NITC NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

Main Street LINK

Phoenix, Arizona

Do TODs Make a Difference?

THE UNIVERSITY OF UTAH
Metropolitan Research Center

OTREC
OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM

Matt Miller, Arthur C. Nelson,
Joanna Ganning, Reid Ewing, & Jenny Liu
University of Utah

6/10/2014

Table of Contents

Table of Figures

Table of Tables

Acknowledgements

This project was funded by the Oregon Transportation Research and Education Consortium (OTREC) through a grant provided by the National Institute of Transportation and Communities (NITC). Cash match funding was provided by the Utah Transit Authority (UTA), Salt Lake County (SLCo), the Wasatch Front Regional Council (WFRC), and the Mountainlands Association of Governments (MAG). In-kind match was provided by the Department of City & Metropolitan Planning at the University of Utah, and by the Nohan A. Toulon School of Urban Affairs and Planning at Portland State University.

Disclaimer

PROJECT TITLE

Project Title: **DO TODs MAKE A DIFFERENCE?**

PRINCIPAL INVESTIGATOR

Name: **Arthur C. Nelson**	Title: **Presidential Professor**
Address: **Metropolitan Research Center** **375 S. 1530 E. Room 235AAC** **Salt Lake City, Utah 84112**	University: **University of Utah**
Phone: **801.581.8253**	Email: **acnelson@utah.edu**

CO-INVESTIGATORS (Add more rows for each additional co-investigator)

Name: **Reid Ewing**		Name: **Jenny Liu**	
University: **University of Utah**		University: **Portland State University**	
Address: **Metropolitan Research Center** **375 S. 1530 E. Room 235AAC** **Salt Lake City, Utah 84112**		Address: **School of Urban Studies & Planning** **P.O. Box 751** **Portland, Oregon 97207**	
Phone: **801.581.8255**	Email: **ewing@arch.utah.edu**	Phone: **503.725.5934**	Email: **jenny.liu@pdx.edu**

CO-INVESTIGATORS (Add more rows for each additional co-investigator)

Name: **Joanna Paulson Ganning**		Name:	
University: **University of Utah**		University:	
Address: **Metropolitan Research Center** **375 S. 1530 E. Room 235AAC** **Salt Lake City, Utah 84112**		Address:	
Phone: **801.587.8129**	Email: **joanna.ganning@utah.edu**	Phone:	Email:

1-INTRODUCTION

This analysis was intended to help answer the following policy questions:

Q1: Are TODs attractive to certain NAICS sectors?
Q2: Do TODs generate more jobs in certain NAICS sectors?
Q3: Are firms in TODs more resilient to economic downturns?
Q4: Do TODs create more affordable housing measured as H+T?
Q5: Do TODs improve job accessibility for those living in or near them?

The first question investigates which types of industries are actually transit oriented. Best planning practices call for a mix of uses focused around housing and retail, but analysis provides some surprises. The second question tests the economic development effects of transit—do locations provided with transit actually experience employment growth? The third question is intended to determine the ability of employers near transit to resist losing jobs; or having lost jobs, to rapidly regain them.

The fourth research question confronts the issue of affordable housing and transit. Transit is often billed as a way to provide affordable housing by matching low-cost housing with employment. Yet proximity to transit stations is also expected to raise land values. Proximity to transit, however, may increase actual affordability, regardless of increases in housing costs, because of the reduction in transportation costs.

The final research question considers the relationship between workplace and residential locations. To be able to commute by transit, both the workplace and home must be near transit. Effective transit should increase both the number and share of workers who work and live along the transit corridor.

Report Structure

The rest of the report is structured as follows. The following section details the study area and corridors used for analysis in all of the research questions with each research question given its own section. Each section contains a short review of relevant research as well as a description of additional data sources and analytical techniques. Each section then provides relevant analysis, discussion of the analysis, and relevant conclusions. The report concludes with a summary of outcomes from each.

2-DATA AND METHODS

Data from before and after the opening of a transit line was analyzed to determine if the advent of transit causes a significant change in area conditions. To control for exogenous factors (such as things affecting the entire metro area), changes in transit corridors were then compared to changes in comparable corridors located in the same metropolitan region, matching length, location, mix of land uses, and suitability for transit. As corridors differ primarily in their lack of transit, the corridor matching represents a 'natural experiment', where one corridor receives the treatment (a fixed guide-way transit line) and the comparable corridor acts as a control. Because of the need to perform this matching, this study used the corridor as its unit of analysis rather than station points. For most transit systems, stations lie within a mile of one another, so the areas are quite similar. Without a network analysis of walking paths, exact distances to transit are difficult to determine.

The remainder of this section describes the selection of existing transit (treatment) corridors, the creation of comparable corridors, and the data used for analysis. It also provides an overview of the transit corridor being analyzed.

Selection of Treatment corridor

The process began with Center for Transit Oriented Development (CTOD)'s Transit Oriented Development (TOD) Database (July 2012 vintage). The database's unit of analysis is the station. For each station there is information about the station's location, providing both address and lat-long points. Station attributes include the transit agency for that station as well as the names of routes using that station. The database was enriched with the addition of transit modes for all stations since many transit stations serve more than one mode.

While the database contained routes, it did not identify the corridor for each station. Most transit routes make use of multiple corridors. While routes change in response to operational needs, a corridor consists of a common length of right-of-way that is shared by a series of stations on the corridor. Typically, all stations along a corridor begin active service at the same time. Transit systems grow by adding additional corridors to the network. Initial systems may consist of only a single corridor.

Distinct corridors for each system were identified on the basis of prior transportation reports (Alternative Analysis, Environmental Assessments, Environmental Impact Statements, Full Funding Grant Agreements) as well as reports in the popular media. Whenever possible, a corridor that started operation after 2002 but before 2007 was preferred. Stations relevant to analysis were then queried out, and imported into Google Earth as a series of points. Using aerial images, the path of the corridor was traced. The corridor was then exported as a KML file and imported into a geodatabase in ArcGIS.

Creation of Comparable Corridors

Numerous draft corridors were created and then compared with the existing transit corridor. The following criteria were used while creating a comparable corridor:

Comparable Corridors Criteria

1. Same MSA
2. Equal length
3. Existing transit route; express transit preferred
4. Direct; no doubling back
5. Anchored on both ends (unless the original line was not)
6. Anchors of equal magnitude; downtowns, transit centers, shopping centers, malls, etc.
7. Along a major corridor; major/minor arterial
8. Similar land use mix along the corridor; both corridors contain substantial commercial development
9. Conformity with existing rapid transit plans
10. Existing corridor; rail or highway
11. Similar relative nearness to a parallel freeway in both distance and degree
12. Commuter rail follows existing corridors; either rail or freeway

Keeping the comparable corridor in the same metro area reduced a large number of confounding effects. Maintaining the same length meant a similar amount of area was included in the analysis. Bus routes in analogous locations were used to create draft corridors. Because of their high cost per mile, rapid transit corridors tend to be direct. They also tend to be 'stretched' until they reach a reasonable terminus to anchor each end. Whenever possible, the type and magnitude of each anchor use was matched.

For comparable corridors, the emphasis was placed on creating corridors that were contiguous and followed a continuous existing right-of-way that was viable as a transit corridor. Availability of right-of-way was the primary concern, and this dictated either existing major roads or existing railway right-of-way. For the former, highways and major arterials were preferred. For the latter, this meant the majority of right-of-way needed to follow an existing rail corridor. Whenever possible, proposed or future corridors from official planning documents were used, with some limitations.

For all commuter rail systems and most light rail corridors, the availability of right-of-way determines the location of the transit line. For many rail lines, this means that the transit corridor is located alongside incompatible or inappropriate uses, such as light industrial or low density single family residential units. These characteristics affect station accessibility. The mix of land uses along the corridor affects ridership in other ways. For instance, commercial locations generate more trips per acre than either residential or industrial uses, so similar levels of commercial exposure were sought in creating comparable corridors.

Finally, proximity to freeways was matched. The benefits ascribed to TOD are on the basis of the improved accessibility provided by transit. Because freeways also provide accessibility, the confounding effect of proximity to a competing mode can be considerable.

Data Source and Extent

The data used originated from the Census Local Employment-Housing Dynamics (LEHD) datasets. Both the Local Employment Dynamics (LED) and LEHD Origin-Destination Employment Statistics (LODES) were used. Employment data are classified using the North American Industrial Classification System (NAICS), and data are available for each Census Block at the two-digit summary level. Data were downloaded for all years available (2002-2011). The geographic units of analysis are 2010 Census Blocks Points. The database contains information on employment within each block. The data was downloaded from http://onthemap.ces.census.gov/ for each metro area, using the CBSA (Core Based Statistical Area) definitions of Metropolitan/Micropolitan. In cases where either the transit or comparable corridor extended beyond a CBSA metro area, adjacent counties were included to create an expanded metropolitan area.

