BUS RAPID TRANSIT AND ECONOMIC DEVELOPMENT: **A QUASI-EXPERIMENTAL TREATMENT AND CONTROL ANALYSIS**

Research Question: Is there an association between BRT and economic development from the Great Recession into the early recovery years?

Bus Rapid Transit Lines Evaluated and Ratings

Pittsburgh South	1977	Basic	
Pittsburgh East	1983	Bronze	
Pittsburgh West	2000	Basic	
Las Vegas MAX	2004	Unrated	
Los Angeles Orange	2005	Bronze	
Kansas City Main Street	2005	Unrated	
Eugene-Springfield Emerald Express	2007	Bronze	
Cleveland Health Line	2008	Silver	
Bronx Pelham Parkway	2008	Unrated	
Phoenix Main Street	2008	Unrated	
West Valley City, UT MAX	2008	Unrated	

Study Period

2008-2011 covering the Great Recession and early recovery years

Research Design

Quasi-experimental, pre-post design and treatment-control applied to each BRT line.

Data

Longitudinal Employer-Household Dynamics (LEHD) by Economic Group within 0.25-mile of BRT stations.

Table 1: Allocation of Jobs by Economic Sectors into Economic Groups

Manufacturing
Manufacturing
<u> </u>
Retall-Lodging-Food Service
Retail Irade
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 Remedia-
tion Services
Other Services (except Public Administration)
Public Administration
Education
Educational Services
Health Care
Health Care and Social Assistance
Art-Entertainment-Recreation
Arts, Entertainment, and Recreation

Source: Census

Method

BRT station

CCt-I

,CCt-I

CCt

,CCt

Shift-share analysis is also used because it assigns the change or shift in the share or concentration of jobs with respect to the region, the industry mix, and the "local" 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 those block groups with centroids within 0.25-mile of the nearest BRT station; this is called 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 "economic group mix" based on the economic groups noted in Table I. Using notations by the Carnegie Mellon Center for Economic Development (undated), the shift-share formula is:

$SS_{i} = CC_{i} + EGM_{i} + BRT_{i}$ Where, $SS_{i} = Shift-Share$ $CC_{i} = Central County share$ $EG_{i} = Economic Group Mix$ $BRT_{i} = BRT Station Area shift$	The method is applied BRT station areas within 0.25 miles and also to 10 comparable or "control" points. The equations for each component of the shift-share analysis are: $CC = (_{i}BRT \text{ station areat-1} \cdot CCt / CCt - I)$ $EGM = [(_{i}BRT \text{ station areat-1} \cdot CCt / CCt - I) - CC]$ $BRT = [_{i}BRT \text{ station areat-1} \cdot (_{i}BRT \text{ station areat} - I - CCt / CCt - I)]$
Where: BRT station areat-1 = number of job	in the BRT station area sector (i) at the beginning of the analysis period (t-1)

areat	=	number o	of jobs i	n the Bl	RT statior	n area i	in sector	(i) a	t the end	l of the a	inalysis	period	1 (t)
			1 6		4					C 1		• • •	

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

Shift-Share is also applied to a control group.

Method to Identify Controls for BRT Stations

- Controls for each BRT station is done through a set of tools coded in ArcGIS Model Builder
- The General Transit Feed Specification (GTFS) reference provided by Google is used to collect BRT station points in ArcGIS.
- Between pairs of closely placed BRT stations, a center point is created and used for analysis. • Major road data from ESRI is used and clipped based on each BRT host county boundary, excluding road segments that belong to highways and highway ramps
- Census block group GIS shapefiles for 13 regions were prepared to generate census and Longitudinal Employer-Household Dynamics (LEHD) data at the block group level.
- These census and LEHD datasets are used to calculate values within a 0.25-mile walkshed of both existing and comparable BRT station points later in the process
- Possible control points were created at random by running several Model Builder tools developed by the research team, and hundreds to thousands of control points were produced.
- Some control points overlapped one another or are very close to each other.
- Since existing BRT stations are generally located along the major roads within the urban area, some randomized control BRT station points outside the urbanized area were excluded.
- Therefore, using another ArcGIS Model Builder tool for randomized selection, approximately 1,000 random control station points within the urbanized area were selected as final possible control points.



