features, there is an important difference. In our view, express bus services do not principally operate on surface streets. They instead operate substantially (though perhaps not exclusively) in freeway high-occupancy-vehicle lanes, abandoned railroads and other abandoned transportation routes, or other means not associated with regular streets. Put differently, where bus rapid transit operates substantially on surface streets, though ideally within dedicate travel lanes and synchronized intersections, express bus service operates substantially on entirely separate conveyances. There is a second distinction: where BRT has evolved does not rely substantially on park-and-ride stations, and express bus service does.

Our distinctions may be subtle but they are important because, without clarity, attempts to measure such things as economic development outcomes may be compromised. In this particular context, we are interested in knowing whether express bus service per se may be associated with economic development. We explore this proposition in our paper. We use the South Miami-Dade Busway as our case study.

6.3 THE SOUTH MIAMI-DADE BUSWAY

The South Miami-Dade Busway, began in 1997, is an eight-mile, two-lane roadway designed for exclusive use by buses and emergency vehicles along a former railroad right-of-way running parallel about 100 feet from US 1 (Baltes, Perk, Perone and Thole, 2003).

The Busway is now a 20-mile, dedicated bus-only facility adjacent to US 1 that operates 24 hours each day, seven days each week over the entire year. Vehicular access to the Busway is currently limited to Miami-Dade Transit Buses and emergency vehicles. The Busway runs in a southwest to northeast orientation and lies within a right-of-way that is typically 100 feet in width. Currently, six local and limited-stop bus routes operate on the Busway. Within its right-of-way, the Busway contains the South Dade Greenway (Greenway). The Greenway is an at-grade, 10-foot wide, pedestrian/bicycle path that generally runs adjacent and parallel to the west side of the Busway.

Since the late 1980s, the State of Florida has required local governments to engage in comprehensive planning to achieve multiple objectives such as coordinating transportation and land use planning to advance economic development (Arrant, 2012). Since then, Miami-Dade County has prepared and amended land use plans that explicitly target transit stations for mixed-use development and especially economic development (Miami-Dade Government, 2015).

For its part, two major efforts to stimulate economic development along the South Miami-Dade Busway include both its designation as a rapid transit corridor in the County's Comprehensive Development Master Plan (CDMP) as well as the designation of various urban centers along the Busway to encourage mixed-use compact development at key activity nodes.

Accordingly, the county's CDMP designates the existing Busway as a rapid transit corridor. It is the policy of the Board of County Commissioners, through the CDMP, that of establishing transit supportive land uses along the designated rapid transit corridors. The CDMP thus designates the area surrounding major rapid transit stations as urban centers and the corridors between stations as mixed-use corridors. The CDMP provides both policy and interpretative language that guide the planning and development of these urban centers and corridors. It provides for significantly higher densities and intensities and variety of land uses within these designated areas with the dual purpose of generating additional transit ridership and to establish pedestrian-friendly urban centers, which over time will serve as hubs of activities for the surrounding communities.

The seven urban centers designated by the CDMP along the Busway are: Downtown Kendall, Perrine, Cutler Ridge, Goulds, Princeton, Naranja and Leisure City. Since 1998, the county has conducted area plans (charrettes) for each of these urban centers. The purpose of the area plans was to develop a community vision of the CDMP policies. During these planning efforts, the communities aided in the design of transit-supportive, pedestrian-oriented development that is compatible and responsive to the current bus rapid transit service along the Busway as well as a potential future upgrade of that service to light rail or heavy rail. The collective community vision for these urban centers has resulted in vertical development of varied intensities along both sides of the Busway that is connected by an improved street grid and dotted with new open spaces. This development pattern illustrates the highly urban form described by the policies and interpretative text of the CDMP.

The area planning efforts along the Busway culminated in February of 2012 when the last of the urban centers (Leisure City) was rezoned by the Board of County Commissioners. Thus, all the Busway urban centers are now regulated by the county's urban center districts and the Standard Urban Center District regulations. These "small area plans and ordinances" are aimed in substantial part to facilitate economic development at transit stations (Miami-Dade Government, 2014).

Figure 6.1 Miami-Dade Transit Park & Ride Parking Lot; Source: provided to the author

The South Miami-Dade Busway is thus more than a means to connect riders to Metrorail—in our view transportation and land use planning aims to make it an economic development opportunity. In the context of express service, are these efforts effective in advancing economic development? We turn now to a review of the data and methods we use to address this question.

6.4 DATA AND METHODS

For our analysis, we rely on the Longitudinal Employment-Household Database (LEHD) for 17 of the 20 two-digit North American Industrial Classification Scheme (NAICS) economic sectors. We exclude agriculture, mining and construction because those workers do not normally occupy building spaces in urban areas. We use LEHD data for 2002 (when the data first became available) through 2011. Though LEHD data are available at the census block level, we aggregate to the block group. We compare change between the central county (CC) – being Miami-Dade County, and the block groups whose centroids are within 0.50-mile Busway stations. For our analysis, we combine the 17 urban-related, space-occupying sectors into eight categories in the manner shown in Table 6.1. This is similar to the combinations used by others (Levinson, Zimmerman, Clinger, Rutherford, Smith, Cracknell and Soberman, 2003).

Table 6.1 Combinations of NAICS Sectors for Analysis

Manufacturing
Manufacturing
Industrial
Utilities
Wholesale Trade
Transportation and Warehousing
Retail-Accommodation-Food Service
Retail Trade
Accommodation and Food Services
Knowledge
Information
Professional, Scientific, and Technical Services
Office
Finance and Insurance
Real Estate and Rental and Leasing
Management of Companies and Enterprises
Administrative and Support and Waste Management and Remediation Services
Other Services (except Public Administration)
Public Administration
Education
Educational Services
Health Care
Health Care and Social Assistance
Art-Entertain-Recreation
Arts, Entertainment, and Recreation

We use shift-share analysis because it assigns the change or shift in the share or concentration of jobs with respect to the region, other economic sectors and the local area. The "region" can be any level of geography and is often the nation or the state. In our case, where we want to see whether there are intra-metropolitan shifts in the share of jobs by sector, our region is the CC of the metropolitan area. The "local" area is often a city or county or even state, but it can be any geographic unit that is smaller than the region. Our local areas are block groups within 0.50 mile of the nearest Busway station; we call this the Busway Station Area. As shifts in the share of jobs may vary by sector over time because of changes in economic sector mixes, there is also an "industry mix" adjustment that we call the Sector Mix. Using notations by the Carnegie Mellon Center for Economic Development (undated), the shift-share formula is:

$$\mathbf{SS_i = CC_i + Busway} \tag{6.1}$$

Where:

SSi = Shift-Share

CCi = Central County share

SMi = Sector Mix

Buswayi = Busway Station Area shift

The CC share measures by how much total employment in a Busway station area changed because of change in the metropolitan area economy during the period of analysis. If metropolitan area employment grew by 10 percent during the analysis period, then employment in the Busway station area would have also grown by 10 percent if there is no Busway effect. The Sector Mix (SM) identifies fast-growing or slow-growing economic sectors in a Busway station area based on the CC growth rates for the individual economic sectors. For instance, a Busway station area with an above-average share of the metropolitan area's high-growth sectors would have grown faster than a Busway station area with a high share of low-growth sectors. The Busway station area shift, also called the "competitive effect," is the most relevant component; it identifies a Busway station area's leading and lagging sectors. The competitive effect compares a Busway station area's growth rate in a given economic sector with the growth rate for that same sector in the metropolitan area. A leading sector is one where that sector's Busway station area growth rate is greater than its metropolitan area growth rate. A lagging sector is one where the sector's Busway station area growth rate is less than its CC growth rate.

The equations for each component of the shift-share analysis are:

$$\mathbf{CC} = ({}_{i}\mathbf{Busway\ station\ area}^{t-1} \bullet \mathbf{CC}^{t} / \mathbf{CC}^{t-1})$$

$$\mathbf{SM} = [({}_{i}\mathbf{Busway\ station\ area}^{t-1} \bullet {}_{i}\mathbf{CC}^{t} / {}_{i}\mathbf{CC}^{t-1}) - \mathbf{CC}]$$

$$\mathbf{Busway} = [{}_{i}\mathbf{Busway\ station\ area}^{t-1} \bullet ({}_{i}\mathbf{Busway\ station\ area}^{t} / \mathbf{iBusway\ station\ area}^{t-1} - {}_{i}\mathbf{CC}^{t} / \mathbf{iCC}^{t-1})] \quad (6.2)$$

Where:

iBusway station area^{t-1} = number of jobs in the Busway station area sector (i) at the beginning of the analysis period (t-1)

iBusway station area^{t} = number of jobs in the Busway station area in sector (i) at the end of the analysis period (t)

CC^{t-1} = total number of jobs in the central county at the beginning of the analysis period (t-1)

CC^{t} = total number of jobs in the central county at the end of the analysis period (t) iCC^{t-1} = number of jobs in the central county in sector (i) at the beginning of the analysis period (t-1)

iCC^{t} = number of jobs in the central county in sector (i) at the end of the analysis period (t)

We apply shift-share analysis to the system of South Miami-Dade Busway stations over the period 2002-2011, or the entire period for which LEHD data were available for our analysis.

However, shift-share analysis by itself does not necessarily ascribe a causal relationship, merely an associative one. In addition, to control for the counter-factual – that is, that development (or lack thereof) would have occurred anyway—we devised an algorithm in ArcGIS to identify 10 alternative locations having comparable attributes to each existing station at the beginning of our study period—2002 (Kim, 2015). We adjust the notation above by substituting “CF,” our counter-factual block groups, for “Busway.” We caution that though this improves causal inference, we are conservative in concluding only associative ones.

6.5 RESULTS

We present our results in Table 7.2. Over the study period, the Busway station areas gained share of jobs (+59.1 jobs per Busway block group) while the counter-factual locations lost share (-57.5 jobs per block group). We note the following Busway positive shifts relative to the CC that are negative with the counter-factual locations:

- Manufacturing
- Industrial
- Retail-Lodging-Food
- Office
- Education

While both the Busway station areas and counter-factual locations had positive outcomes with respect to the knowledge sectors, the Busway station areas gained about 2.5 times more share.

6.6 SUMMARY AND IMPLICATIONS

Using shift-share analysis we find that the South Miami-Dade Busway is associated with substantially improved economic development when compared to the central county as well as counter-factual locations. We surmise that, on the whole, the Busway system contributed to economic development; that is, economic development may not have happened without it.

To an important extent, we surmise the market appears to respond to Busway investments. Where they improve access to employment centers along their routes and where there are opportunities for redevelopment, the Busway appears to facilitate economic development. We also surmise that planning has been effective in generating positive economic development outcomes associated with Busway investments (Nelson, 2014). We note that planning is likely needed to assure market-feasible development opportunities, while incentives are needed to help offset the additional cost of redeveloping otherwise problematic sites lest new development is lured to lower-cost land elsewhere that may impose higher social, environmental and economic costs on metropolitan areas (Nelson, 2013).