There is a vast difference between TOD, and Transit Adjacent Development (TAD). The latter refers to any development happens to occur within the Transit Station Area (TSA), or half mile buffer around a fixed guide-way transit station, while the former refers to land uses and built environment characteristics hospitable to transit. This analysis assumes that while the existing development during the year of initial operations (YOIO) may not be TOD, land uses respond to changes in transportation conditions over time, phasing out TAD and replacing it with TOD. On this basis, the TOD is conflated with TSA for the purpose of this analysis.

Data Processing

ArcGIS was used to create a series of buffers around each corridor in 0.25 mile increments. Those buffers were then used to select the centroid point of the LED block groups within those buffers, and summarize the totals. Because the location of census block points varies from year to year (for reasons of non-disclosure), it was necessary to make a spatial selection of points within the buffer for each year rather than using the same points each year. Figure 1 shows an example corridor, the buffers around the corridor, and the location of LED points in reference to both.

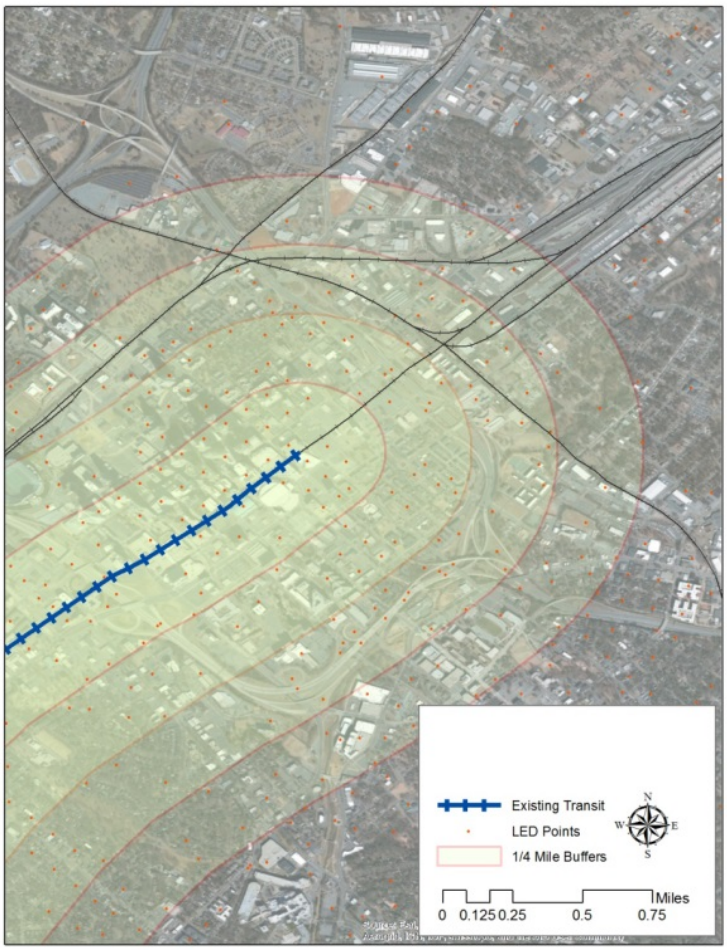

Figure 1: Example corridor, buffers, and LED census block points

Study Area

This study examines Metro Transit's Main Street Link BRT. The line begins at the eastern terminus of the Metro

Light Rail and continues eastward on Mesa Main street to Power Road, and thence South to the Superstition Springs Mall, where it meets with other buses at a transit center. The corridor is approximately 12.9 miles long. It's year of initial operation was 2008. The comparable corridor was the future BRT corridor along Arizona Avenue. Figure 2 shows the transit and comparable corridors as well as the location of LED points.

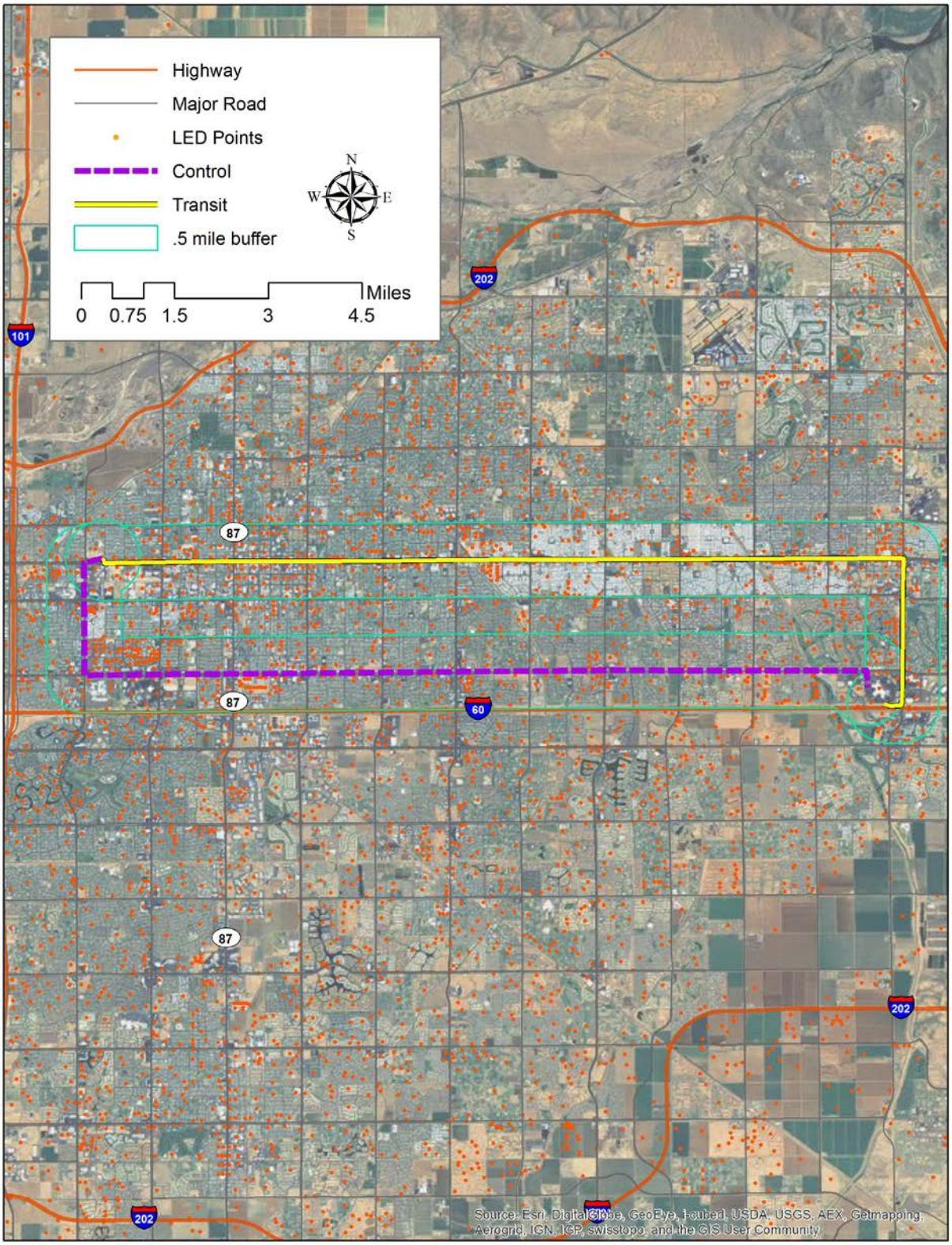

Figure 2: Transit and comparable corridor locations

3-EMPLOYMENT CONCENTRATION

Introduction

This section is intended to determine if TODs are more attractive to certain NACICS industry sectors. Case studies indicate that economic development and land use intensification are associated with heavy rail transit (HRT) development (Cervero et al. 2004; Arrington & Cervero 2008). Case studies associated with light rail transit (LRT) have inconsistent results, suggesting that much of the employment growth associated with transit stations tends to occur before a transit station opens (Kolko 2011). A study by CTOD (2011) examined employment in areas served by fixed guide-way transit systems, and explored how major economic sectors vary in their propensity to locate near stations, finding high capture rates in the Utilities, Information, and Art/Entertainment/Recreation industry sectors.

Data & Methods

To analyze the difference in the attractiveness of TODs, location quotient was used to analyze the concentration of different industries over time. Location quotient is a calculation that compares the number of jobs in each industry in the area of interest to a larger reference economy for each corridor. The analysis then compares the location quotients of each industry between each corridor. A 0.5mile buffer around each corridor was used as the unit of analysis.

Results

The location quotients within a 0.5 mile buffer for the transit corridor is shown in Table 1. Location quotients are shown for the first and final years, with a sparkline to show trends between the years. Changes in location quotient between the 2002 and the advent of transit are calculated, as well as the advent of transit and 2011. The final column is the difference between the changes in the two periods.

Both corridors are located in a pre-existing, built-up urban area, so additional growth must occur through redevelopment of existing urban land, while the urban area that forms the denominator of the location quotient continues to grow through both development and redevelopment. With an expanding urban area, the location quotient for a fixed area would be expected to fall over time. Any increase in location quotient for a corridor should indicate locational advantage.