Figure 1: Major road and blockgroup GIS shapefiles are prepared (left). Then, through the ArcGIS Model Builder toolboxes, random control points are produced, and the approximately 1,000 control points are selected for analysis (middle and right).

Because control points do not have any properties, the next step is to consolidate values for each different measure into these controls. This research assesses properties of controls based on five measures – total population, employment, median household income, the total number of housing units, and the total number of households. To do this, the ArcGIS Model Builder tool coded for getting values of both existing and control station points is necessary. Through running the third ArcGIS Model Builder tool, 0.25-mile walksheds for existing and comparable BRT points are created because a 0.25-mile walkshed is the primary area of influence for BRT systems in this research. All values for the five measures are collected based on this walkshed. Also, to get values of the five measures for existing and control points, areal fraction ratios are calculated by dividing the total area of blockgroups intersecting with a 0.25-mile walkshed by the areas of parts of blockgroups that actually intersect with the 0.25-mile walkshed. By using these areal fraction ratios, values for the five measures are estimated for all existing and control points through the iteration model of the processes above.



Figure 2: First, blockgroups that intersect with a 0.25-mile walkshed of each point are selected (left). Then, through spatial intersection of these two polygon features, only partial blockgroup areas within the walkshed are selected (middle). Finally, through dissolving these parts into one polygon and calculations for the five properties – population, employment, median household income, the number of housing units, and the number of households, properties of each point – are produced (right).

To select control points similar to the five properties of existing BRT stations, the quadrance score matching method is used. Using the five basic properties of existing and control station points, quadrance scores of each control station point compared to each existing BRT station points are calculated based on the following Euclidian distance formula:

> $Quadrance_{T_n}^2 = (Population_{T_n} - Population_{Comp_n})^2 + (Employment_{T_n} - Population_{Comp_n})^2 +$ $Employment_{Comp_n}^{2} + (MedHHInc_{T_n} - MedHHInc_{Comp_n})^{2} + \cdots$ $(Housing_Units_{T_n} - Housing_Units_{Comp_n})^2 + (Households_{T_n} Households_{Comp_n})^2\P$

Quadrance scores of all control points are different according to different existing BRT stations. The formula suggests that control points with small quadrance scores have similar values of the five properties to existing BRT points. Based on the quadrance score results of all control points relative to properties of each existing BRT station, the top ten control points with the smallest quadrance score are finally selected. This means that 4,610 control points similar to 461 existing BRT stations are selected for comparison of demographic and economic changes of existing and control points between 2000 and 2010. Also, while selecting the top ten control points for each existing BRT stations, we selected these points whose 0.25-mile walksheds do not overlap with one another.

Finally, for both existing and the top ten control points, additional data calculation processes are implemented. Through modification of models for calculating five measures, other additional census data and LEHD data for both existing BRT and control station points are calculated based on areal fraction ratios of a walkshed to the intersecting blockgroups. These are estimated based on 2000 and 2010 block group boundaries that also contain all census and LEHD data at the block group level. The final outcome tables are organized by year (2000 and 2010) and types of points (existing BRT stations and top ten control points).





Figure 3: For example, quadrance scores of five properties of all control walksheds compared to five properties of existing BRT station walkshed (a red circle in the left figure) are calculated by using the quadrance score formula. Then, through the iteration models for selecting the final top ten control station points, the final top ten control station points whose properties are similar with those of existing BRT stations are selected. This process is repeated until we can get the top ten control points for each existing BRT stations (461 existing BRT station points).