Table 6.2 Miami-Dade South Busway Shift-Share Results

Busway Block Groups **Sector**	**Busway 2002**	**Busway 2011**	**CC 2002**	**CC 2011**	**Busway Change**	**CC Change**	**CC Share**	**SM Share**	**Busway Shift**
Manufacturing	37.3	32.5	24.5	19.2	-13.0%	-21.9%	35.3	-6.2	3.3
Industrial	59.2	55.7	91.5	85.6	-6.0%	-6.5%	56.1	-0.7	0.3
Retail-Lodging-Food	334.0	394.1	124.4	147.0	18.0%	18.1%	316.3	78.3	-0.5
Knowledge	75.3	89.2	59.5	53.1	18.4%	-10.7%	71.3	-4.1	21.9
Office	192.0	223.0	142.1	148.5	16.1%	4.5%	181.8	18.8	22.3
Education	3.1	16.9	57.1	58.2	447.4%	2.0%	2.9	0.2	13.7
Health Care	47.0	57.5	71.8	92.0	22.4%	28.2%	44.5	15.7	-2.7
Arts-Entertain-Recreation	4.9	5.6	8.1	8.0	13.0%	-1.4%	4.7	0.2	0.7
Total	752.9	874.3	579.0	611.5	16.1%	5.6%	712.9	102.3	59.1
Counter-Factual Block Groups									
Sector	**CF 2002**	**CF 2007**	**CC 2002**	**CC 2011**	**CF Change**	**CF Change**	**CC Share**	**SM Share**	**CF Shift**
Manufacturing	32.7	19.0	24.5	19.2	-42.0%	-21.9%	30.9	-5.4	-6.6
Industrial	86.5	64.0	91.5	85.6	-26.0%	-6.5%	81.9	-1.1	-16.9
Retail-Lodging-Food	130.3	149.6	124.4	147.0	14.8%	18.1%	123.4	30.6	-4.4
Knowledge	88.9	87.9	59.5	53.1	-1.1%	-10.7%	84.2	-4.8	8.5
Office	204.8	187.5	142.1	148.5	-8.4%	4.5%	193.9	20.1	-26.5
Education	219.9	206.4	57.1	58.2	-6.2%	2.0%	208.3	16.0	-17.9
Health Care	113.3	151.0	71.8	92.0	33.3%	28.2%	107.3	37.9	5.8
Arts-Entertain-Recreation	11.2	11.3	8.1	8.0	1.5%	-1.4%	10.6	0.4	0.3
Total	887.6	876.7	579.0	611.5	-1.2%	5.6%	840.5	93.7	-57.5

7.0 BUS RAPID TRANSIT AND LOCATION AFFORDABILITY

7.1 INTRODUCTION

Conventional theory of location and land use, especially residential location, in post-World War II, automobile–dominant, American metropolitan areas has household demand for location as a function of income, household size. and location costs. That is, the transportation costs associated with accessing work, shopping, services, recreation and other purposes from a prospective home. House and lot size increased the farther from centers one went. At some point, a household achieved equilibrium where preference for housing and neighborhood attributes were maximized given location costs. Conventional models of location and land use decisions (Alonso, 1964; Mills, 1967; Muth, 1969), however, did not consider lenders' underwriting standards, which often capped principal-interest-taxes-insurance payments at 28 percent of the household's income available to service a mortgage.

By failing to consider location costs in the mortgage underwriting decision, lenders induce households to purchase homes farther away from centers than they may have chosen otherwise, resulting in more land-extensive development patterns across America's metropolitan landscapes. Combined with the ability to deduct mortgage interest against taxable income, the practice in most states to undervalue owner-occupied homes for property tax assessment purposes, average-cost pricing of utility services resulting in high-cost areas paying less than their costs with low-cost areas paying more, and heavily subsidized highway investments, among other actions (Pamela Blais, 2010), led to inefficient land use patterns. Some call it sprawl.

In recent years a growing body of literature has argued that housing and transportation costs need to be considered together when considering housing affordability. Ewing and Hamidi (2015) note that HUD's definition of affordability—where no more than 30 percent of a household's income would be spent on housing—along with indexes of others are "structurally flawed in that they only consider costs directly related to housing, ignoring those related to utilities and transportation" (Ewing and Hamidi, 2015). The 2013 Consumer Expenditure Survey, for instance, reports that total housing costs consume 33.6 percent of income while transportation costs consume another 17.6 percent for a total H+T of 51.2 percent. If a household's transportation costs could be reduced by half, however, it would not be able to acquire a mortgage for a more expensive home in a more efficient location that capitalizes on the savings, even though it would not be economically worse off.

Conceptually, transportation cost savings are realized by locating in or near such places as downtowns, mixed-use developments and transit stations. Studies only estimate these savings in two ways. First, a suite of studies based on work by the Center for Neighborhood Technology uses secondary data to estimate the share of trips by mode and household type at the block group, and then derive vehicle miles traveled through inferences based on other secondary data. The actual distance from block groups to such points as downtowns and transit is not estimated directly. For several household types, CNT's studies estimate housing costs that are constant across large geographies such as counties while transportation costs vary by block group.

Another set of studies use hedonic regression analysis to estimate the variation in real estate values with respect to distance from such points as the downtown center and transit stations. Higgins and Kanaroglou's (2015) review of 40 years of literature on market responsiveness to transit investment provides a thorough review of the models, methods and outcomes using this technique. Transportation costs per se are not included in any of those studies.

We know of no research that estimates variation in transportation costs spatially. Our study helps close this gap. Our particular interest is in knowing whether and the extent to which proximity to transit stations affects the share of transportation costs incurred by households. If so, the finding may help explain part of the capitalization effect numerous studies find with respect to residential property values and rents. It may also add new information to the discussion on the relationship between housing affordability and transportation costs as a function of transit station proximity. In establishing this relationship, we will also explore similar relationships with respect to distance from downtown and freeway interchanges.

We begin with a discussion of our analytic approach, model and data. We then report results and interpretations. We finish our article with implications for planning and housing policy, and future research.

7.2 ANALYSTIC APPROACH, MODEL AND DATA

As modeling depends on the availability and nature of data, we start with a general discussion of our data with details presented in the context of individual variables below.

Our aim is to measure the variation in household transportation costs with respect to distance from bus rapid transit (BRT) stations. Fortunately, HUD's Location Affordability Index (LAI) includes a block group-level database of all metropolitan counties in the U.S. It includes estimates of median household transportation costs for the year 2010 (U.S. HUD, 2015). Among the several household types for which estimates are made, we use figures for the "regional typical" household. The methodology is transparent and consistently applied to all block groups. We use other data for 2010 as described below.

Because our main interest is the variability of transportation costs with respect to BRT stations, we apply our analysis to all 12 BRT lines operating in the U.S. in 2010. For each system, we construct a database geocoding all BRT stations and then measuring their distance to the centroids of the nearest block group. Our study area is 20 miles from the CBD of each BRT system.

We use the standard-form ordinary least squares regression model adapted for our purposes:

Transportation Cost Share = ***f(Income, Minority and Household Type, Tenure and Vacancy, Jobs-Housing Ratio, Metropolitan Controls, Location)***

(5.1)

Transportation Cost Share is the dependent variable. It is defined as the percent of median household income consumed by transportation costs for the regional typical household at the block group-level in 2010.

Income, Minority Status and Household Type is a vector estimating transportation costs as a share of median household income, minority affiliation and household type. Income is from the five-year ACS for block groups. As median houshold income increases, the share of its income used for transportation falls (Lipman, 2006). We hypothesize a negative association between median household income and transportation costs.

We include percent block-group households whose householders are other than white non-Hispanic, calling them ***Minority Householder Share***. Data are from the five-year ACS for block groups. We suspect that minority households will spend a higher share of income on transportation. The reason is that minority households are segregated away from key destinations such as work (Galster and Cutsinger, 2007).

In addition to income, transportation costs vary by household type. In assessing motivations to move, household satisfaction, mode journey-to-work and other factors, Emrath and Siniavskaia (2009) allocate households by married couples with and without children, single parents, single persons, and all others. We adapt their scheme to estimate the share of median household income consumed by transportation costs based on the share of block-group households reported in the five-year ACS for block groups that have children, have two or more adults without children, and single persons. Because it has the highest median household income, our model excludes two-or-more-adult households without children (the referent). The operational variables are ***Percent HHs with Children and Percent Single-Person HHs***. Compared to the referent household group, we expect households with children to spend more on transportation while single-person households will spend less as a share of household income.

The **Tenure and Vacancy** vector relates to key measures of housing at the block-group level. One measure is the ***Homeownership Rate*** and a second is the ***Residential Vacancy Rate***. In most metropolitan areas, the homeownership rate increases with respect to distance from downtowns, but it also means transportation costs rise as well. We expect a positive association between the block-group homeownership rate and share of median household income applied to transportation costs. Likewise, as vacancy rates for all residential units tend to increase with respect to distance from downtowns, we expect a positive association between block-group residential vacancy rates and share of median household income at the block-group level consumed by transportation. We use block-group data from the five-year ACS for these variables.

Stoker and Ewing (2014) show that the higher the ***Jobs-Housing Ratio*** the lower the transportation costs as a share of median household income at the block level. The reasoning is that more plentiful job opportunities closer to home increase the chances of working closer to home. Also, some households will self-select to live closer to work if job and housing opportunities are proximate. We expect a negative association between share of income spent on transportation and the block group's jobs-housing ratio. For jobs, we use data from the Longitudinal Employment Dynamics (LED) database published by the Census Bureau at the block-group level for 2010. Total jobs from the LED are the numerator and total occupied housing units from the five-year ACS are the denominator.

As our analysis includes all 12 BRT lines operating in 2010, we need to include **Metropolitan Controls** to capture the unique contributions of the central county of each metropolitan area to our regression equation. We use the smallest central county, Lane County, OR (the Eugene-Springfield BRT systems), as our referent. We have no a priori expectations of the direction of associations with respect to any given metropolitan area.

The experimental vector estimates the association between block-group **Location** and share of median household income consumed by transportation based on three location measures. We measure the centroids of each block group to the center of the CBD, nearest freeway interchange, and nearest BRT station. In all cases, we expect a positive association between distance from these locations and share of median household income spent on transportation. That is, the farther away a block group is from these locations the higher the transportation costs as a share of income.

For the **CBD Distance** and **BRT Distance** variables, we include quadratic transformations of the distance measure. This allows us to estimate the distance from those points where transportation costs as a share of household income peak. Only the linear version of the **Freeway Distance** variable provided a significant direction of association consistent with expectations.

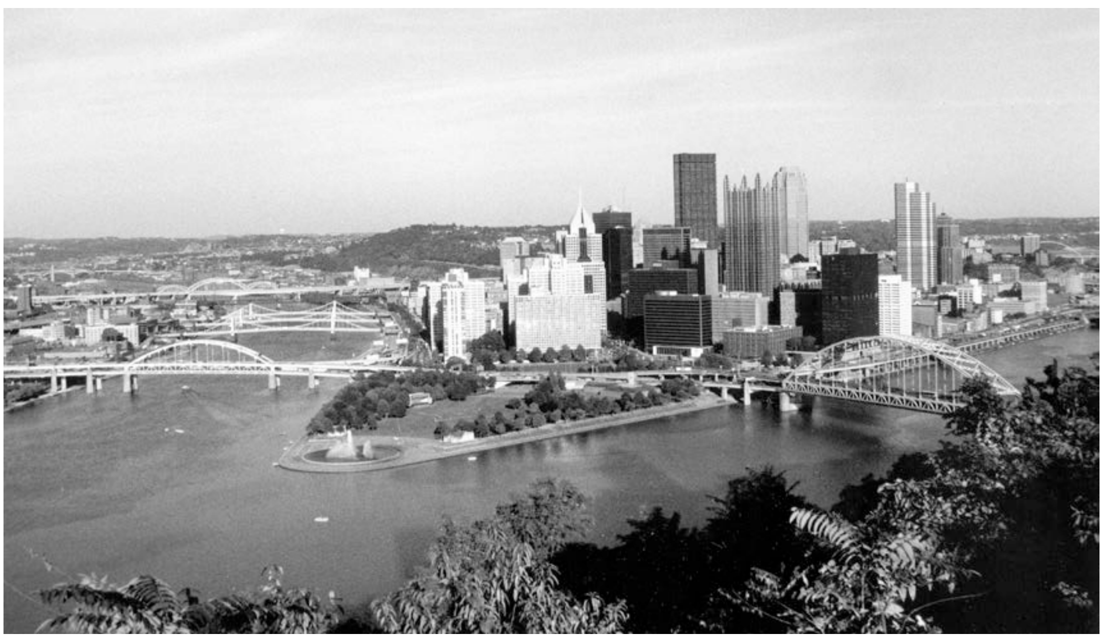

Figure 5.1 The Central Business District of Pittsburgh, Pennsylvania. The Location of the Nation's First BRT Line.