Industry	Location Quotient			Changes		Differences in Changes
	2002	2002-2011	2011	Δ 2002-2008	Δ 2008-2011	Δ 2002-2008 & Δ 2008-2011
Utilities	0.01		0.00	-0.01	0.00	0.01
Construction	0.89		0.66	-0.17	-0.06	0.10
Manufacturing	0.29		0.32	0.11	-0.08	-0.19
Wholesale	0.50		0.40	-0.01	-0.09	-0.08
Retail	1.31		1.01	-0.16	-0.15	0.01
Transportation	0.14		0.13	0.06	-0.07	-0.13
Information	2.35		0.79	-1.05	-0.51	0.54
Finance	0.53		0.44	-0.07	-0.02	0.04
Real Estate	0.53		0.73	-0.02	0.23	***0.25***
Professional	0.62		0.42	-0.11	-0.09	0.01
Management	0.11		0.11	0.02	-0.03	-0.04
Administrative	0.57		0.61	-0.06	0.10	***0.15***
Education	3.03		3.45	0.49	-0.07	-0.57
Health Care	0.84		1.31	0.33	0.15	-0.18
Arts, Ent. Rec.	0.62		0.86	0.08	0.16	0.08
Lodging & Food	1.27		0.92	-0.38	0.02	***0.40***
Other Services	1.00		0.89	0.12	-0.24	-0.36
Public Admin	1.52		1.49	0.22	-0.25	-0.47

Table 1: Location quotients comparison for transit corridor

After the advent of transit, the most significant increases in location quotient occur in Real Estate, Health Care, and Arts/Entertainment/Recreation sectors. In contrast, the most significant decreases occur for Information, followed by the Other services and Public Administration sectors. Differences between the two time periods show that a number of sectors experience substantial changes in location quotient changes. A positive number indicates that the trend in location quotient is better after transit than before. Finally, a number of industries that had falling location quotients before the advent of transit now have rising location quotients, such as Real Estate, Administration, and Lodging/Food.

For both the transit and comparable corridors, changes in location quotient for the time period after the advent of transit are shown in Figure 3. The y-axis is numeric change in location quotient.

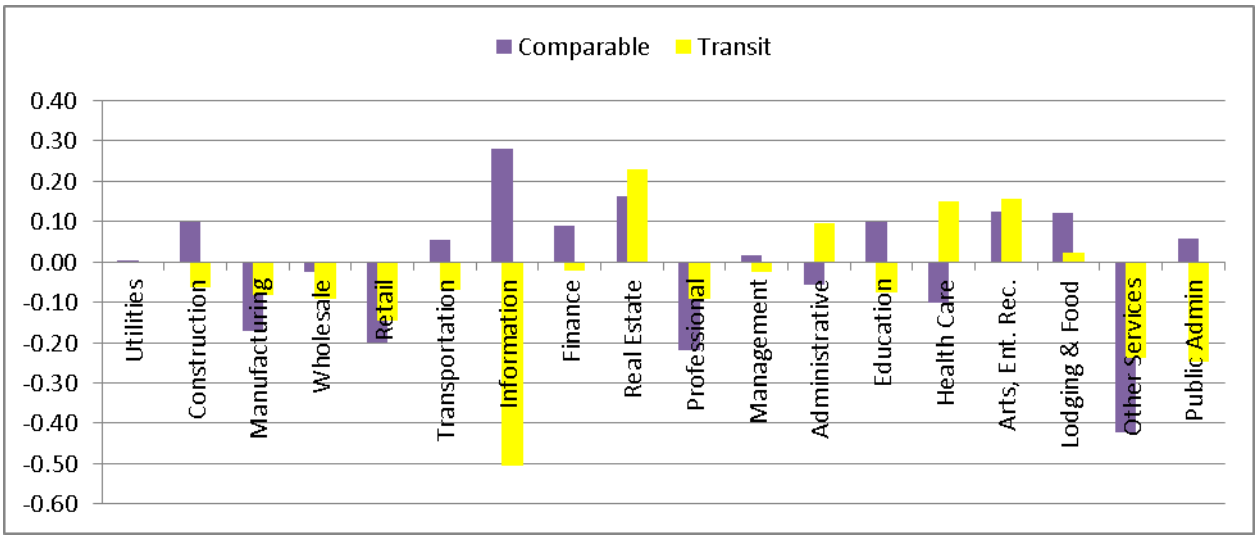

Figure 3: Changes in location quotient by corridor for the time period after the advent of transit

Employment in the Information, Construction, and Public Administration sectors experience a reduction in location quotient in the transit corridor and increasing employment in the comparable corridor. The reverse is true for the Administrative and Health Care sectors. Finally, while the location quotient for Real Estate and Arts/Education/Recreation sectors increases in both corridors, it increases more for the transit corridor.

Discussion & Implications

Attributing causal effect to transit lines is always problematic. Designing successful transit networks is largely a game of connect-the-dots, linking together major employment centers with employee housing along congested corridors. Many stations are co-established with new campuses for major institutions, or at public events venues, so increases in Healthcare and Arts/Entertainment/Recreation make sense. The increase in the location quotient for Real Estate is curious, and the results may be confounded by proximity to the Superstition Freeway.

The severe decline in the location quotient for Information is unexpected. The sparkline indicates that the decline has been a steady one, over the entire time series, so it is unlikely transit is the cause. Likewise, the decline in the Other Services and Public Administration is unexpected. Both tend to cluster around transit stations. However, in addition to a BRT system, Phoenix also has a very long light rail system, (METRO light rail), which may be attracting those industries instead.

Contrasting the transit corridor with the comparable corridor only makes the decline in the Information sector more curious, although it mitigates the mysteriousness of Real Estate, which does well in both corridors. The result of other confounding effects may be explained that the Main Street BRT runs along Main Street in Mesa, where there are sustained and strenuous efforts to develop it as a downtown and urban center for the city of Mesa, Arizona.

4-EMPLOYMENT GROWTH BY SECTOR

Introduction

This section is intended to determine if TODs generate more jobs in certain NAICS sectors. To determine if the new jobs are actually created as a result of proximity to transit, it is necessary to determine what portion of changes in employment can be attributed to transit and what portion of changes is determined by other factors.

In theory, employment in different NAICS sectors should be variable depending on the NAICS code, as some industry sectors are better able to take advantage of the improved accessibility offered by transit. For example, industries in which employment is characterized by low-income workers in need of affordable transportation or salaried office workers with long distance commutes are more likely to make use of transit. Likewise, arts and entertainment venues prone to serious congestion (due to their high peaks of visitors) would also benefit. Finally, institutions with large parking demands (universities, colleges, hospitals, and some government offices) could be expected to find proximity to transit valuable.

It is difficult to determine to what degree employment growth is caused by location near transit, and what is a product of self-selection, as rapidly growing industry sectors locate next to transit. Shift-Share analysis helps answer this question.

Data and Methods

A shift-share analysis attempts to identify the sources of regional economic changes to determine industries where a local economy has a competitive advantage over its regional context. Shift-share separates the regional economic changes within each industry into different categories and assigns a portion of that the change to each category. For the purpose of this analysis, these categories are Metropolitan growth effect, Industry mix, and the Corridor share effect.

1. Metropolitan growth effect is the portion of the change attributed to the total growth of the metropolitan economy. It is equal to the percent change in employment within the area of analysis that would have occurred if the local area had changed by the same amount as the metropolitan economy.
2. Industry mix effect is the portion of the change attributed to the performance of each industrial sector. It is equal to the expected change in industry sector employment if employment within the area of analysis had grown at the same rate as the industry sector at the metropolitan scale (less the Metropolitan growth effect).
3. Corridor share effect is the portion of the change attributed to location in the corridor. The remainder of change in employment (after controlling for metropolitan growth and shifts in the industry mix) is apportioned to this variable. Within regions, some areas grow faster than others, typically as a result of local competitive advantage. While the source of competitive advantage cannot be exactly identified, the methods of analysis used suggest that the cause of

competitive advantage can be directly attributed to the presence of transit, or factors leveraged by the presence of transit.

Results

A shift-share analysis of changes in employment within a 0.5 mile buffer of the transit corridor is presented in Table 2. The first batch of columns shows numeric and percentage changes in the metropolitan area, and the second batch of columns shows the numeric and percentage changes in the buffer around the transit corridor. The third batch of columns is the actual shift-share analysis, and apportions the numeric change in the buffer around the corridor. The shift-share analysis is representative of a 0.5 mile buffer around the transit corridor.