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Descriptive Comparisons

Table 2: BRT Station Area Treatment and Control BRT Station Area Control Area Job Percentage Change, Great Recession into Recovery, 2008-2011												
	Pittsburgh South	Pittsburgh South	Pittsburgh West	Las Vegas Max Line	Los Angeles Or-	Kansas City Main Street	Eugene- Springfield EmX	Cleveland Health-line	Bronx Pelham Park-way	Phoenix Main Street	West Valley City Max	All BBT Systems
Economic Group	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	BRT Change	Change
BRT Rating	Basic	Bronze	Basic	Bronze	Bronze	Unrated	Bronze	Silver	Unrated	Unrated	Unrated	NA
					BRT Stati	on Area Treatment						
Manufacturing	-26.4%	-18.4%	-26.9%	-30.7%	-16.9%	-3.0%	-14.2%	-27.2%	8.6%	-38.9%	10.1%	-16.7%
Industrial	-37.1%	5.7%	15.2%	-5.9%	0.0%	2.9%	14.3%	-14.6%	169.3%	-15.8%	-0.7%	1.7%
Retail-Lodging-Food	14.5%	18.0%	8.8%	-21.3%	-9.5%	-3.5%	-5.5%	-10.3%	10.8%	-10.3%	-5.6%	-5.9%
Knowledge	-3.2%	5.1%	-10.0%	-11.5%	-2.4%	-11.3%	-8.6%	-28.8%	-9.6%	-47.8%	-5.5%	-9.9%
Office	-4.7%	-5.1%	17.0%	14.3%	-3.6%	-0.4%	-4.1%	-18.1%	-6.6%	-10.3%	38.5%	4.8%
Education	-23.5%	-27.3%	38.9%	13.3%	131.0%	0.0%	2.2%	-24.9%	13.1%	-7.5%	11.6%	3.6%
Health Care	-16.1%	31.0%	18.3%	-6.0%	-42.9%	8.5%	9.5%	26.2%	95.8%	24.4%	23.6%	11.7%
Arts-Entertain-Recreation	-24.5%	-2.7%	76.4%	38.2%	17.0%	-9.2%	-11.4%	-39.0%	30.8%	22.9%	23.8%	18.8%
Total	-9.3%	10.1%	12.5%	-5.8%	-4.2%	-1.9%	-1.0%	-10.9%	39.4 %	-7.9%	12.2%	0.7%
Economic Group	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change
					Control BR1	Station Area Contro	1				1	
Manufacturing	-7.3%	-14.1%	-13.8%	-17.6%	-5.5%	-28.6%	-34.1%	-32.3%	-23.7%	-8.9%	-17.4%	-22.7%
Industrial	6.7%	-10.1%	-7.0%	-7.6%	-7.4%	-34.1%	-17.2%	-34.3%	11.7%	-16.4%	-12.0%	-13.3%
Retail-Lodging-Food	-12.4%	-0.5%	1.6%	8.3%	-4.6%	-15.6%	-4.5%	-24.8%	15.7%	-18.3%	-13.5%	-3.1%
Knowledge	-1.7%	-0.7%	9.8%	2.2%	-5.2%	-14.3%	-5.3%	-39.4%	7.2%	-18.7%	-2.8%	-6.5%
Office	17.3%	15.2%	19.5%	-19.2%	-1.7%	-5.0%	-7.7%	-18.3%	10.7%	-1.7%	-3.3%	-2.9%
Education	1.0%	10.2%	11.4%	507.3%	7.8%	-6.4%	6.3%	-27.2%	15.1%	18.3%	-12.4%	28.8%
Health Care	0.7%	4.8%	-8.3%	7.5%	-1.7%	-16.3%	14.1%	20.1%	20.5%	24.8%	18.3%	7.9%
Arts-Entertain-Recreation	-72.6%	-8.5%	-14.4%	-7.2%	-1.7%	-21.0%	-16.3%	-33.4%	-4.1%	-7.7%	-3.8%	-11.8%
Total	-0.9%	3.5%	3.3%	15.4%	-2.2%	-14.4%	-8.4%	-18.7%	14.1%	-4.2%	-6.3%	-1.3%

Note: Z-scores show that change in total BRT station area jobs is significantly different than change in total control BRT station area jobs with respect to total central county change in jobs at p < 0.01 with the exception of the Los Angeles Orange Line. Best-performing treatment and control BRT station areas are highlighted in bold red, as are best-performing economic groups.