7.3 RESULTS AND INTERPRETATIONS

Table 7.1 reports our regression results. The model is robust as it explains more than 90 percent of the variation in transportation costs as a share of median household income among more than 12,000 block groups across the nine central counties within which the 12 BRT systems operate. With few exceptions, the coefficients for all variables are significant and in the correct directions. Except for the metropolitan controls, we interpret the performance of variables within each of the other control vectors briefly. We then discuss outcomes of the experimental—**Location**—variables in some detail.

Table 7.1 Household Transportation Cost Variation with Respect to Distance from Bus Rapid Transit Stations

Variable	**Beta**	**Error**	
Constant	25.339	0.133	*
Income, Minority and Household Type			
Median HH Income	0.000	0.001	*
Minority Householder Share	0.001	0.002	**
Percent HHs with Children	0.000	0.002	
Percent Single-Person HHs	-0.045	0.001	*
Tenure and Vacancy			
Home Ownership Rate	0.067	0.001	*
Residential Vacancy Rate	-0.001	0.002	
Jobs-Housing Ratio			
Jobs-Housing Ratio	0.001	0.000	*
Metropolitan Controls—Central Counties			
Maricopa (Phoenix MSA)	-8.186	0.086	*
Los Angeles (Los Angeles MSA)	-10.797	0.082	*
Jackson (Kansas City MSA)	-9.03	0.155	*
Clark (Las Vegas MSA)	-7.56	0.083	*
Bronx (New York City MSA)	-13.295	0.093	*
Cuyahoga (Cleveland MSA)	-5.859	0.085	*
Allegheny (Pittsburgh MSA)	-6.287	0.082	*
Salt Lake (Salt Lake City MSA)	-9.787	0.086	*
Location			
Freeway Interchange Distance	0.107	0.010	*
CBD Distance	0.228	0.010	*
CBD Distance Squared	-0.006	0.000	*
BRT Distance	0.017	0.006	*
BRT Distance Squared	0.001	0.000	*
Regression Summary		**Metric**	
Dependent: Transportation Costs as Share of HH Income			
Analytic unit: Census block groups, 2010			
Number of observations		12,379	
Adjusted R2		0.931	
F-ratio		8393.359	
F-significance		0.000	
* p < 0.01, one-tail			
** p < 0.05, one-tail			
Distance from CBD maxima		-19.00	

Distance from BRT Station maxima	-8.50

Our analysis indicates that the higher the median household income the higher the share of transportation costs incurred by the household. While somewhat inconsistent with the literature (Fan and Huang, 2011) the very small size of the coefficient renders this outcome essentially trivial. We also find that even controlling for income and household composition (discussed in detail below), households with minority householders incur higher transportation costs as a share of income than non-minority households. This is consistent with our interpretation of Galster and Cutsinger).

Compared to the block group share of households with two or more adults without children, single-person households spend a smaller share of their incomes on transportation while households with children spend more. This is consistent with other research. Emrath and Siniavskaia (2009), for instance, find that married couples with children, as well as single-parent households, had longer commutes in terms of distance and time, and owned more cars than single-person households. Married couples without children had comparable commutes and cars as married couples with children, but from the consumer expenditure survey we also know they earn higher incomes so their transportation cost shares would be lower (Haas, Makarewicz, Benedict and Bernstein, 2008).

Our analysis confirms that homeowners spend more on transportation as a share of their income than renters (Reichenberger, 2012). One reason may be that America's conventional home mortgage underwriting standards limit mortgages to about 28 percent of a household's expenditures for the home but do not consider transportation costs. Economic savings attributable to location thus cannot be capitalized into higher home mortgages. The result is that households often "drive to qualify" (Gallagher, 2014). But there is a downside to this: as total housing plus transportation costs are higher farther away from centers, the overall market for more distant housing weakens with the consequence that vacancy rates for all residential property tend to rise with respect to distance from centers.

In addition to providing an updated literature review generally on the concept of jobs-housing balance, Stoker and Ewing (2014) use ACS journey-to-work data to determine that "more people live and work in the same commute shed if there is job–worker balance and income matching" (p. 485). Unexpectedly, more jobs with respect to housing units in a block group are associated with a very small, arguably trivial increase in the share of household income devoted to transportation costs.

Our analysis includes estimates of the association between three different metropolitan locations and the share of household income consumed by transportation. Those controls were distance from the CBD, distance from the nearest freeway interchange, and distance from the nearest BRT station.

It should not be necessary to assert that the farther one lives from a downtown the higher their transportation costs. This is the foundation of pioneering urban spatial economic theories (Alonso, 1964; Mills, 1967; Muth, 1969). Redding and Turner (2014) update the key literature of this genre, offering several insights based on empirical work such as "… highways cause the decentralization of economic activity … (and)… cause a dramatic increase in driving…" (p. 35).

While we find what should be expected—that household transportation costs increase as a share of income the farther they live from downtowns, we also find something that is not often reported in literature: The distance-decay function extends about 19 miles based on the mean from our universe of all block groups in the nine central counties where 12 BRT systems operate. This is the utility of the quadratic transformation of the distance variable.

Similarly, we find that transportation costs as a share of income increases with respect to distance from freeway interchanges, though we could not find a significant association using the quadratic specification.

Of central interest to us is whether and the extent to which transportation costs as a share of income increases with respect to distance from BRT stations. Over the years there have been numerous studies reporting that residential property values increase the closer they are to BRT stations, which is an implicit measure of transportation costs as savings that are presumably capitalized (Higgins and Kanaroglou, 2015). Based on the regression equation, we find that household transportation costs as a share of income increases with respect to distance from BRT stations to about eight miles away.

7.4 IMPLICATIONS FOR PLANNING AND HOUSING POLICY, AND FUTURE RESEARCH

That households' share of income devoted to transportation increases with respect to BRT stations to about eight miles elicits two important policy implications from us.

First, our findings may be used to relax early efforts to calibrate location-efficient mortgages (LEM). For the most part, the LEM calculations were weighted substantially toward the central business district. Considering just this limitation, research by Blackman and Krupnick (2001) conclude that LEMs do not raise mortgage default rates and should be weighed against anti-sprawl benefits they may offer (Hicky, Lubell, Haas and Morse, 2012). We suspect default rates will be lower the closer properties are to BRT stations. Further research may explore the relationship between proximity to BRT stations, if not all fixed-guideway transit stations and foreclosure rates.

Second, assumptions about planning land uses around BRT stations if not all fixed-guideway transit stations may need to be relaxed. The so-called half-mile circle planning area has already been challenged through a case study of the Salt Lake County light rail transit system, which finds that LRT stations confer a market value on apartments to more than one mile (Petheram, Nelson, Miller and Ewing, 2013). Some of us have also found that office rents capitalize on proximity to LRT stations in metropolitan Dallas to nearly two miles (Nelson, Eskic, Hamidi, Petheram, Ewing and Liu, 2015). Our empirical analysis suggests that BRT station-planning protocols may need to extend many miles from stations. Not that station planning areas need to extend up to eight miles, but station accessibility strategies might be reconsidered given the evidence suggesting that households realize important transportation cost savings within that distance.

The nation will add about 100 million people between now and mid-century. Nelson (2013) has estimated that about a quarter of American households want to live near fixed-guideway transit opportunities, though less than 10 percent have those options now. Perhaps one reason is that Americans understand the cost savings associated with living near transit stations. Yet, even if all new homes built between now and mid-century were built near existing or planned fixed-guideway transit stations, including BRT stations, the demand for living near those stations would still not be met.

8.0 BUS RAPID TRANSIT AND WAGE-RELATED JOB CHANGE

8.1 Introduction

Scholars and civil rights organizations assert that America's transportation policies perpetuate social and economic inequity. Sanchez and Brenman (2008), for instance, show that highway-based transportation investments limit low-income and people-of-color access to education, jobs and 55 services. Echoing their concern is the Leadership Conference Education Fund (Leadership Conference Education Fund, 2011a; 2011b), a civil rights organization which asserts that low-wage jobs are inaccessible to those who are transit-dependent. Public transit is seen as one way to connect people to low-wage jobs, reduce poverty, increase employment, and help achieve social equity goals (Blumenberg and Manville, 2004; Sen, Metaxatos, Soot and Thakuriah, 1999).

In recent decades, such transit has included bus rapid transit (BRT) systems. A growing number of studies report a relationship between new rail transit investment and job growth (Nelson, M. Miller, Ganning, Stoker, Liu and Ewing, 2014). But do rail transit investments attract lower-wage jobs? To this question we add: do rail transit investments change the share of jobs in a region across multiple wage groups?

Our paper addresses this question. It begins with a review of literature on the relationship between BRT and change in jobs by wage level. We then evaluate the change in jobs by wage level between BRT station areas and their larger regions – in this case, the central counties within which they operate. To control for the counter-factual – that the changes would have occurred anyway—we identify locations that were comparable to BRT station areas at the base year of our analysis. We further divide our analysis into periods before the Great Recession (2002 to 2007—or 2004 in the case of Phoenix for reasons noted below) and during recovery (2008 through 2011). We conclude with planning and policy implications.

8.2 LITERATURE

Fan, Guthrie and Levinson (2010) provide an especially pertinent review of literature addressing our question. Citing Kain's (1968) pioneering work, they observe that the urban poor are harmed for want of affordable housing near job opportunities and reliable public transit to connect them to those jobs (Blumenberg, Ong and Mondschein, 2002; Sanchez, 2008).

A limiting factor in gaining access to lower-wage jobs is that the income from such jobs is often insufficient to buy and operate an automobile to access those jobs in the first place. Sanchez (1999) and Sanchez, Shen and Peng (2004) note that it is difficult for public transit to reduce the spatial mismatch between lower-income jobs and residential options for a number of reasons. One problem is that bus systems often do not provide sufficient service for the kinds of working hours that make low-skill/entry-level, temporary, and evening/weekend shift-work jobs feasible (Giuliano, 2005). Public transit, especially if it is more rapid and reliable than conventional buses—a feature of BRT systems, may be one way to connect lower-income urban workers from their lower-income neighborhoods to lower-wage jobs (Fan, Guthrie and Levinson, 2012).

Unfortunately, there are very few empirical studies showing whether and the extent to which LRT generates these outcomes. It seems that just as many studies show a positive outcome (Ong and Houston, 2002; Kawabata, 2002; Kawabata, 2003) as there which show small or ambiguous associations (Thakuriah and Metaxatos, 2000; Cervero, Sandoval and Landis, 2002; Bania, Leete and Coulton, 2008).

Two recent studies have further shown different results. In the first, McKenzie (2013) studies neighborhoods in Portland, OR, to identify differences in transit access for those neighborhoods. Using 2000 Census and five-year 2005–2009 American Community Survey data, McKenzie compares changes in levels of transit access across neighborhoods based on their concentrations of blacks, Latinos and poor households. The study found that neighborhoods with high Latino concentration have the poorest relative access to transit and that transit access declined for black and Latino-dominated neighborhoods. McKenzie did not evaluate job growth along transit lines serving or near those neighborhoods, however.