NAICS Sector	Metro				Transit Corridor				Sources of Employment Change		
	2008	2011	# Change	% Change	2008	2011	# Change	% Change	Metro Share	Industry Mix Share	Corridor Effect
Utilities	15,769	15,294	(475)	-3%	-	-	-	0%	0	-	-
Construction	146,482	82,834	(63,648)	-43%	2,678	1,289	(1,389)	-52%	-166	(1,164)	(59)
Manufacturing	131,286	117,141	(14,145)	-11%	1,339	885	(454)	-34%	-83	(144)	(227)
Wholesale	89,876	81,452	(8,424)	-9%	1,105	757	(348)	-31%	-69	(104)	(176)
Retail	215,136	201,502	(13,634)	-6%	6,241	4,762	(1,479)	-24%	-387	(396)	(696)
Transportation	60,298	58,070	(2,228)	-4%	298	173	(125)	-42%	-18	(11)	(96)
Information	33,331	29,815	(3,516)	-11%	1,091	555	(536)	-49%	-68	(115)	(353)
Finance	109,197	108,774	(423)	0%	1,276	1,126	(150)	-12%	-79	(5)	(66)
Real Estate	41,305	36,454	(4,851)	-12%	524	628	104	20%	-33	(62)	198
Professional	104,372	97,022	(7,350)	-7%	1,352	961	(391)	-29%	-84	(95)	(212)
Management	23,422	21,885	(1,537)	-7%	77	54	(23)	-30%	-5	(5)	(13)
Administrative	181,797	160,550	(21,247)	-12%	2,347	2,292	(55)	-2%	-146	(274)	365
Education	146,135	148,176	2,041	1%	12,966	11,992	(974)	-8%	-804	181	(351)
Health Care	179,399	215,800	36,401	20%	5,265	6,654	1,389	26%	-327	1,068	647
Arts, Ent. Rec.	33,004	35,689	2,685	8%	585	721	136	23%	-36	48	125
Lodging & Food	164,891	156,919	(7,972)	-5%	3,726	3,390	(336)	-9%	-231	(180)	75
Other Services	53,625	51,111	(2,514)	-5%	1,517	1,062	(455)	-30%	-94	(71)	(290)
Public Admin	78,996	78,759	(237)	0%	3,461	2,759	(702)	-20%	-215	(10)	(477)
Total	**1808321**	**1697247**	**-111074**	**-6%**	**45848**	**40060**	**-5788**	**-13%**	**-2845**	**-1339**	**-1605**

Table 2: Shift-share analysis for 0.5 mile buffer of transit corridor

The entire metropolitan area suffers a serious decline in employment of 6 percent. However, the transit corridor suffers worse, with a decline in employment of about 13 percent, representing almost 6,000 lost jobs. In numeric terms, the only industry to enjoy the significant numeric increases is Health Care. In addition, Health Care enjoys a significant percentage increase in employment, as do Real Estate and Arts/Entertainment/Recreation industries. All industries enjoy an increase of over 20 percent, while the majority of industries in the corridor suffer equal or larger declines, with Construction, and Information losing over half their employment.

After using Shift-Share analysis to disaggregate the cause of change in employment, different patterns emerge. About half of the change in employment can be attributed to metro-scale trends, and another quarter to the industry mix within the corridor. However, the total corridor effect is still negative. But the Corridor Effect varies by industry. While this largely confirms the analysis of numeric changes (Health Care, Administrative, and Real Estate still appear to benefit from being located in the corridor), the Shift-Share Analysis suggests that both the Administrative and Lodging/Food industry sectors benefit from being located in the corridor.

Information about the corridor effect is presented for both the transit and comparable corridor in Table 3. Differences between the corridors are also presented. It is intended to confirm that the corridor effects attributed to transit are specific to the transit corridor, and not the result of another effect. The corridor benefit relates the change employment in employment totals to the change due to the Corridor Effect. A value of 1 indicates that almost all the change can be attributed to the corridor effect, while a value of zero means that the corridor has almost no effect.

Industry	Comparable			Transit			Transit Advantage	
	# Change	Corridor Effect	Corridor Benefit	# Change	Corridor Effect	Corridor Benefit	Employment Change	Corridor Effect
Utilities	1	1	1.0	0	0	#DIV/0!	-1	-1
Construction	-695	225	0.3	-1389	-69	0.0	-694	-294
Manufacturing	-453	-285	-0.6	-454	-227	-0.5	-1	58
Wholesale	-103	-10	-0.1	-348	-176	-0.5	-245	-166
Retail	-1245	-376	-0.3	-1479	-696	-0.5	-234	-320
Transportation	47	57	1.2	-125	-96	-0.8	-172	-152
Information	-40	195	4.9	-536	-353	-0.7	-496	-548
Finance	137	193	1.4	-150	-66	-0.4	-287	-259
Real Estate	56	110	2.0	104	198	1.9	48	88
Professional	-473	-287	-0.6	-391	-212	-0.5	82	75
Management	-5	11	2.1	-23	-13	-0.6	-18	-24
Administrative	-603	-7	0.0	-55	365	6.6	548	372
Education	232	266	1.1	-974	-351	-0.4	-1206	-606
Health Care	823	-123	-0.1	1389	647	0.5	566	771
Arts, Ent. Rec.	93	86	0.9	136	125	0.9	43	39
Lodging & Food	44	469	10.7	-336	75	0.2	-380	-394
Other Services	-424	-311	-0.7	-455	-290	-0.6	-31	21
Public Admin	72	76	1.0	-702	-477	-0.7	-774	-552
Total	**-2536**	**279**	**0.1**	**-5771**	**-1586**	**-0.3**	**-3252**	**-1865**

Table 3: Shifts by corridor and comparison between corridors

The comparable and transit corridor benefit different industries. The corridor benefit for the Real Estate industry is similar to both corridors, indicating that growth may be caused by similarities between the corridors. In contrast, the Corridor Benefit for the Administrative industry in the transit corridor is much larger, suggesting that proximity to transit is highly beneficial.

The corridor shift associated with the comparable and treatment corridors are substantially different for most industries. Differences in the corridor effect show that the transit corridor enjoys a substantial advantage over the comparable corridor in the Health Care and Administrative sectors. For almost all other industries, the comparable corridor is favored, most notably in Education, Information, and Public Administration.

Discussion & Implications

The Shift Share Analysis suggests that the proximity to the Main Street BRT has positive effects for the Health Care, and Arts/Entertainment/Recreation sectors. Contrast with the comparable corridor confirms Healthcare, but also suggests that the Administrative sector may benefit.

Drawing any conclusion for the Main Street BRT is difficult due to confounding factors. Metropolitan Phoenix is still suffering from the Great Recession, including a housing market had still not found its bottom in 2011.

The original plans called for the alignment to be served by light rail. Due to political uncertainty, the Metro light rail system that was constructed stopped at the boundary of Mesa. There have always been plans to extend the light rail further east into Mesa. BRT is largely being used as an interim measure. Development along the corridor may be in abeyance, pending better economic conditions, and the extension of the light rail line. Additional confounding factors with the alignment include proximity to several major freeways, either within a half mile, or intersecting with the BRT alignment. Employment is likely responding to that proximity, rather than the BRT.

While the Main Street LINK lacks the dedicated or exclusive guideway associated with a proper BRT, it does enjoy quality branding, with special buses, stations, and callouts on transit maps. It has a stopping pattern consistent with rapid transit. This highlights an emerging trend in Bus Rapid Transit: The use of rapid buses to connect transit centers. Transit centers are the modern equivalent of hub airports, Union stations, or central bus depots, where it is possible to transfer between multiple different lines. In both Eugene and Phoenix, BRT is being used as a distinct 'Functional Class' of bus. Traffic engineers have long made the distinction between different classes of roads, trading off accessibility and mobility. While local buses provide excellent accessibility, they move slowly with frequent stops. The Main Street Link is a higher functional class of bus, with reduced accessibility (less frequent stops) but also higher mobility. It runs at a much higher frequency that a traditional express bus, facilitating transfers, making it possible to have a bus network, rather than just a bundle of bus routes.

However, it means that the accessibility generated by the BRT is dispersed over a larger area, rather than concentrated around stations. Secondly, any collection of diesel buses is a noisy, noxious nuisance, making transit oriented development around transit centers problematic.

5-EMPLOYMENT RESILIENCE

Introduction

Resilience is a characteristic defined as the ability to absorb and recover from shocks or disruptions. Resilient systems are characterized by diversity and redundancy. The resilience of employment is a critical factor in community economic health. For many communities, the loss of a single primary employer can be catastrophic, resulting in a state of sustained collapse. Employment resilience is the capacity to recover from such disruptions, due to locational characteristics.

Access to transit can help improve employment resilience because proximity to transit is a source of competitive advantage for some industries. Firms located near transit also benefit from reduced employee and visitor parking needs. This translates into an ability to economize on the size of parcels required, both reducing costs and increasing the number of viable sites for business locations.

Transit provides a mechanism to meet transportation needs and usual or unexpected conditions, such as an automobile breakdown or lower income, and it provides alternate transportation options during conditions that impair other modes, such as weather, construction projects, or accident-induced delay. It also provides accessibility to a population unable to drive such as the young, the elderly, and the poor (VPTI 2014). These factors act to reduce tardiness and absenteeism, thus reducing employment turnover.

Transit also helps create 'thick' markets for employment, whereby employees can match themselves to numerous different employment opportunities. This reduces the time necessary to find matches, unemployment duration, and the unemployment rate.