Shift-Share Results

Table 3: BRT Station Area Treatment and Control BRT Station Area Control Shift-Share Resultsa, Great Recession into Recovery, 2008-2011												
Economic Group	Pittsburgh South Line BRT Change	Pittsburgh South Line BRT Change	Pittsburgh West Line BRT Change	Las Vegas Max Line BRT Change	Los Angeles Or- ange Line BRT Change	Kansas City Main Street BRT Change	Eugene-Spring- field EmX BRT Change	Cleveland Health-line BRT Change	Bronx Pelham Park-way BRT Change	Phoenix Main Street BRT Change	West Valley City Max BRT Change	All BRT Systems Change
BRT Rating	Basic	Bronze	Basic	Bronze	Bronze	Unrated	Bronze	Silver	Unrated	Unrated	Unrated	NA
BRT Station Area Treatment (figures are mean jobs per block group comprising the analysis area)												
Manufacturing	-6.9	-2.2	-6.3	-1.1	-2.6	2.7	13.2	-2.7	0.4	-9.9	10.3	-8.8
Industrial	-15.5	2	5.8	0.3	1.2	3.5	28.7	0.4	10	-2.8	1.3	28.6
Retail-Lodging-Food	10.7	14.9	13.6	-68.5	-11.5	2.4	-2.8	-2.5	-2	-9.4	0.5	-61.5
Knowledge	-4	2.5	-20.9	0.6	-3.5	3.9	-2.7	-4	-0.8	-20.9	-1.5	-55.8
Office	-39.9	-9.9	51.8	49.5	-27.6	-4.8	9.8	-9.8	-4.4	-8.4	72.1	77.6
Education	-30.5	-10.6	19.8	0.2	48.7	2.8	-2.7	-7.3	-0.2	-27.7	5.1	-7.1
Health Care	-20.1	32.7	5.1	-5.9	-61.9	-2.3	-9.5	-0.4	37.6	4.5	3.4	-9.6
Arts-Entertain-Recreation	-2.5	-2.3	17.4	11.7	1.7	1.8	0.7	-2.8	0.2	1.7	3.8	28.8
Total	-108.8	27.2	86.4	-13.1	-55.4	9.9	34.8	-29.1	40.8	-72.9	95	-7.7
Economic Group	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change	Control Change
			Cont	rol BRT Station Area	Control (figures are n	nean jobs per block g	roup comprising the	e analysis area)				
Manufacturing	0.3	-1.6	-1.7	0.8	6.5	-3.2	-5.2	-5.2	0	0.4	-7.7	-50
Industrial	1.1	-2.3	-3.7	0	-2.9	-9.6	-3.3	-5	0.3	-6.6	-10.9	-52.6
Retail-Lodging-Food	-9.1	-0.4	1.5	67.4	-2.2	-8.8	0.9	-11.4	0.3	-25.2	-18.1	-9.3
Knowledge	-0.3	0	6.2	5.8	-19.1	1.1	1.1	-5.2	0.3	-10.7	-2.2	-16.8
Office	3.9	5	14.7	-33.8	-21.5	-9.5	-3.9	-8.2	0.7	11.6	-9.6	-87.1
Education	-2.4	1.1	1.9	185.5	-12.1	0.1	1.1	-5.8	0.1	7.2	-10.6	181.6
Health Care	-1.5	-2.9	-18.3	-2.6	-16	-17.9	3.5	-3.4	-5.8	5.5	2.5	-51.6
Arts-Entertain-Recreation	-2.1	-1.6	-3.9	0.5	0.1	0.2	-0.7	-1.5	-0.1	-2.4	-0.5	-18.8
Total	-10	-2.7	-3.3	223.5	-67.2	-47.6	-6.5	-45.8	-4.2	-20.3	-57.1	-104.5

^a Only the BRT and Control BRT station area ("local") shift-share results are reported for brevity. Note: Best-performing treatment and control BRT station areas are highlighted in bold red, as are best-performing economic groups.

Table 4: Summary Results of Descriptive and Shift-Share Analysis of BRT Station Areas (Treatment) and Control BRT Station Areas, 2008-2011

	Descriptive BRT	Descriptive Control	Shift-Share BRT	Shift-Share Control
BRT Line	Station Area	BRT Station Area	Station Area	BRT Station Area
	Treatment	Control	Treatment	Control
Pittsburgh South—1977 – Basic	-9.3%	-0.9%	-108.8	-10.0
Pittsburgh East—1983 – Bronze	10.1%	3.5%	27.2	-2.7
Pittsburgh West— 2000 – Basic	12.5%	3.3%	86.4	-3.3
Las Vegas MAX—2004 - Unrated	-5.8%	15.4%	-13.1	223.5
Los Angeles Orange—2005 - Bronze	-4.2%	-2.2%	-55.4	-67.2
Kansas City Main Street—2005 - Unrated	-1.9%	-14.4%	9.9	-47.6
Eugene-Springfield Emerald Express—2007 -	-1.0%	-8.4%	34.8	-6.5
Bronze				
Cleveland Health Line—2008 - Silver	-10.9%	-18.7%	-29.1	-45.8
Bronx Pelham Parkway—2008 - Unrated	39.4%	14.1%	40.8	-4.2
Phoenix Main Street—2008 - Unrated	-7.9%	-4.2%	-72.9	-20.3
West Valley City MAX—2008 - Unrated	12.2%	-6.3%	95.0	-57.1
Mean Total BRT and Control Station Area Change	0.7%	-1.3%	-7.7	-104.5
Overall hest Performance	7	Δ	Q	3