The other is the study by Fan, Guthrie and Levinson (2010). They find that residential proximity to light rail stations and bus stops offering direct connection to rail stations are associated with statistically significant gains in accessibility to low-wage jobs (Fan, Guthrie and Levinson, 2010). On the other hand, their analysis covered just a short number of years before the Great Recession: 2004 to 2007. The Center for Transportation Research at the University of Minnesota (Fan, 2010) goes further by reporting that between 2004, when the Hiawatha Line LRT line opened, and 2007, just before the Great Recession, low-wage jobs accessible within 30 minutes of transit within Hennepin County grew by 14,000, with another 4,000 where the LRT was accessed directly by bus.

In summary, there are very few studies showing the relationship between the provision of fixed-guideway transit systems and higher levels of lower-wage jobs, and none evaluate this association with respect to BRT. Our paper helps close this gap in literature.

8.3 RESEARCH DESIGN, STUDY AREAS AND DATA

Our principal interest is measuring the change in share of lower-wage jobs before the Great Recession and during the recovery associated with BRT stations. Doing so will also require measuring the change in share of other wage categories such as middle- and upper-wage jobs. The analysis requires wage-related employment data at a reasonably small geographic scale. Both needs are met by the Longitudinal Employment-Household Dynamics (LEHD) database.

We first convert the LEHD data into wage categories. As we wish to compare change of jobs between geographic units, those jobs should be stationary; that is, jobs should be based mostly at a single location in urbanized areas. We therefore exclude agriculture, mining and construction jobs. We also want to create categories of jobs based on wages. We estimate average annual wages per worker from the County Business Patterns (for 2013) and apportion the nation's jobs into roughly equal thirds, defined as lower-wage, middle-wage and upper-wage jobs by North American Industrial Classification System (NAICS) sector, excluding those noted above. Table 8.1 shows our allocation.

Table 8.1 Allocation of Jobs by Lower-, Middle- and Upper-Wage Category

NAICS	**Description**	**Mean Annual Wages**	**Category**
44	Retail Trade	$25,779	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		***$23,696***	***31%***
48	Transportation and Warehousing	$45,171	Middle
53	Real Estate and Rental and Leasing	$46,813	Middle
56	Administrative, Support, Waste Mgmt., Remediation	$35,931	Middle
61	Educational Services	$35,427	Middle
62	Health Care and Social Assistance	$44,751	Middle
Weighted Mean Wages and National Share of Jobs		***$41,723***	***35%***
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		***$70,490***	***34%***

Source: County Business Patterns, 2013.

We then use shift-share analysis as our quasi-experimental method. Shift-share analysis assigns the change or shift in the share or concentration of jobs with respect to the region, other economic sectors and the local area. The "region" can be any level of geography and is often the nation or the state. In our case, where we want to see whether there are intra-metropolitan shifts in the share of jobs by sector, our region is the central county of the metropolitan area. The "local" area is often a city or county or even state, but it can be any geographic unit that is smaller than the region. Our local areas are block groups with centroids within 0.50 mile of the nearest BRT station; we call this these the BRT station areas. The local areas are also block groups within 0.50 mile of the nearest counter-factual location (described below). As shifts in the share of jobs may vary by sector over time because of changes in economic sector mixes, there is also an "industry mix" adjustment. Our "industries" in this context are the sector-based wage categories. Our analytic method is similar to that used by Nelson et al. (2013).

We apply shift-share analysis to each of the 12 BRT systems operating in 2010. We divide analytic periods into the pre-recession, 2002-2007—or in the case of Phoenix from 2004-2007—because of data reporting limitations, and recovery from 2008 to 2011, the latest year for which data were available for our analysis.

However, shift-share analysis by itself does not necessarily ascribe a causal relationship, merely an associative one. To control for the counter-factual – that is, that changes in jobs by wage category would have occurred anyway – we devised an algorithm in ArcGIS to identify 10 alternative locations having comparable attributes to each existing station at the beginning of our study period—2002 for all systems except Phoenix, which is 2004 (Kim, 2015).

Because there are more counter-factual block groups than BRT station area block groups, shift-share results comparing the central county and counter-factual block groups will be skewed being biased against BRT station areas. We normalized this by taking the means of block groups for all three geographic units including the central county of the respective metropolitan area, BRT station areas and counter-factual locations. We caution that though this improves causal inference, we are conservative in concluding only associative ones.

We do not evaluate BRT systems put into service after 2009. The reason is that the market needs at least three years to respond to the BRT investment (Golub**,** Guhathakurta and Sollapuram, 2012). After reporting results for all 12 BRT systems and their counter-factual locations, we offer a qualitative assessment of whether there is an association between BRT systems and change in jobs by wage category. Although our principle interest is in the change in share of lower-wage jobs over time, we assess changes for all three wage categories.

8.4 RESULTS

For brevity, we report only the “industry shift” part of the shift-share analysis for each of the 12 BRT systems before the recession and during recovery, in three tables: lower-wage jobs (Table 8.2), middle-wage jobs (Table 8.3), and upper-wage jobs (Table 8.4). The industry shift coefficients are reported for BRT station areas and counter-factual locations with respect to the central county.

Table 8.2 Change in Lower-Wage Jobs before the Recession and During Recovery Associated with Bus Rapid Transit Station Areas and Counter-Factual Locations

BRT System	Counter-Factual Pre-Recession	BRT Pre-Recession	Counter-Factual Recovery	BRT Recovery
Pittsburgh South – 1977	-17.3	-10.2	-10.3	4.0
Pittsburgh East – 1983/2003	-6.4	-4.7	0.2	9.3
Pittsburgh West – 2000	-4.7	13.7	-2.0	37.7
Las Vegas MAX – 2004	-38.3	-99.6	66.0	-57.4
Los Angeles Orange – 2005	8.7	6.6	-2.6	-10.6
Los Angeles Silver – 2009	10.3	-61.5	-8.5	131.9
Kansas City Main Street – 2005	0.8	-3.1	-9.3	2.7
Eugene-Springfield Emerald Express - 2007	0.7	-1.9	-0.1	-0.6
Cleveland Health Line – 2008	-1.7	0.8	-15.1	-9.3
Bronx Pelham Parkway – 2008	-0.8	0.5	0.4	-0.9
Phoenix Main Street – 2008	-14.9	-67.0	-28.5	-17.2
Salt Lake City MAX – 2008	-22.1	-37.4	-19.1	8.8
Positive Shifts in Job Share	4	4	3	6
Unweighted (summed) means*	-95.9	-202.4	-20.5	-33.3

*Excludes Los Angeles Silver Line;

Note: Coefficients are the “industry share” of the shift in mean jobs per block group from shift-share analysis comparing change in share of lower-wage jobs between BRT station areas and counter-factual locations with respect to their central county over pre-recession (2002-2007 except Phoenix is 2004-2007) and recovery (2008-2011) periods.

Table 8.3 Change in Middle-Wage Jobs before the Recession and During Recovery Associated with Bus Rapid Transit Station Areas and Counter-Factual Locations

BRT System	Counter-Factual Pre-Recession	BRT Pre-Recession	Counter-Factual Recovery	BRT Recovery
Pittsburgh South – 1977	14.6	54.5	1.2	-30.5
Pittsburgh East – 1983/2003	-9.4	-11.5	3.3	-8.7
Pittsburgh West – 2000	-22.3	-49.7	17.2	-4.2
Las Vegas MAX – 2004	-58.1	-75.8	157.7	42.3
Los Angeles Orange – 2005	31.8	-10.2	-21.5	39.0
Los Angeles Silver – 2009	18.5	30.6	-39.6	786.6
Kansas City Main Street – 2005	12.9	-4.9	-14.5	-1.5
Eugene-Springfield Emerald Express -2007	-8.1	18.1	3.6	-10.1
Cleveland Health Line – 2008	-4.0	-9.6	-9.4	-10.4
Bronx Pelham Parkway – 2008	-2.8	10.2	-0.2	-2.0
Phoenix Main Street – 2008	14.0	2.3	9.6	-8.2
Salt Lake City MAX – 2008	-17.5	8.9	-24.3	46.6
Positive Shifts in Job Share	5	6	6	4
Unweighted (summed) means*	-49.0	-67.7	122.7	52.3
*Excludes Los Angeles Silver				

Note: Coefficients are the "industry share" of the shift in mean jobs per block group from shift-share analysis comparing change in share of lower-wage jobs between BRT station areas and counter-factual locations with respect to their central county over pre-recession (2002-2007 except Phoenix is 2004-2007) and recovery (2008-2011) periods.

Table 8.4 Change in Upper-Wage Jobs before the Recession and During Recovery Associated with Bus Rapid Transit Station Areas and Counter-Factual Locations

BRT System	Counter-Factual Pre-Recession	BRT Pre-Recession	Counter-Factual Recovery	BRT Recovery
Pittsburgh South – 1977	-13.1	-134.0	-1.0	-79.7
Pittsburgh East – 1983/2003	37.7	42.5	-4.6	16.2
Pittsburgh West – 2000	5.7	-147.7	-18.2	73.7
Las Vegas MAX – 2004	-47.2	-31.9	7.0	-5.4
Los Angeles Orange – 2005	-12.5	79.5	-31.1	-67.6
Los Angeles Silver – 2009	3.4	-61.4	15.3	132.9
Kansas City Main Street – 2005	-6.2	0.5	-23.8	8.5
Eugene-Springfield Emerald Express - 2007	2.4	-3.7	-36.3	113.0
Cleveland Health Line – 2008	-11.0	-13.9	-18.9	-3.0
Bronx Pelham Parkway – 2008	0.7	-10.7	-3.9	46.9
Phoenix Main Street – 2008	-10.2	4.9	4.4	-16.0
Salt Lake City MAX – 2008	-26.3	-16.9	-14.6	35.6
Positive Shifts in Job Share	5	4	3	7
Unweighted (summed) means*	-80.1	-231.2	-141.0	122.2
*Excludes Los Angeles Silver Line				

Note: Coefficients are the "industry share" of the shift in mean jobs per block group from shift-share analysis comparing change in share of lower-wage jobs between BRT station areas and counter-factual locations with respect to their central county over pre-recession (2002-2007 except Phoenix is 2004-2007) and recovery (2008-2011) periods.

For the most part, BRT station areas and counter-factual locations had comparable results before the Great Recession. Among the lower-wage categories, four each gained share and nearly equal numbers for the middle- and upper-wage categories. All BRT station areas and counter-factual locations lost mean share of jobs with BRT station areas losing more across all income categories. Among the three oldest systems, all located in Pittsburgh (Allegheny County), the number of positive and negative shifts between BRT station areas and counter-factual locations were about the same.

Relationships appear to change during the recovery, which also coincides with half the BRT systems starting up (between 2007 and 2009). In the lower-wage job category, half (six) of the BRT systems gained share compared to a quarter (three) of the counter-factual locations. This trend was mirrored in the upper-wage category, where slightly more than half (seven) of the BRT station areas gained share compared to a quarter (three) of the counter-factual locations. In contrast, half (six) of the counter-factual locations gained share of middle-income jobs compared a third (four) of the BRT station areas.

The tables also report unweighted (summed) means of shift in block group share of jobs for each wage category. (The Los Angeles Silver Line is excluded as it appears to be an outlier in positive performance.) Among the jobs in the lower-wage category, BRT station areas and counter-factual locations lost mean share of lower-income jobs relative to their central counties. While both lost mean share of middle-income jobs before the recession, both gained share during the recovery with counter-factual locations gaining more. The upper-wage category is most interesting: While both lost mean share of upper-income jobs relative to their central counties, counter-factual locations continued to lose share during the recovery while BRT station areas gained considerably.