Data and Methods

An interrupted time series was used to compare the resilience of employment in both areas to determine if proximity to transit represents a locational advantage. An interrupted time series divides a time series dataset into two time series with the datasets separated by an 'interruption' and compares the differences. For the purpose of this analysis, the interruption is the Great Recession, considered to have begun in 2007.

If an interruption has a causal impact, the second half of the time series will display a significantly different regression coefficient than the first half. Failure to be adversely affected by a severe economic shock indicates employment resilience. A low R-squared (R^2) represents larger variability in total employment. Industry sectors with a high R^2 demonstrate robust trends, indicating that employment failed to change regardless of the effects on the larger economy. The regression coefficient represents the relationships between the change in variables, and the R^2 explains how much of the variance in the data is explained by the regression equation—a measure of the 'goodness' of the regression.

Results

A line graph of the employment by industry time series is presented in Figure 4. The time series (2002-2011) for each is interrupted in 2008. The vertical axis shows total employment in each industry sector along the corridor. Illustrative regression lines with R^2 values have been added for some of the industries. The trend lines and associated R^2 values for all industry sectors can be found in Table 4.

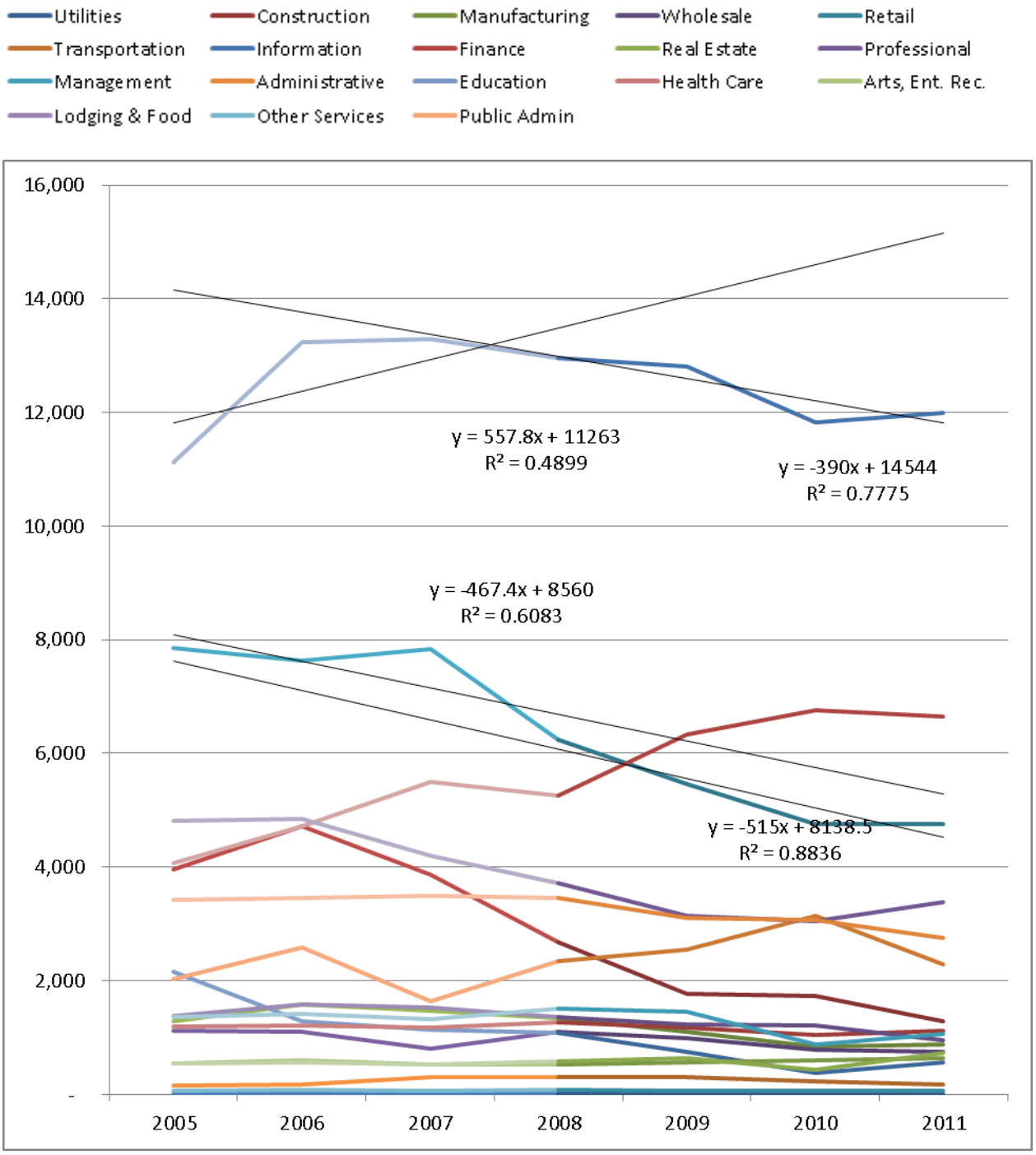

Figure 4: Regression trend lines and R-squared values for different industries

As the graph shows, industry employment varies by year, with many industries affected by substantial fluctuations in employment, both before and after the recession. While visual inspection is valuable, more rigorous interpretation is necessary.

Resilience by industry is presented in Table 4. It highlights the resilience of different industries between 2002-2007 and 2007-2011. The trend number is the linear regression line on industry employment over time. Trend indicates whether total employment increases or decreases during each time period. A negative trend indicates sustained loss of employment while a positive trend indicates a sustained gain. The trend number is the slope of the regression line. However, industries with larger total employment will have larger slopes. To normalize trend numbers for comparison between industries, the trend percent is presented. It is calculated by dividing the trend number for a time period by the average employment for that period. Finally, the R^2 column indicates how strong a trend is. Industry sectors with a high R^2 demonstrate robust trends—trends in employment change that are consistent over time with less tendency to fluctuate.

The change in the trend between the two time periods is given in the differences column. A positive value for the trend number represents a change from employment loss to employment gain, or a reduction in the rate of decline in employment for that industry. The change in strength of trend is given by the R2 column. A positive value indicates that a previously erratic trend has become more consistent. A negative value means a previously consistent trend has become more erratic.

Industry	2005-2008			2008-2011			Differences		
	Trend #	Trend %	R2	Trend #	Trend %	R2	Trend #	Trend %	R2
Utilities	1	40%	0.07	0	#DIV/0!	#DIV/0!	-1	#DIV/0!	#DIV/0!
Construction	-471	-12%	0.52	-422	-23%	0.87	49	-10%	0.35
Manufacturing	3	0%	0.00	-162	-16%	0.84	-165	-16%	0.83
Wholesale	-33	-3%	0.08	-126	-14%	0.93	-92	-11%	0.85
Retail	-467	-6%	0.61	-515	-10%	0.88	-48	-3%	0.28
Transportation	58	25%	0.82	-46	-18%	0.86	-104	-43%	0.04
Information	-336	-24%	0.74	-197	-28%	0.71	139	-5%	-0.04
Finance	23	2%	0.41	-59	-5%	0.58	-82	-7%	0.17
Real Estate	-12	-2%	0.21	35	6%	0.99	47	8%	0.78
Professional	-16	-1%	0.03	-119	-10%	0.89	-104	-9%	0.85
Management	5	7%	0.56	-8	-11%	0.99	-12	-19%	0.44
Administrative	2	0%	0.00	43	2%	0.02	41	2%	0.02
Education	558	4%	0.49	-390	-3%	0.78	-948	-8%	0.29
Health Care	439	9%	0.79	459	7%	0.75	20	-2%	-0.04
Arts, Ent. Rec.	12	2%	0.42	21	3%	0.05	8	1%	-0.38
Lodging & Food	-392	-9%	0.89	-110	-3%	0.22	282	6%	-0.66
Other Services	37	3%	0.34	-196	-16%	0.65	-232	-19%	0.31
Public Admin	13	0%	0.39	-213	-7%	0.91	-226	-7%	0.52

Table 4: Changes in employment trends for 0.5 mile buffer of the transit corridor

During the 2008 to 2011 period, most industries still had falling employment. While Health Care, and Real Estate and Arts/Entertainment/Recreation all experienced percentage increases, but only Health Care saw a substantial numerical increase. However, the R^2 values indicates that the trend for the Arts/Entertainment/Recreation and Administration industries are very weak, indicating erratic trends.

Differences in trends (number and percent) and the strength of trends (R^2) indicate which industries in the corridor did better after the recession. Notably, the Real Estate and Lodging/Food sectors enjoyed the largest percent increases, although the numeric increase was insignificant for Real Estate. However, Lodging/Food experiences a substantial drop in the R^2, indicating the trend improvement is not consistent.

Prior to the recession, both Education and Healthcare enjoyed strong employment growth. The trend for the Education industry was reversed after the interruption of the Great Recession, while Health Care continued to enjoy robust employment growth during both periods. There is a slight dip in the R2, but overall, the Heath Care industry proves very resilient.