Note: Coefficients are the sum of the BRT Station Area 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 control BRT station areas with respect to change in central county jobs from the Great Recession into recovery, 2008-2011. All differences are statistically significant at p < 0.01.

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Findings

- 7 of 11 BRT lines performed better that control areas • ses, jobs increased in the BRT station areas relative to
- pseudo BRT station areas— • BRT lines serving substantially built-out suburban areas increased jobs relative to their controls in Pittsburgh South and West lines, Bronx Pelham Parkway and West
- In downtowns, both treatment and control study areas lost iobs overall but the BRT station areas lost less
- In 4 situations, control areas gained over BRT station areas—Pittsburgh South line, Las Vegas, Los Angeles and Phoenix. In all cases, BRT lines served principally suburban areas that were especially hard-hit during the
- Overall, total jobs increased within BRT station areas by 0.7 percent but decreased in control areas by 1.3 percent, a total difference of nearly 170 jobs per block group
- 5 economic groups appear to be more attracted to BRT station areas than controls \rightarrow manufacturing, industrial,
- office, health care and arts-entertainment-recreation. • Control areas performed slightly better than BRT station areas \rightarrow retail-lodging-food and knowledge economic
- Control areas did much better than BRT station areas in the education economic group.

Findings

- 8 of 11 BRT station areas had better overall performance than control BRT station areas
- BRT station areas performed many times better than control BRT station areas.
- Where the mean BRT station area lost 7.7 jobs per block group between 2008 and 2011, the mean control BRT station area lost 104.5 jobs during the same period, about 13.5 times more.
- 5 of the 8 economic groups performed better in the BRT station areas than in the control BRT station areas \rightarrow manufacturing, industrial, office, health care and artsentertainment-recreation.
- The others fared much better in control BTR station areas than the treatment group \rightarrow retail-lodging-food, knowledge and education
- Among the BRT systems, Pittsburgh West Line in Pittsburgh and West Valley MAX BRT in Salt Lake City experienced rapid job growth.
- Generally, Higher rated BRT lines saw more job growth than lower rated ones.

Table 4 summarizes our descriptive and shift-share analysis.

- Though the worst-performing BRT line in our analysis was Pittsburgh's South line, it is also a historically underserved area perhaps with more economic development challenges than other parts of Allegheny County.
- The other two BRT lines operating in Allegheny County are among the best performers overall and among most economic groups.
- The Las Vegas Max line serves a historically under-invested area that has largely been bypassed by the new economic investment of the past few decades which may account for its performance.
- The Main Street line in Phoenix also serves a substantially built-out, aging suburban area that suffered from the Great Recession perhaps more than the rest of the nation.
- Shift-share analysis shows that the BRT station areas of Kansas City, Eugene-Springfield, Bronx, and West Valley City (Salt Lake City metropolitan area) enjoyed substantial, positive performance in contrast to their control areas, which were mostly negative performance.
- Los Angeles' Orange line and Cleveland's HealthLine lost share of jobs but less so than their central counties as a whole
- Manufacturing and industrial economic groups performed much better in BRT station areas than controls. The manufacturing sector is perhaps the most diverse. Micro-breweries are manufacturing enterprises but are popular in downtowns with restaurants. Other activities include woodworkers, steel fabricators, hardware prototypers, coffee roasters, and a host of specialty garment operations. Industrial jobs include those in the utility industry which includes mostly office and clerical workers.
- That BRT station areas also perform better than controls in the office, health care and arts-entertainment-recreation economic groups is not surprising as these activities tend to be attracted to centers with easy transit access.
- Though surprised that education jobs favored control areas, this may be attributable to the highly dispersed nature of educational facilities
- On the whole, BRT station areas contribute to economic development compared to controls.