8.5 SUMMARY AND IMPLICATIONS

We are impressed that there was such a rapid shift in the share of jobs in BRT station areas across all wage categories during the recession. Figure 8.1 illustrates these trends. While BRT station areas continued to lose share of lower-wage jobs compared to their central counties, it may only be a matter of time before they gain share, insomuch as the trends illustrated can be extrapolated. Or maybe not, as we discuss below.

We caution that not all BRT systems are designed to serve the same needs or comparable areas, and that each of their central counties are different in such respects as demographics, economic structure, political-economy, land use patterns, age of capital stock and so forth. Future research will evaluate each of these BRT systems more carefully. Future research will also benefit from more current information. Moreover, our recovery period extended only to 2011; the nation’s economy has been improving steadily since then, with 2015 having a third less unemployment than 2011 (from nearly 9 percent to less than 6 percent). More current data will help understand whether earlier recovery trends continue or are changing.

While not wishing to overstate our findings, we see that BRT station areas may be more attractive to upper-wage jobs and less attractive to lower-wage ones. We are uncertain about middle-wage jobs; after all, only a third of the BRT systems did better than their central counties while half of the counter-factual locations did better, and the sum of change in mean block group middle-wage job shift was more than double that of the BRT station areas.

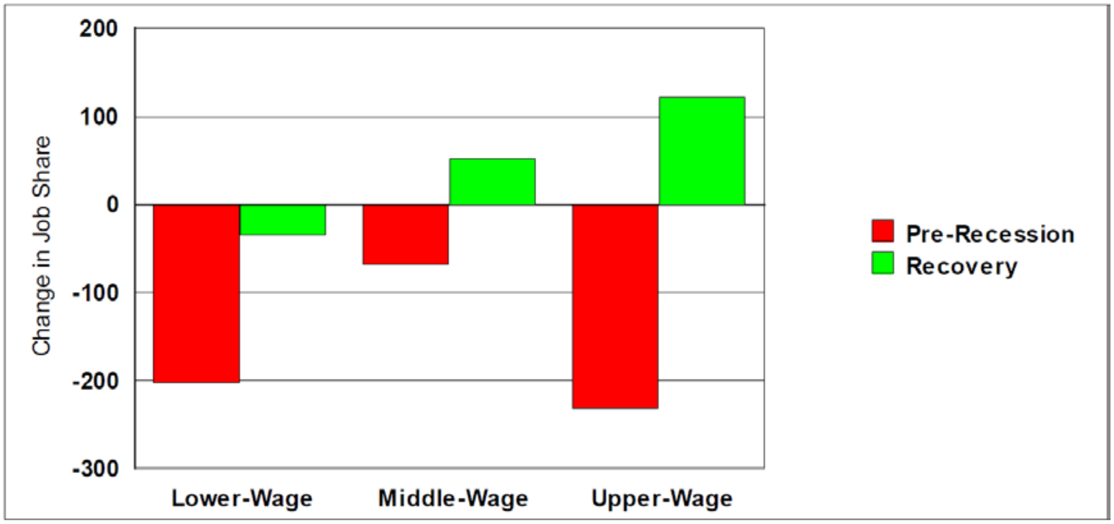

Figure 8.1 Change in Share of Jobs by Wage Category for BRT Station Areas Compared to their Central Counties During Pre-Recession and Recovery Periods

There are important reasons for BRT stations areas becoming more attractive to upper-wage jobs and less attractive to lower-wage and perhaps middle-wage jobs.

For one, the real estate market values permanence in transportation investments when deciding to make long-term development decisions (Nelson, 2014; Nelson, 2013). A key advantage of rail transit is once the investment has been made, the real estate industry can usually rely on its permanence over the many decades it takes to maximize profits from high-density investments at or near stations. Our results suggest BRT systems may have similar effects on real estate development decisions.

If the real estate market does respond to BRT investments, as would be expected (Higgins and Kanaroglou, 2015), land values will rise. To cover costs, developers will need to build more intensive projects and charge the rent needed to cover costs and assure a reasonable return on investment. In turn, this means workers need to be more productive so this lends itself to jobs paying higher wages. Though a certain number of lower- and middle-wage jobs would certainly be generated, the greater share may be upper-wage jobs. Some evidence of this was found in a case study of the Eugene-Springfield Emerald Express BRT system (Nelson et al., 2013).

Real estate development along transit corridors can be expensive due to infrastructure upgrades or replacements, removing older buildings, and other high-cost renovations (especially historically significant buildings). While there are examples of BTR systems stimulating redevelopment (Institute for Transportation and Development Policy, 2013), our observation is that new development is decidedly for upper-wage and perhaps some middle-wage jobs.

We cannot rule out that BRT may improve opportunities for lower-wage jobs, but emerging evidence based on our work indicates BRT investment may attract more upper-wage and perhaps middle-wage jobs than lower-wage jobs.

9.0 INFLUENCES OF BUS RAPID TRANSIT ON THE LOCATION OF PEOPLE AND HOUSING

9.1 LITERATURE

TODs have many promises. Of interest in this chapter is the extent to which BRT stations attract people and housing consistent with TODs generally (Belzer et al., 2007; Belzer and Poticha, 2010; Belzer et al, 2011; Carrigan et al., 2013; Cervero et al., 2004; Dawkins and Buehler, 2010; Dawkins and Moeckel 2014).

For the most part, however, there is very little research assessing whether TODs accomplish these objectives. Analysis in the U.S. has been limited to case studies mostly of individual TOD areas but not of metropolitan areas as a whole (Cervero and Seskin, 1995; Cervero et al., 2004; Kolko, 2011). No studies analyze change in population and housing associated with BRT systems in the U.S. The only metropolitan-scale studies addressing the influence of BRT systems on population and housing are from outside the U.S. (Carrigan et al., 2013; Cervero, 2013).

Only one study addresses population and housing change for all TODs in the U.S. - the Center for Transit Oriented Development (2014). It does not differentiate by type of system nor does it provide detailed information for individual metropolitan areas. We adapt its language for our purposes in terms of population and households.

9.1.1 Population

Between 2000 and 2010, population increased both within transit sheds (areas within 0.50 mile of transit stations) and in their larger regions. In transit sheds, the rate of growth has not kept pace with the transit regions. The rate of growth varies depending on the size and growth of the transit systems themselves. Regions with extensive transit systems (located primarily in the Northeast) had more modest population growth in transit sheds than did regions with smaller expanding systems. For small to large transit systems, the population in the South, West, South and Sunbelt expanded between 4-16 percent while their transit sheds grew from 2-6 percent. (Adapted from p. 9)

Population growth in individual transit systems varied substantially. Newer, small systems in the Southeast such as Tampa and Charlotte saw their transit shed populations increase by more than 30 percent in their new station areas. Among the large systems, the transit sheds in Portland and Denver each grew approximately 20 percent. Extensive systems experienced more modest percentage gains but, in absolute numbers, recorded much larger growth. While New York’s transit shed added nearly 200,000 residents, both Washington D.C. and San Francisco grew between 75,000 and 81,000. (Adapted from p. 10)

Some systems actually lost population. Cleveland, Baltimore, Detroit and Buffalo have seen declines in regional population for decades and are known for being weak market cities. Cook County in Chicago, where many of CTA's stations are located, also experienced population decline. Dallas County in Texas experienced slower growth than in the past, with only a 7 percent growth rate compared to at least 17 percent gains every decade since 1970. Finally, the population of Sacramento, CA, in transit zones declined while the region grew at almost 20 percent. Most of this growth appears to be in suburban areas and not near transit stations (Adapted from p. 10).

9.1.2 Households

Transit sheds are attracting an increasing share of small households. The share of smaller one- and two-person households increased from 2000 to 2010 in both transit regions and sheds, while larger three-person or more households decreased. This shift was more pronounced within transit sheds. Shares of one- and two-person households grew about 6 and 3 percent, respectively, from 2000 to 2010 while households with three or more people declined by 8 percent. This trend may reflect the attraction of urban living for singles and couples near transit (Adapted from p. 12).

9.2 RESEARCH QUESTIONS AND DATA

In this chapter, we address the following questions:

- Relative to the metropolitan area as a whole, is there an association between BRT and change over time in population; households by householder age and household type; and housing by total supply, vacancy rates and tenure?

- Is there a relationship between these changes and the number of years a line has been operating?

- Is there a relationship between these changes and the design and technology features of BRT systems?

Our study areas include the entire metropolitan statistical area as defined in 2010 for comparisons to change with one-half mile of census block-group centroids to BRT stations. While the largest share of influences likely occur within the first one-half mile, emerging literature indicates the full effect of transit systems is felt up to two miles away (see Nelson et al. 2015). Nonetheless, literature shows that the largest share of change occurs within the first one-half mile of fixed-guideway transit systems (see Center for Transit Oriented Development, 2014).

Our data are census data from the 2000 and 2010 censuses of population for persons and household types.

9.3 ANALYTIC SCHEME

Our analysis calculates the change in BRT study area outcomes between 2000 and 2010 compared to the change for the metropolitan area as a whole. We use the universe of block groups (BGs) whose centroids are within one-half mile of BRT stations and compare the weighted sum of those BGs to the entire metropolitan area. As there is no sampling involved, we can use the direct comparisons for analytic purposes. (In other words, if the weighted average change in population of all BGs in the BRT study area was 14 percent the change and the metropolitan area grew by 13 percent, the BRT study area gained share of population relative to the metropolitan area.) We calculate ratios to make this comparison. If the ratio of population change among the BGs in our BRT study area compared to the population change of the metropolitan area as a whole is 1.01, we find that the BRT study area added more people proportionately than the metropolitan area. Conversely, if the ratio is 0.99, the BRT study area grew less proportionately than the metropolitan area.

We make a further observation. For the most part, new fixed-guideway transit systems are built where development already exists to maximize ridership to maximize revenues. In metropolitan areas prone to sprawl, new development is more likely to occur away from fixed-guideway transit systems than toward them. We might expect, a priori, change ratios of less than one in growing metropolitan areas reflecting the ease of adding development away from transit than the potential problems associated with adding development where development already exists.

We developed four categories of performance measures: population and income change; transit-based journey-to-work; households by householder age and type; and housing. The specific performance measures and how they are calculated are presented next.

9.3.1 Population and Income Change

These include population change and relative change in median household income.

Population Change Ratio—The quotient of census 2010 and 2000 population for the BRT study area divided by the quotient of census 2010 and 2000 population, respectively.

HH Income Change Ratio—The quotient of census 2010 and 2000 median household income for the BRT study area divided by the quotient of five-year American Community Survey (ACS) census 2010 and 2000 median household income, respectively.

9.3.2 Households by Householder Age and Type

Six performance measures are included in this category: three measure change in households by householder age (under 35, between 35 and 64, and 65 and over) while three measure change in households by household type (households with and without children, and single-person households.

HH <35 Share Ratio—The quotient of census 2010 and 2000 householders under 35 years of age and total households from the 2000 census for the BRT study area divided by the quotient of householders under 35 from the 2010 census for the metropolitan area, respectively.

HH 35-64 Share Ratio—The quotient of census 2010 and 2000 householders 35 to 64 years of age and total households from the 2000 census for the BRT study area divided by the quotient of householders 35 to 64 from the 2010 census for the metropolitan area, respectively. These tend to be households needing housing space to raise families and may also prefer detached homes on larger lots, so we would not be surprised if BRT study area shares fell relative to the metropolitan area.