The same trend information for a comparable corridor is presented Table 5. Industries with similar trends and trend strengths in both corridors are likely due to factors affecting both corridors, such as metropolitan scale trends.

Industry	Differences						Differences in Differences		
	Transit			Comparable					
	Trend #	Trend %	R2	Trend #	Trend %	R2	Trend #	Trend %	R2
Utilities	-1	#DIV/0!	#DIV/0!	2	84%	0.01	-2	#DIV/0!	#DIV/0!
Construction	49	-10%	0.35	103	-3%	0.03	-54	-7%	0.32
Manufacturing	-165	-16%	0.83	-83	-18%	0.02	-82	2%	0.81
Wholesale	-92	-11%	0.85	40	3%	0.35	-132	-14%	0.50
Retail	-48	-3%	0.28	46	0%	-0.14	-94	-3%	0.41
Transportation	-104	-43%	0.04	28	21%	0.15	-132	-64%	-0.12
Information	139	-5%	-0.04	-13	-1%	0.23	152	-4%	-0.27
Finance	-82	-7%	0.17	126	13%	-0.23	-208	-20%	0.40
Real Estate	47	8%	0.78	366	53%	-0.64	-320	-45%	1.42
Professional	-104	-9%	0.85	-229	-19%	0.03	126	10%	0.82
Management	-12	-19%	0.44	55	26%	-0.53	-68	-45%	0.96
Administrative	41	2%	0.02	-247	-9%	-0.32	289	10%	0.34
Education	-948	-8%	0.29	84	15%	0.61	-1032	-23%	-0.32
Health Care	20	-2%	-0.04	-79	-2%	0.02	99	0%	-0.06
Arts, Ent. Rec.	8	1%	-0.38	-8	-4%	-0.48	16	6%	0.10
Lodging & Food	282	6%	-0.66	65	2%	-0.07	217	4%	-0.59
Other Services	-232	-19%	0.31	-74	-14%	-0.05	-159	-5%	0.36
Public Admin	-226	-7%	0.52	22	30%	0.55	-248	-37%	-0.03

Table 5: Comparison of resilience by corridor

Small differences in R2 values indicate trend consistency between the time period before the Great Recession and the time period after. Positive values indicate an increase in trend strength, and negative values indicate a reduction in trend strength. To be resilient, industry employment requires not only a small difference in R2, but also similar trends, with small differences between the two. By these criteria, with the transit corridor, the Information industry proves resilient, as Administration and Healthcare.

The differences in differences columns show where the transit corridor has an advantage over the comparable corridor. Larger numbers are better. The only industries to do better in the transit corridor than the comparable corridor are the Professional sector, which can largely be attributed to the weakness of the comparable corridor.

Discussion & Implications

To be resilient is to have the capacity to endure shocks and recover to a previous equilibrium. That equilibrium may refer to a prior employment level, or to a prior employment trend. In the transit corridor, both the Real Estate and Lodging/Food industries have better trends after the recession than before. For Lodging/Food, this is insignificant, as the trend for the time period before is strongly negative. Real Estate improved from a slight negative trend before the recession, to a slight positive trend afterward. It is likely the improvement is associated with redevelopment in downtown Mesa, rather than the BRT line. Industries with a positive trend before the recession, which experience a decline in their trend, but experience only minor decreases, may be considered to be resilient. By these criteria, the Health Care industry proves resilient. A combination of an aging population and unemployment induced poverty mean that an increasing number of Americans fall under either Medicaid or Medicare. Correspondingly, a larger total of spending of Health Care is government, rather than private. Such spending is thus counter-cyclical (or a-cyclical) to economic conditions.

Some caveats are necessary. Employment in any industry sector is variable. The area within a half-mile buffer is fixed, so new development requires the displacement of existing development. The new development may employ workers in different industries, or new residential development may replace existing employment. Because the geographic unit of analysis is small, the amount of fluctuation is larger, where changes might average out over a larger unit of geographic aggregation. In a given year, the relocation of a single firm, or the addition of a new building, would be sufficient to dramatically change employment trends in any industry.

6-HOUSING AFFORDABILITY

Introduction

It is not always possible to maintain a supply of affordable housing for a growing population by adding housing at the urban periphery. Such locations are the furthest from employment and services, requiring long distance travel to meet basic needs. Total cost of automobile ownership is considerable, given not only the cost of the automobile itself, but also the operations and maintenance costs associated with fuel, insurance, and repairs. Housing in exurban locations may be cheap without actually being affordable.

It is necessary for housing affordability to include both housing and transportation costs (H + T). Housing costs do not exist in isolation but within the context of transportation costs. While housing in an urban location with transit access may cost more than suburban housing, it may still be more affordable once the effect of associated transportation costs has been taken into account. Low-income households tend to spend a high proportion of their income on basic transportation (VPTI 2012). Faced with high transportation costs, close proximity to public transit networks is an effective solution. Populations in poverty remain concentrated in central cities partially because such locations enjoy high quality public transit (Glaeser et al 2008).

While the effects of heavy rail transit on housing affordability has been extensively researched, the effects of non-heavy rail TOD on housing affordability is mixed. Matching low-income employment to high-income housing fails to improve housing affordability, and matching high-income employment to low-income housing may actually decrease affordability through gentrification-induced displacement. Maintaining affordable housing through TODs may require the allocation of affordable housing resources (NAHB 2010). A review of the hedonic literature reporting the price effects of transit stations on housing suggests that TODs may be an anathema to the provision of affordable housing, given their propensity to increase housing values (Bartholomew and Ewing 2011).

Calthorpe (1993) initially proposed a ten-minute walk, or about 0.5 mile radius, as the ideal size for a TOD. Empirical studies confirm that while the majority of walk trips occur for distances of or equal to a half mile, the effects of proximity to transit can be detected out to 1.5 miles away (Nelson 2011). Access to fixed guide-way transit systems is frequently by non-walk modes such as bicycle, bus, and automobile. The characteristics of the built environment within a mile buffer of a station can still affect transit ridership (Guerra, Cervero, & Tischler 2011).

Data and Methods

This section describes the data used for analysis, and the techniques used to process and analyze the data. Unlike all other analysis contained in this report, the H+T analysis included data from multiple 0.25 mile buffers, not just a single 0.5 mile buffer. Doing so makes it possible to relate the magnitude of the effect of proximity to transit. Near things are more related than distant things (Tobler 1970). This makes it possible to track the relationship between magnitude of effect and proximity to transit. The area within the smallest buffers should show the strongest reaction.

Data Source and Geography

This study uses the Housing + Transportation (H+T) Affordability Index developed by the Center for Neighborhood Technology (CNT). The Index was initially developed for St. Paul, Minnesota in 2006. By the end of the 2006 year, the Center for Housing Policy had expanded the H+T index to include 28 metropolitan areas. With support from the Brookings Institution, it was expanded to 52 metropolitan areas in 2008. In March 2010, CNT included additional metros in the index, for a total of 337 metropolitan areas. The H+T Index has since been expanded to include almost 900 metro areas. The 2010 vintage was used for this analysis.

The unit of analysis for the dataset is the 2000 Decennial Census Block Group. The data extent is the Census 2000 Metropolitan Areas. The H+T Index was developed using Decennial Census 2000 data, and then expanded to a time series format using data from the American Community Survey five-year estimates, 2009 vintage. Differences in Census data collection procedures means the two dataseries are not directly comparable. As a result, transportation costs were calculated using the National Median Income. This may result in over-estimation or underestimation of the value transportation cost amounts, but suffices for the purpose of trend detection.

This analysis makes use of five characteristics: Transportation Costs, Transportation Costs as a Percent of Income, Housing Costs, Housing Cost as a Percent of Income, and H+T costs as a Percent of Income. Data from both the 2000 and 2009 time periods were used.

Data Processing

Census Block Groups represent an unacceptably large geography for transit relevant analysis. It was necessary to devise an alternative to determining buffer membership by selecting a centroid. Instead, ArcGIS was used to create a series of buffers around each corridor, in 0.25-mile increments, out to 2 miles. Those buffers were then used to clip the block groups. The H+T characteristics of each block were then weighted by geographic ratio, which is the ratio between the area of the block group, and the area of the portion of the block group that was within a buffer. For instance, if a block group represented 3 percent of the area in the buffer, H+T characteristics for that block group received a weight of 3 percent. The weighted variables were then summed to obtain a geographically weighted value for the buffer.

For the purpose of comparison, a metro H+T Index was devised. Because the metropolitan area contains all census blocks, characteristics could not be weighted by area. Nor would it have been appropriate to do so. Census block groups are intended to contain similar amounts of population, rather than volumes of area, so the size of Census block groups varies by orders of magnitude. Consequently, the comparison H+T Index value for the metro area was calculated by weighting the block group characteristics by Census 2000 block group population. This weighted average is intended to provide a referent for what are normal H+T values for the metropolitan area.