HH 65+ Share Ratio—The quotient of census 2010 and 2000 householders 65 years of age and older and total households from the 2000 census for the BRT study area divided by the quotient of householders 65 years of age and older from the 2010 census for the metropolitan area, respectively. These tend to be downsizing households who are mostly empty-nesters and may prefer to relocate to smaller homes on smaller lots, or attached homes. We may expect an increasing share of these households living near BRT stations relative to the metropolitan area.

HH w/ Children Share Ratio—The quotient of census 2010 and 2000 households with children present and total households from the 2000 census for the BRT study area divided by the quotient of households with children present from the 2010 census for the metropolitan area, respectively. These tend to be households needing housing space to raise families and may also prefer detached homes on larger lots, so we would not be surprised if BRT study area shares fell relative to the metropolitan area.

HH no Children Share Ratio—The quotient of census 2010 and 2000 households without children present and total households from the 2000 census for the BRT study area divided by the quotient of household without children from the 2010 census for the metropolitan area, respectively. These are households who may have already raised their children and are empty-nesters, have yet to raise children, or may never raise children. We suspect that a larger share of these households will locate near BRT stations relative to the metropolitan area.

1-Person HH Share Ratio—The quotient of census 2010 and 2000 single-person household and total households from the 2000 census for the BRT study area divided by the quotient of single-person household from the 2010 census for the metropolitan area, respectively. Together with households < 35, we suspect a higher share of single-person households will live near BRT stations than the metropolitan area as a whole.

9.3.3 Housing

Unit Change Ratio—The quotient of census 2010 and 2000 housing units and total housing units from the 2000 census for the BRT study area divided by the quotient of housing units from the 2010 census for the metropolitan area, respectively. If BRT station areas attract new housing demand, there should be a shift in change in total housing units favoring the BRT study area.

Vacancy Rate Change Ratio—The quotient of vacancy rates in the BRT study area for 2010 and 2000 divided by the quotient of vacancy rates for the metropolitan area for 2010 and 2000. If BRT study areas become more attractive to the market, vacancy rates should fall near BRT stations relative to the metropolitan area. Index measures less than 1.0 indicate vacancy rates in the study area fell faster than for the metropolitan area as a whole.

Renter Change Ratio—The quotient of home rental rates in the BRT study area for 2010 and 2000 divided by the quotient of home rental rates for the metropolitan area for 2010 and 2000. If BRT study areas become more attractive to younger households and single-person households, we suspect there will be a greater change in the share of housing that is rented in the BRT study areas relative to the metropolitan area.

Because there are relatively few metropolitan areas with BRT systems, our analysis is essentially a series of case studies. While we may predict the association of direction between the analytic variables and BRT study areas, we wish to err on the side of conservativism. We thus use the two-tailed difference of means test based on z-scores where significance is set at the 0.01 level.

Our analytic scheme is thus applied to individual or groups of metropolitan areas for reasons we note next.

9.4 SUMMARY OF BRT SYSTEM RATINGS

Of the nation's six BRT lines rated Basic, Bronze or Silver, four are located in the Rustbelt metropolitan areas of Pittsburgh—one rated Bronze and the others Basic—and Silver-rated Cleveland, which is the highest rating in the U.S. Both metropolitan areas lost about 3 percent of their population during the 2000s. The other two are the Los Angeles Orange Line, rated Bronze, and the Eugene-Springfield Emerald Line, also rated Bronze. We will compare changes in population, households and housing between 2000 and 2010 with respect to these BRT systems individually.

9.5 RESULTS AND INTERPRETATIONS

We will now present results for each system we studied and offer interpretations within the limits of data. In all tables, we have highlighted significant relationships between individual variables and BRT study area outcomes compared to the metropolitan area as a whole. Except for ridership change, the results are based on the ratio of BRT study area change compared to metropolitan area change. Index figures greater than 1.0 indicate the BRT study area out-performed the metropolitan area while figures less than 1.0 indicate it underperformed. For ridership change, we calculated the share of metropolitan area journey-to-work ridership occurring in the BRT study areas.

Our analysis is organized chronologically based on metropolitan areas with the oldest operating BRT systems.

9.5.1 Pittsburgh

Table 9.1 reports results for Pittsburgh's South Line, East Line and West Line. We highlight performance measures with significant z-scores based on our criteria.

Population and Income Change—In all cases, as metropolitan Pittsburgh lost population, population in the BRT study areas fell but at a slower pace (hence index figures less than 1.0).

In this respect, the BRT study areas may be more resilient in retaining population than the metropolitan area as a whole.

Median household incomes grew proportionately less in the South Line and West Line study areas, but more in the East Line study area, than the metropolitan area.

Resident Transit-Based Journey-to-Work—We note that overall transit ridership in the metropolitan area fell between 2000 and 2010, as did population. Likewise, transit ridership for the journey-to-work among study area residents fell along the South Line but actually rose along the West Line (the change in ridership along the East Line was ambiguous).

Households by Householder Age and Type—All lines grew proportionately more in share of households age 65 and over compared to the metropolitan area. This was the only statistically significant difference in household change among the study areas relative to the metropolitan area.

Housing—During the study period, the South Line study area added more housing units while the East Line study area added fewer housing units proportionate to the metropolitan area.[2] Results for the West Line were ambiguous. In the South Line study area—along which the nation's oldest BRT system runs—rental units gained share of total occupied units at a rate 1.76 times the rate of the metropolitan area as a whole.

Table 9.1 BRT Population, Household and Housing Outcomes with Respect to Pittsburgh South, East and West Study Areas, 2000-2010

Performance Measure	South Line (1977-Basic)	East Line (1983-Bronze)	West Line (2000-Basic)
Population and Income Change			
Population Change Ratio+	0.93*	0.93*	0.85*
HH Income Change Ratio	0.86*	1.13*	0.91*
Households by Householder Age and Type			
HH <35 Share Ratio	1.45	1.01	1.40
HH 35-64 Share Ratio	0.92	1.02	0.96
HH 65+ Share Ratio	2.01*	1.97*	1.84*
HH w/ Children Share Ratio	0.93	1.13	0.81
HH no Children Share Ratio	1.01	0.96	1.05
1-Person HH Share Ratio	1.24	0.85	1.08
Housing			
Unit Change Ratio	1.03*	0.87*	1.02
Vacancy Rate Change Ratio	1.19	0.89	1.19
Renter Change Ratio	1.76*	0.79	1.17

*$p < 0.05$, two-tailed test

+Because the metropolitan area lost population, index figures less than 1.0 indicate the study areas lost population at a slower pace than the metropolitan area.

++The signs for *Ridership Change Share* have been reversed to facilitate interpretation. Metropolitan ridership fell between 2000 and 2010 and so did ridership along the South and East lines but mathematically their signs would be positive thereby implying an increase in ridership. The change in signs shows that ridership fell along those two lines but rose along the West Line.

[2] Although the Pittsburgh metropolitan area lost about 75,000 residents it added about 24,000 housing units during the 2000-2010 study period.

On the whole, we find that Pittsburgh's BRT lines had somewhat more resilient outcomes relative to the Pittsburgh metropolitan area's population trends during the study period. We also note that senior households (65+)—which may be downsizing—appear to have gained share of such households in BRT study areas at about twice the rate of change for the metropolitan area. We cannot say for certain that those households are relocating to BRT study areas, but it is an observation that future research might address. Finally, we observe that population and income change performance was somewhat better along the East Line—rated Bronze—than the other lines, though the others performed better than the housing indicators. We cannot say for certain the reason is the difference in planning and design approaches between the lines.

We next proceed with a review of metropolitan areas with two BRT lines: Kansas City, Los Angeles and Phoenix.

9.5.2 Kansas City

More than 20 years after Pittsburgh, in 2005 Kansas City along with Los Angeles became the nation's next metropolitan areas with a BRT system.

The Kansas City lines allow us to compare performance of an established system; the Main Street Line started in 2005, with a new line opened at the end of our study period (the Troost Line in 2011). From Table 9.2, however, we see there are not many statistically significant relationships.

Population and Income Change—Study areas along both lines lost share of population during the study period though less so along the Main Street Line than the Troost Line. On the other hand, median household incomes rose at a faster pace along the Troost Line—which serves an area with among the highest incomes in the metropolitan area—while the Main Street study area fell compared to the region.

Resident Transit-Based Journey-to-Work—Study areas along both lines saw fewer transit-based, journey-to-work riders among the study area in 2010 than in 2000, with the Main Street Line accounting for nearly twice the share of loss. Overall journey-to-work transit ridership among residents increased by less than 300 between 2000 and 2010, but fell from 1,543 to 973 and from 1,484 to 1,183 in the Main Street and Troost study areas, respectively.

Households by Householder Age and Type—Aside from the Troost Line study area losing share of households with children relative to the metropolitan area, none of the household-related variables were significant.

Housing—The share of the metropolitan area's supply of housing in both study areas fell during the study period, but none of the other housing-related variables were significant.

Unlike many other BRT systems, for the most part we do not detect meaningfully positive changes in population, household and housing outcomes associated with the presence of either the Main Street or Troost BRT lines. On the other hand, we cannot know the counter-factual: that is, to what extent are outcomes attributable to BRT nonetheless better than what they would have been in the absence of BRT? After all, the Kansas City metropolitan area is among the nation's most sprawling (see Ewing and Hamidi, 2014). Combined with just growth, it may take many years or decades for new transit investments to change development patterns.

Table 9.2 BRT Population, Household and Housing Outcomes with Respect to Kansas City Main Street and Troost Study Areas, 2000-2010

Performance Measure	Main Street Line (2005-Not Rated)	Troost Line (2011-Not Rated)
Population and Income Change		
Population Change Ratio	0.91*	0.80*
HH Income Change Ratio	0.98*	1.17*
Households by Householder Age and Type		
HH <35 Share Ratio	1.09	1.18
HH 35-64 Share Ratio	1.04	0.95
HH 65+ Share Ratio	1.41	1.22
HH w/ Children Share Ratio	1.34	0.73*
HH no Children Share Ratio	0.93	1.09
1-Person HH Share Ratio	0.86	1.14
Housing		
Unit Change Ratio	0.82*	0.93*
Vacancy Rate Change Ratio	0.89	0.95
Renter Change Ratio	0.90	0.98

*$p < 0.05$, two-tailed test

9.5.3 Los Angeles

Table 9.3 reports results for the Orange Line (Bronze) initiated in 2005 and Silver Line (not rated) commencing in 2009 in the Los Angeles metropolitan area.

Performance of the Silver Line is remarkable as z-scores are significant for all performance measures. It appears that the Silver Line was either planned to serve an area of Los Angeles that was expected to grow or that it stimulated some of that development itself, along the half-mile study area corridor, or a combination of both.

Population and Income Change—Both lines saw significant outcomes in performance measures, but while the Orange Line lost share of growth and income with respect to the metropolitan area, the Silver Line gained share. We suspect there is more infill and redevelopment occurring along the Silver Line than the Orange Line.

Resident Transit-Based Journey-to-Work—While the Orange and Silver lines lost share of transit in the journey-to-work during the study period, transit-based, journey-to-work ridership among study area residents nonetheless accounted for 1.6 percent and 2.5 percent of the share of new transit riders, respectively.

Households by Householder Age and Type—Both lines gained share of metropolitan households with householders under 35 years of age as well as 65 years of age and over, and were just about on par with respect to middle-aged householders. Those lines also gained share households without children and single-person households but lost share among households with children.

Housing—The South Line study area also saw greater growth in housing units and faster decline in vacancy rates relative to the metropolitan area. The share of rental housing in both study areas compared to the metropolitan area increased slightly.

Table 9.3 BRT Population, Household and Housing Outcomes with Respect to Los Angeles Orange and Silver Study Areas, 2000-2010

Performance Measure	Orange Line (2005-Basic)	Silver Line (2009-Not Rated)
Population and Income Change		
Population Change Ratio	0.96*	1.20*
HH Income Change Ratio	0.88*	1.45*
Households by Householder Age and Type		
HH <35 Share Ratio	1.08	1.37*
HH 35-64 Share Ratio	0.95	1.01*
HH 65+ Share Ratio	1.75	1.22*
HH w/ Children Share Ratio	0.94*	0.87*
HH no Children Share Ratio	1.01	1.04*
1-Person HH Share Ratio	1.06	1.07*
Housing		
Unit Change Ratio	0.91	1.42*
Vacancy Rate Change Ratio	1.49	0.84*
Renter Change Ratio	1.02*	1.01*

*p < 0.05, two-tailed test

The Orange and Silver lines are a study in contrasts as the one with Basic rating—Orange—did not perform nearly as well as the one with no rating—Silver. The Silver Line also has about half the ridership as the Orange Line—about 14,000 daily passengers to 25,000 daily passengers in 2014, respectively. However, our review of development patterns suggests that infill and redevelopment are occurring more intensively along the South Line than the Orange Line for reasons related mostly to market demand and cost.

9.5.4 Phoenix

Two BRT lines were added to the Phoenix fixed-guideway transit system in recent years. The Main Street Line opened in 2008 while the Arizona Line was started in 2010. Neither have sufficient BRT features to be rated. Table 9.4 reports performance measures for both.

Population and Income Change—Both lines saw significant losses in share of metropolitan population over the study period, though we cannot know if those losses were lessened by BRT presence. While the slightly older Main Street Line area increased in median household income relative to the metropolitan area, the slightly newer Arizona Line study area lost relative income.

Resident Transit-Based Journey-to-Work—There were no statistically significant changes in transit-based, journey-to-work measures for either of the Phoenix BRT lines.

Households by Householder Age and Type—Both lines gained share of metropolitan households with householders age 65 and over, with the Main Street Line study area increasing at twice the metropolitan pace while the Arizona Line study area gained at three times the pace.

Housing—Both study areas saw declining shares of housing relative to the metropolitan area.

Table 9.4 BRT Population, Household and Housing Outcomes with Respect to Phoenix Main Street and Arizona Study Areas, 2000-2010

Performance Measure	Main Street Line (2008-Not Rated)	Arizona Line (2010-Not Rated)
Population and Income Change		
Population Change Ratio	0.89*	0.63*
HH Income Change Ratio	1.04*	0.8*
Households by Householder Age and Type		
HH <35 Share Ratio	1.23	0.70
HH 35-64 Share Ratio	1.28	0.79
HH 65+ Share Ratio	2.18*	3.62*
HH w/ Children Share Ratio	1.42	0.59
HH no Children Share Ratio	0.89	1.24
1-Person HH Share Ratio	0.82	1.64
Housing		
Unit Change Ratio	0.69*	0.91*
Vacancy Rate Change Ratio	0.58	2.27
Renter Change Ratio	1.00	1.06

*$p < 0.05$, two-tailed test

These BRT lines were built in areas substantially built out so, given the rapid pace of growth in the Phoenix metropolitan area, it is not surprising to see share of population and housing units fall relative to the metropolitan area. We note, however, the strong rate of growth of households age 65 and over relative to the metropolitan area.

We proceed next with a review of the Cleveland BRT system which, like Pittsburgh, operates in a stagnating metropolitan area, followed by the New York City BRT system.

9.5.5 Cleveland

Like Pittsburgh, the Cleveland metropolitan area lost population during the 2000s. Results for Cleveland's HealthLine, which opened in 2008, are reported in Table 9.5.

Population and Income Change—Population in the HealthLine study area fell at a faster pace than the metropolitan area as a whole. Its median household income, however, rose at a slightly faster pace than the metropolitan area.

Resident Transit-Based Journey-to-Work—There were no statistically significant changes in transit-based, journey-to-work measures in the HealthLine study area.

Households by Householder Age and Type—The HealthLine study area gained share of metropolitan households with householders age 65 and over, gaining nearly twice as fast. No other household-related measure was statistically significant.

Housing—As for population, the metropolitan share of residential units existing in the HealthLine study area fell at a faster pace than the metropolitan area as a whole.

On the whole there is little to associate the presence of the BRT with changes in demographic measures of development. Indeed, measures of demographic performance suggest it is lagging behind the metropolitan area, though it is possible that without the BRT it may have lost population and housing units at a faster pace.

Table 9.5 BRT Population, Household and Housing Outcomes with Cleveland HealthLine Study Area, 2000-2010

Performance Measure	HealthLine (2008-Silver)
Population and Income Change	
Population Change Ratio	0.85*
HH Income Change Ratio	1.04*
Households by Householder Age and Type	
HH <35 Share Ratio	1.28
HH 35-64 Share Ratio	0.94
HH 65+ Share Ratio	1.72*
HH w/ Children Share Ratio	0.82
HH no Children Share Ratio	1.03
1-Person HH Share Ratio	1.03
***Housin**g*	
Unit Change Ratio	0.91*
Vacancy Rate Change Ratio	0.80
Renter Change Ratio	0.98

*p < 0.05, two-tailed test

9.5.6 New York City—Bronx

New York City initiated the Pelham Parkway BRT Line in 2008, substantially serving Bronx County. Performance results are reported in Table 9.6.

Population and Income Change—Population in the Pelham Parkway study area grew at a slower pace than the metropolitan area as a whole. The median household income measure was not statistically significant.

Resident Transit-Based Journey-to-Work—Journey-to-work transit ridership among residents in the Pelham Parkway study area accounted for 3.4 percent of the total change in such ridership for metropolitan New York, which we find remarkable considering its extensive transit network.

Households by Householder Age and Type—The Pelham Parkway study area gained share of metropolitan households with householders age 35 to 64 and 65 and over, the latter gaining about 1.5 times as fast. All other household-related measures were not statistically significant.

Housing—Similar to population, the metropolitan share of residential units existing in the Pelham Parkway study area grew at a slower pace than the metropolitan area as a whole.

Table 9.6 BRT Population, Household and Housing Outcomes with Respect to Bronx Pelham Parkway Line Study Area, 2000-2010

Performance Measure	Pelham Parkway Line (2008-Not Rated)
Population and Income Change	
Population Change Ratio	0.94*
HH Income Change Ratio	1.00
Households by Householder Age and Type	
HH <35 Share Ratio	0.89
HH 35-64 Share Ratio	1.06*
HH 65+ Share Ratio	1.47*
HH w/ Children Share Ratio	0.97
HH no Children Share Ratio	1.03
1-Person HH Share Ratio	1.01
Housing	
Unit Change Ratio	0.92*
Vacancy Rate Change Ratio	0.75
Renter Change Ratio	1.01

*p < 0.05, two-tailed test

While population growth on the whole lagged in the Pelham Parkway study area relative to the metropolitan area as a whole, households with householders age 35 and more gained share. Moreover, the study area accounted for a significant share of the increase in journey-to-work transit ridership during the study period.

We next review the performance of four single-line BRT systems in the West: Eugene-Springfield, Fort Worth, Las Vegas and Salt Lake City.

9.5.7 Individual Single-Line Western Systems: Eugene-Springfield, Fort Worth, Las Vegas and Salt Lake City

Four single-line BRT systems in the West round out our analyses of demographic-driven performance indicators. They are the Eugene-Springfield Emerald Express (EmEx) Line, the Fort Worth Spur Line, the Las Vegas MAX/LVB Line and the Salt Lake City MAX Line. Performance results are reported in Table 9.7.

Population and Income Change—Except for the EmEx study area, all study areas lost share of population relative to respective metropolitan areas. Median household incomes lagged behind metropolitan areas in Eugene-Springfield and Las Vegas, but gained in the Fort Worth BRT area.

Resident Transit-Based Journey-to-Work—The Fort Worth and Las Vegas BRT study areas lost journey-to-work transit riders among residents, though such riders increased in their respective metropolitan areas. No other transit-based performance measures were significant.

Households by Householder Age and Type—Three performance measures in this category were significant: The share of households with householders age 65 and over fell relative to the metropolitan area in the Eugene-Springfield study area; the share of households with householders age 35 to 64 increased relative to the metropolitan area in the Las Vegas study area; and the share of households with children increased relative to the metropolitan area in the Salt Lake City study area.

Housing—The Eugene-Springfield, Fort Worth and Las Vegas study areas gained share of total housing units relative to their metropolitan areas, while vacancy rates fell dramatically in the Eugene-Springfield study area compared to its metropolitan area and rental housing lost share in the Salt Lake study area relative to its metropolitan area. No other indicators were statistically significant.

Table 9.7 BRT Population, Household and Housing Outcomes with Respect to Eugene-Springfield Emerald Express (EmX), Fort Worth Spur, Las Vegas MAX/LVB and Salt Lake City MAX Study Area, 2000-2010

Performance Measure	**Eugene-Springfield EmX (2007-Bronze)**	**Fort Worth Spur (2011-Not Rated)**	**Las Vegas MAX/LVB North (2004-Not Rated)**	**Salt Lake City MAX (2008-Not Rated)**
Population and Income Change				
Population Change Ratio	1.00	0.91*	0.71*	0.95*
HH Income Change Ratio	0.92*	1.09*	0.83*	0.99
Households by Householder Age and Type				
HH <35 Share Ratio	1.74	1.10	0.94	1.01
HH 35-64 Share Ratio	0.94	1.07	1.05*	0.95
HH 65+ Share Ratio	0.99*	1.18	1.07	1.02
HH w/ Children Share Ratio	0.96	0.95	0.99	1.27*
HH no Children Share Ratio	0.93	1.02	1.01	0.99
1-Person HH Share Ratio	0.65	1.03	0.96	1.01
Housing				
Unit Change Ratio	0.93*	0.88*	0.73*	1.03
Vacancy Rate Change Ratio	0.65*	1.04	0.97	1.04
Renter Change Ratio	0.97	1.06	1.01	0.90*

*$p < 0.05$, two-tailed test

Among the significant associations, we find mixed results. On the whole, among these growing metropolitan areas, BRT station areas are not attracting a greater share of people, households or housing units than their metropolitan areas as a whole. On the other hand, we cannot know whether results would be less impressive in the absence of BRT systems in these metropolitan areas.

9.6 SUMMARY OBSERVATIONS

For the most part we find that BRT systems are not associated with substantial shifts in population, household and housing unit location over time. This is illustrated in Table 9.8 where most indicators of change with respect to BRT station areas are negative when compared to respective metropolitan areas. Notably and maybe surprisingly, BRT systems seemed to attract older households (where householders were more than 35 years of age) as well as more renters. Nonetheless, as noted above, we cannot know whether outcomes would have been less impressive without BRT systems among the metropolitan areas we evaluated.

Table 9.8 Binary Composite BRT Population, Household and Housing Outcomes

Performance Measure	**Overall**
Population and Income Change	**Summary >1.0=+ and <1.0 = -**
Population Change Ratio+	**-**
HH Income Change Ratio	**-**
Households by Householder Age and Type	
HH <35 Share Ratio	
HH 35-64 Share Ratio	**+**
HH 65+ Share Ratio	**+**
HH w/ Children Share Ratio	**-**
HH no Children Share Ratio	
1-Person HH Share	
Housing	
Unit Change Ratio	**-**
Vacancy Rate Change Ratio	**-**
Renter Change Ratio	**+**

10.0 SUMMARY AND IMPLICATIONS

We find substantial though often circumstantial evidence that bus rapid transit systems can influence development patterns in important ways. Here we summarize key findings in terms of physical and economic development patterns, and population and housing location patterns. We then consider the role of BRT system quality—determined through an international rating system—in advancing positive development outcomes. We conclude with implications for the future of BRT planning and development for many of American's metropolitan areas.