Results

The change in housing and transportation (H+T) costs are presented below with three results presented:

1. Housing, Transportation, and H+T dollar costs for the transit corridor

2. Change in H+T costs for transit corridors
3. Change in H+T costs for transit and comparable corridors

For interpreting the CNT H+T Affordability Index, housing is considered affordable if total housing and transportation costs do not exceed 45 percent of income.

The 2009 combined housing, transportation, and H+T dollar costs for the transit corridor are shown in Figure 5. The vertical axis shows the dollar cost of housing and transportation. The horizontal axis shows how the total varies by buffer distance from the transit corridor.

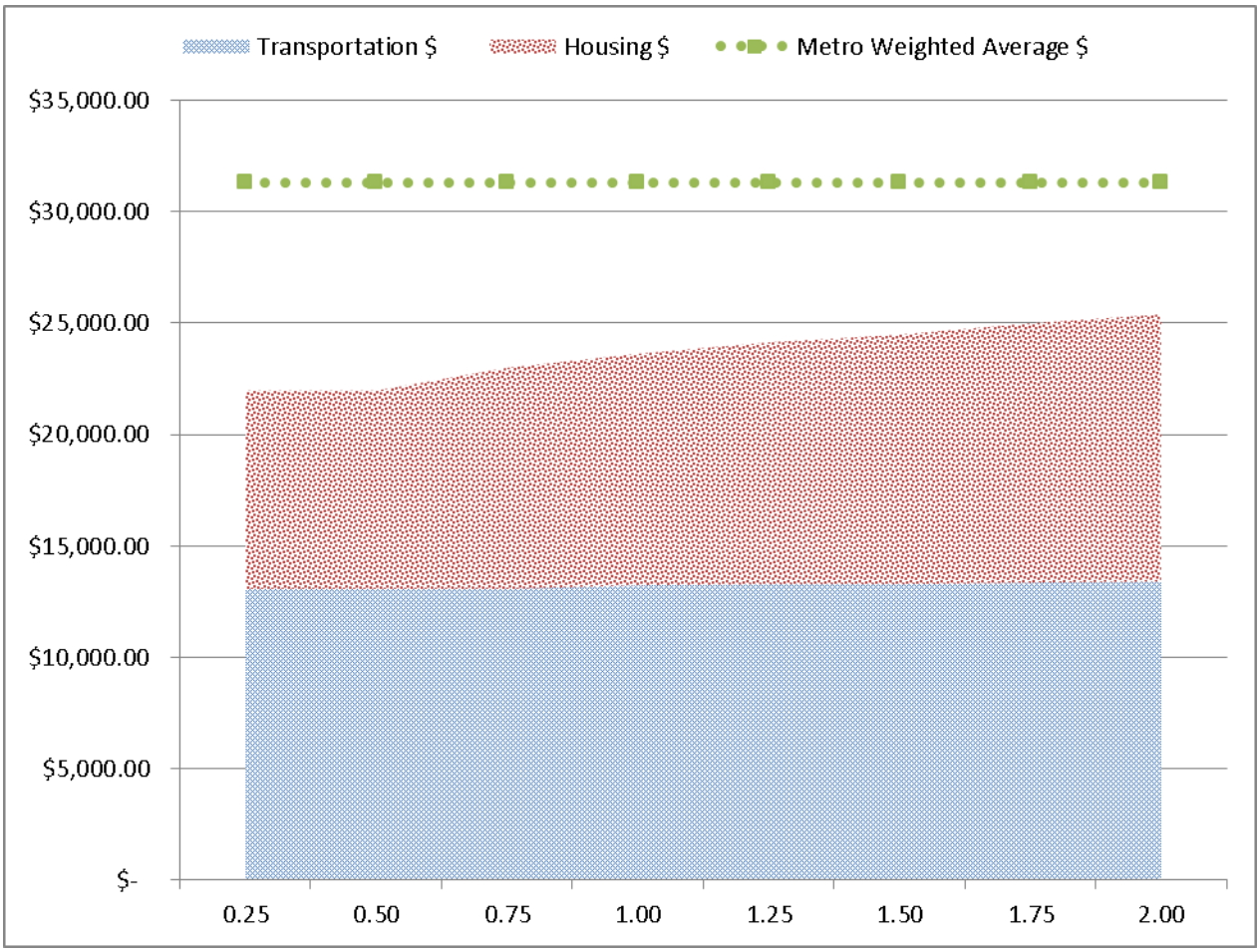

Figure 5: Housing, transportation, and H+T costs for the transit corridor, 2009, by buffer distance

As the above graph shows, H+T costs near the transit line are lower than the metropolitan average. Housing costs are generally lower nearer to the transit line, and higher at more distance locations. Transportation costs are constant at all distances to the transit line. This is consistent with the type of development along the corridor, which includes a substantial number of trailer parks.

Percentage point changes in housing, transportation, and H+T costs are shown below in **Figure 6**. The vertical axis shows the percentage point change in housing and transportation costs. The horizontal axis shows how the total varies by buffer distance from the transit corridor. The changes represent the

difference in the percentage of income calculated to be necessary for housing and transportation expenditures. A stacked graph has been used to display the disaggregated effects of housing and transportation on H+T affordability. The vertical axis shows the change in percentage points needed to meet housing and transportation costs. The horizontal axis shows how the total varies by buffer distance from the transit corridor. The time series analysis is intended to show if changes in H+T cost respond to proximity to transit.

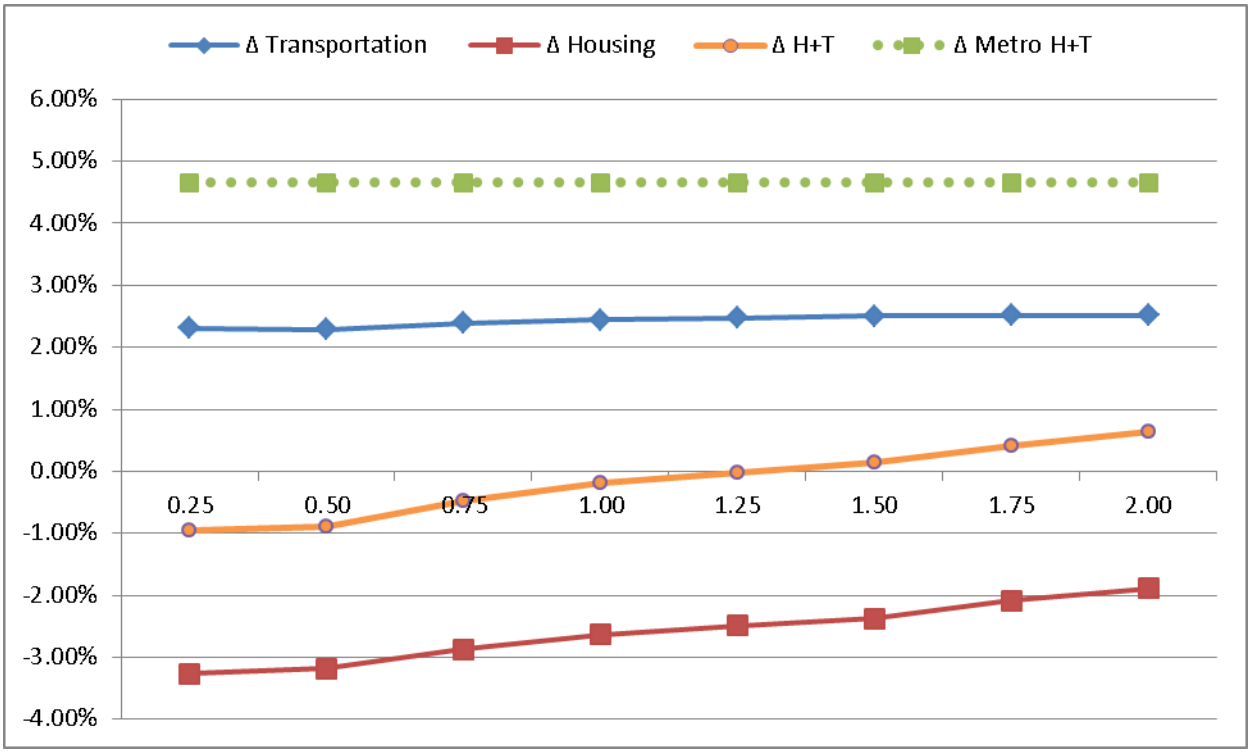

Figure 6: Change in housing and transportation costs, 2000-2009, for transit corridor, by buffer distance

Changes in H+T costs vary with distance to the transit corridor. The magnitude of change in the H+T value is directly and inversely proportional to the distance from transit. Housing and transportation costs are both lower nearer to the transit line, although largely due to a very large decline in housing costs. Excitingly, there is a perceptible difference in transportation costs within proximity to the transit corridor.

Percentage point changes in housing, transportation, and H+T costs for the transit corridor, comparable corridor, and metro area are shown below in Figure 7. The vertical axis shows the percentage point change in housing and transportation costs. The horizontal axis shows how the total varies by buffer distance from the transit corridor. Theoretically, differences between the affordability for the two corridors can be attributed to proximity to transit.