10.1 PHYSICAL AND ECONOMIC DEVELOPMENT

Though we offer only circumstantial evidence that BRT systems can influence physical and economic development patterns, it is nonetheless substantial and consistent with theoretical expectations.

In Chapter 2 we began with a review of a national assessment of the private-investment return to public-sector BRT investments, finding roughly a 9:1 return. This can only happen if substantial development occurred near BRT stations, but the evidence could be considered anecdotal. That is, it is based on how (and perhaps even by whom) data were collected and reported without controls. We use controls to objectively measure the change in the square feet of office and multifamily residential development within 0.50 mile of most BRT systems we evaluated. (We excluded the Bronx and Los Angeles because BRT outcomes may be attributable to other forms of fixed-guideway transit systems operating substantially within the same corridors.) We compared the change in the metropolitan share of new office and apartment development occurring within 0.50 mile of BRT corridors during two periods of time: 2000-2007, which was before the Great Recession, and 2008-2015, which occurred during the recession and recovery. We found a statistically significant change in the share of new development occurring in the latter period compared to the baseline period, indicating an association between BRT corridors and new office and apartment development. Notably, we found that for metropolitan counties with BRT systems, transit corridors increased their share of new office space by a third and apartments by twice. Although we cannot claim causality, results are consistent with theoretical expectations.

Using shift-share analysis, we evaluated the change in share of jobs by major job sector in Chapter 3. Our baseline period was 2002 (2004 in the case of Phoenix) to 2007, before the Great Recession, while our treatment period was 2008 through 2011 (the latest year for which data were available for our analysis). Our study area was 0.50 mile from the nearest BRT station compared to the metropolitan central county within which the station was located. Using a spatially based algorithm, we advanced our analysis by devising 10 control stations for each BRT station being statistically comparable to the BRT station areas at the beginning of the study period. This allowed us to compare BRT-related results to the counter-factual to help ascertain the extent to which BRT stations per se made a difference. We found that whereas both the BRT station areas and the counter-factual station areas performed similarly (somewhat favoring counter-factual station areas) during the base period, we found that BRT station areas attracted a larger share of the jobs than the counter-factual station areas during the treatment period. Though we caution against over-interpreting our results, because our design used reasonable controls we may conclude that BRT station areas made some difference in influencing the change in the distribution of jobs over time.

In a different analysis, reported in Chapter 4, we used regression techniques to determine which economic sectors may be attracted to BRT station areas. Our study area was a 0.25-mile radius from BRT stations. We used the same federal data and counter-factual stations as reported in Chapter 2. We found only one economic sector where BRT stations had a statistically significant difference in job change over time—manufacturing. There are three reasons for the difference in outcomes with respect to Chapter 3. First, the study areas were different, being 0.50 mile in Chapter 3 and 0.25 mile in Chapter 4. Second, in many cases there were positive changes in the regression model but they did not satisfy tests for statistical significance. Third, different methods may simply reveal different outcomes. While more research will be needed to clarify outcomes, on the whole results from chapters 3 and 4 are consistent with theoretical expectations.

There is a large body of literature showing that office properties capitalize on the benefits of rail transit proximity into higher rents and values, but none addresses this in the context of BRT. Chapter 5 helps to close this gap in literature. It finds that in most metropolitan areas, BRT systems are associated with higher office rents per square foot within 0.50 mile of BRT corridors. We find that BRT systems may influence non-residential property rents in ways similar to rail transit.

As we note throughout this report, many types of non-conventional bus systems can be called BRT even if, in our view, they are planned and designed to meet different purposes. We note this in Chapter 6 with respect to express bus systems. We are interested to know whether express bus services may have positive effects on development patterns; we also note there is no research on this issue. To help close this gap in literature, we evaluate the change in jobs and share of jobs within 0.50 mile of the express bus stations comprising the South Miami-Dade Busway over the period 2002-2011. We also controlled for the counter-factual. Using shift-share analysis we find that Miami-Dade's Express Bus corridors generated positive changes in jobs over time relative to the central county.

We conclude that the weight of the evidence suggests a causal relationship in that bus rapid transit systems can influence new development and job location patterns over time.

10.2 POPULATION AND HOUSING LOCATION

We now address the relationship between BRT and how it may influence the location of people and housing.

We begin this assessment in Chapter 7 by determining whether BRT systems influence total transportation costs such that homes closer to BRT stations incur lower total transportation costs than homes farther away. Using ordinary least squares regression analysis, we evaluate block-group data for all 12 BRT lines operating in the U.S. in 2010. We found that 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. In other words, BRT stations confer transportation cost savings that may be capitalized into residential property values, making them more valuable.

As people are sensitive to where their jobs are located, in Chapter 8 we explore the association between BRT systems and change in jobs over time based on their wage levels: lower, middle and upper. We note that literature suggests fixed-guideway transit systems may attract more lower-wage jobs near transit stations. If so, perhaps lower-income households may also locate near those stations to economize on transportation costs near where they work. For our analysis, we allocated jobs by lower-, middle- and upper-income categories and used shift-share analysis to discern change in share of those jobs over time. As in other studies, we controlled for the counter-factual to help assess the possibility of causality. We found that before the recession, the shift in jobs for all wage groups was about the same between BRT station areas and counter-factual locations. During the recession and recovery, however, BRT station areas saw larger shifts compared to counter-factual locations for lower-wage and upper-wage jobs. On the other hand, BRT station areas were associated with the largest positive shift in the share of upper-wage jobs during economic recovery, while the share of lower-wage jobs in BRT station areas fell both compared to their central counties and counter-factual locations. We conclude that BRT stations may be attracting higher-value jobs but displacing lower- and middle-wage ones. This is consistent with theory in which more efficient locations—such as BRT stations—attract higher-value investments which often employ higher-value labor.

Because of their novelty, little research has addressed whether and the extent to which BRT systems influences the location of people and housing. Chapter 9 helps close this gap in research though with mixed outcomes. Notably and maybe surprisingly, BRT systems seemed to attract older households (where householders were more than 35 years of age) as well as more renters.

10.3 THE ROLE OF SYSTEM QUALITY IN ADVANCING POSITIVE DEVELOPMENT OUTCOMES

We are able to address, though indirectly, the association between development outcomes and the overall quality of the BRT system. This is important because unlike all other fixed-guideway transit systems, BRT systems vary considerably based on their choice of technology. As we have noted elsewhere, we find circumstantial evidence suggesting that more technologically advanced BRT systems may contribute to positive economic development outcomes. We also find, circumstantially, that BRT systems using higher-quality design and technology options tended to enjoy better population and housing outcomes than those that chose lesser options. We confess that much more research is needed to establish conclusive relationships between BRT system quality and development outcomes.

10.4 IMPLICATIONS FOR BRT PLANNING AND DEVELOPMENT

Unlike the presumptions of some, bus rapid transit systems have important effects on metropolitan development patterns. At substantially lower cost than rail transit options, BRT generates important and sometimes impressive development outcomes. This leads us to suggest a framework for BRT planning and development.

We note that transit systems are designed to maximize ridership given constraints of property ownership patterns, land use planning decisions, terrain, funding and other considerations. We also know that transit works best when their corridors serve areas of higher urban densities, mixed uses, connections with other transportation opportunities, and other factors (Ewing and Cervero, 2010; Glaeser, 2011; Graham, 2007; Venables, 2007). Giuliano illustrates a simplistic perspective of these interactions in Figure 10.1.

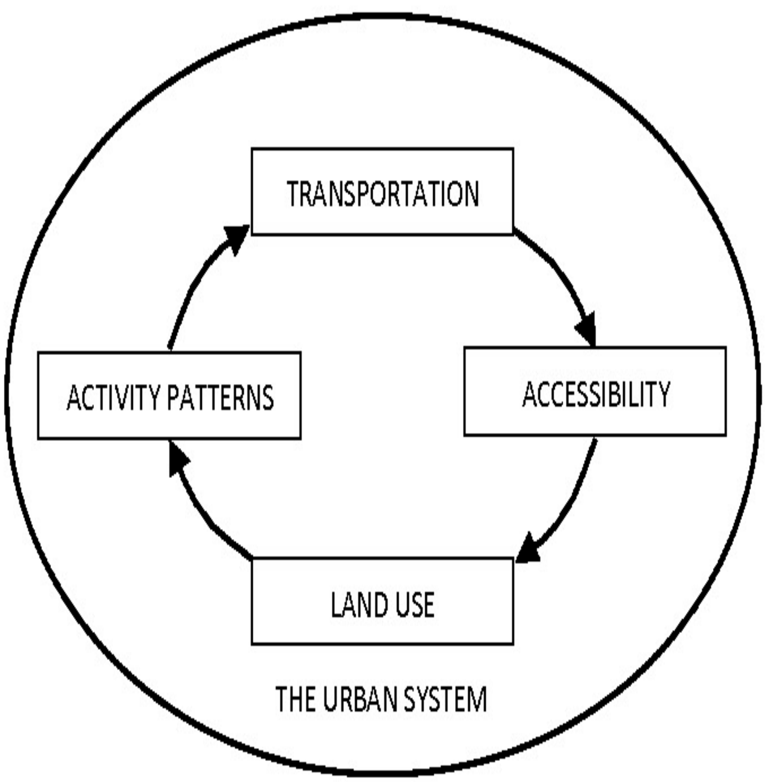

Figure 10.1
The Transportation–Land Use Connection
Source: Giuliano (2004)

We are guided by prior work that outlines elements for transit decision-making that is synthesized by Higgins, Ferguson and Kanaroglou (2014). They identify six key elements for transit planning and investment deliberations relevant to BRT systems:

1. ***Accessibility***. Transit systems must connect people and workers from where they start a journey to where they end it. This seems simplistic but, for instance, the San Diego Trolley LRT system passes through large sections where neither people nor workers are served. BRT systems may be more adaptive and thus responsive to economic development prospects.
2. ***Growth and demand***. Although it may seem obvious, there must be growth of some form (whether economic or population—they are not synonymous) to justify transit investment. But growth need not be of the metropolitan area as a whole—it is often in just submarkets.
3. ***Positive physical conditions*****.** Transit facilities must not impose on prospective riders the kinds of physical barriers identified by A. Loukaitou-Sideris and T. Banerjee (2000), including unattractive neighborhood characteristics such as low income, high unemployment and crime along with physical barriers to transit stations.
4. ***Positive social conditions*****.** Likewise, there must be a positive social milieu that also does not discourage riders from accessing transit (A. Loukaitou-Sideris and T. Banerjee, 2000).
5. ***Land*****.** It should go without saying that land sufficient for development or redevelopment needs to be available. Local redevelopment agencies can play an important role in this respect.
6. ***Local government commitment.*** Through various means, local government needs to be a partner to facilitate the success of investments in transit. This can range from changes in land use plans and codes to providing modest relief from development decision processes and fees to being a partner (Nelson, 2014).

We conclude that what matters most in choosing between transit options is determining that which maximizes accessibility between origins and destinations; takes best advantage of growth and demand; minimizes physical and social barriers; assures a sufficient supply of buildable land along corridors and within station areas; and has local government facilitating private-sector investment through a wide range of public-private partnerships. We posit that bus rapid transit systems may show more promise than other alternatives to advance these objectives.

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NITC
NATIONAL INSTITUTE for
TRANSPORTATION and COMMUNITIES
Transportation Research and Education Center
Portland State University
1900 S.W. Fourth Ave., Suite 175
Portland, OR 97201