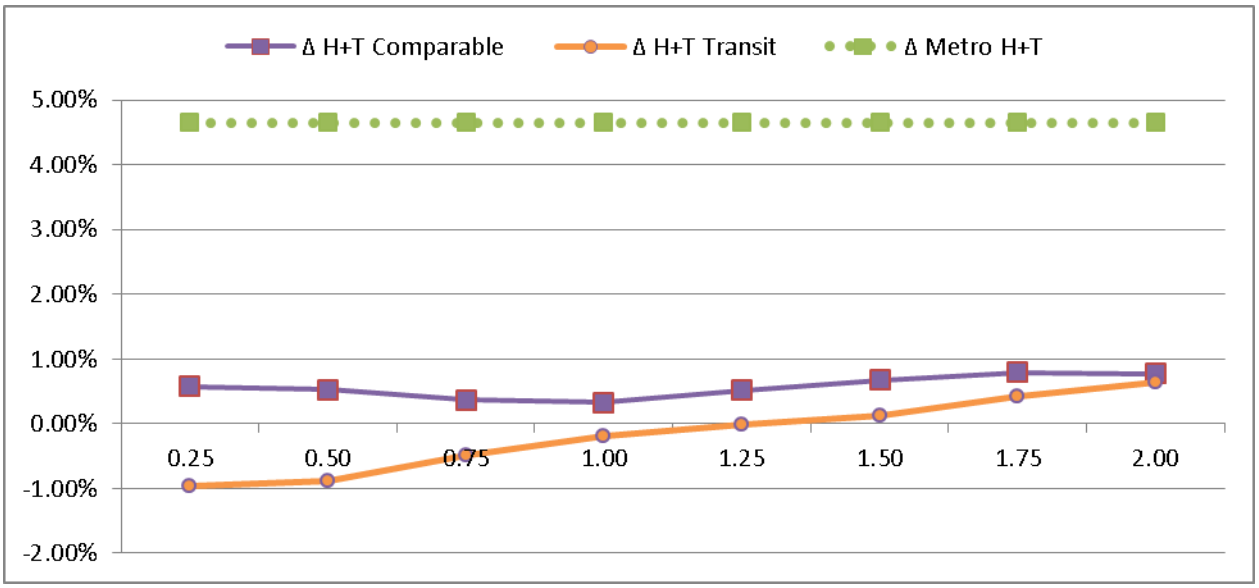

Figure 7: Changes in H+T, 2000-2009, for transit and comparable corridors, by buffer distance

The corridors display notable patterns in changes in H+T costs. The changes experienced for either corridor are less than that for the metropolitan area. While the change in H+T costs for the two corridors are almost the same within 2 mile buffer around each corridor, the H+T costs for the transit corridor are almost two percentage points lower within a quarter mile. The change in H+T costs for the transit corridor is consistently lower than the comparable corridor, and is actually negative within the 1.25 mile buffer.

Discussion & Implications

The data suggests that the Main Street Link has strongly improved affordability. For the area within 2 miles of the Main Street LINK, housing costs were between 2-3% lower in 2009 than in 2000. Results suggest that most of the decline in H+T costs can be attributed to decline in housing costs. This contradicts theory. Theoretically, the value of the additional accessibility generated by proximity to transit should be capitalized into property value, resulting in rising housing costs.

Housing Costs and Property Values are two sides of the same coin. The reduction in housing costs is more likely a result of falling property values. Phoenix was one of the metropolitan areas most severely afflicted by the sub-prime mortgage housing crisis. It experienced a sustained run of subdivision development over the decade, responding to the flush of new buyers generated by sub-prime financing. The run was of such duration and resilience that speculative development in advance of predicted

demand became common. Consequently, the crash in housing prices has been among the most severe and most sustained in the nation.

A metropolitan scale effect fails to explain why appreciation was less in the corridors than for the metropolitan region. It also fails to explain why the transit corridor experiences much lower increases in H+T costs than the comparable corridor for all buffer distances.

Differences in tenure and development type help explain the difference. Because land values remain low in Phoenix, the amount of redevelopment is quite limited. Large parcels of vacant land remain available throughout the metropolitan area. Correspondingly, rather than being redeveloped, marginal and low-rent uses for urban land tend to endure for longer, depreciating further, becoming cheaper and lower quality.

This effect is compounded by housing tenure. Owners tend to be lavish a non-economic level of maintenance on their homes. Thus, owner occupied homes depreciated less than rental unit. Renters are much more economically rational about housing than owners. Unable to re-capture the value of any improvements to a property, renters make none.

There are numerous large trailer parks adjacent to the Main Street LINK. Neither quite renting nor owning, trailer parks suffer the worst of both tenures. Typically, the trailer or mobile homes are owned by the residents, while the land is owned by a property management company. The owner-occupiers have only the depreciating portion of the asset, which the property management company has no financial interest in maintaining.

Most mobile homes are not mobile. Rather, most mobile home parks are filled with manufactured housing that has been built offsite and erected on-location. Relocating manufactured housing represents a substantial cost, so that the owner-occupiers of mobile homes typically rent or sell mobile homes in situ.

The property management company owning the land is unable to realize any increases in land value. Doing so would require closing the trailer park and displacing all the residents. Doing so is politically difficult, and thus risky. Trailer parks furnish an important supply of affordable housing for a community. By the time the land value has increased to the point where it makes financial sense to redevelop the trailer park, housing prices have risen considerably in the surrounding area. Compounding this, the population of a mature trailer park is typically older, poorer and more vulnerable than the rest of the city. For many, the cost of relocating an older mobile home may exceed the value of the structure, rendering the population homeless.

Nor are trailer parks amenable to piecemeal redevelopment. Leases are for slots within the trailer park, so there are no actual parcels that can be independently redeveloped. Trailer parks typically have shared access and interconnected utility systems. For these reasons, trailer parks are extremely difficult to redevelop often become astonishingly durable part of the built environment.

Yet trailer parks lie at the bottom of the ownership hierarchy. They have no potential for appreciation, so their sole virtue is affordability. But the affordability comes with conditions—all the liabilities associated with ownership, and all the uncertainty associated with renting.

The decline in housing costs along the corridor suggests that the value of living in a trailer park fell dramatically over the last decade. Before the Great Recession, looser mortgage lending standards made full ownership possible. Afterwards, the enormous crash in housing prices and accompanying recession meant that many houses were available at a fraction of their previous value. Given that much of Arizona's population growth comes from in-migration rather than natural increase, it seems natural that new-comers would choose from the supply of suddenly affordable housing ownership, rather than making do with a trailer park. Together, these two forces explain the substantial decline in housing costs along the transit corridor, and thus the decline in H+T costs.

6-JOB ACCESSIBILITY

Introduction

Commuters have the ability to travel long distances more rapidly by fixed guide-way transit, making it possible to connect to destinations that are otherwise too distant. TOD is based on the premise that locating housing and employment in close proximity to transit stations will significantly enhance the accessibility of those locations. Because each transit line connects multiple stations, it creates a Transit Oriented Corridor (TOC) where people can live or work near any station and use the rapid transit system to access destinations at any other station along the corridor. Therefore, transit oriented development should significantly enhance employment accessibility along the corridor.

To achieve jobs-housing balance, there should be a rough proportionality between the amount of employment and the amount of housing. However, merely matching the total number of jobs and housing along a corridor is not enough. In recent years, the jobs-housing balance has been refined to include how well jobs (by income) are matched to housing (by income), to ensure that people working in the corridor can afford to live in the corridor. Proximity to light rail stations and bus stops offering rail connections is associated with low-wage job accessibility, but proximity to bus networks alone does not show the same correlation (Fan 2012). To check the degree of match between employment and residence, this analysis controls for both low and high wages. To further check for the degree of match, it compares the occupation balance of how well the number of people employed in the corridor matches the number of people residing in the corridor. If an industry is making heavy use of transit along the corridor, the numbers should be near equivalent.

If transit has a positive effect on jobs-housing balance, there should be a detectable change in the employment resident balance for both wage categories and for all occupation categories. Comparing the changes in these balances to the comparable corridor will ensure that the effect is contingent upon the transit corridor rather than metropolitan trends.

Data & Methods

The data used comes from the Census Local Employment-Housing Dynamics (LEHD) data source, using the Local Employment Dynamics (LED) datasets. Because the LODES data contains both place of employment and place of residence, it is possible to aggregate data to obtain both workplace area characteristics (WAC) and residential area characteristics (RAC). The ratio between the total workers at these different geographies was used as the jobs-housing balance. Corridors with better jobs-housing balance were presumed to have better job accessibility.

Three analyses were performed to determine job accessibility within the corridors: overall jobs-housing balance, jobs-housing balance by earnings category, and jobs-housing balance by industry. In addition to providing total number of employees per Census Block, the LED employment data are classified by earnings category. The LED classifies income by monthly earnings, into the following categories:

- $1250/month or less
- $1251/month to $3333/month

- Greater than $3333/month

The categories have been treated as low-medium-high income classifications. The actual monthly values are less significant than changes over time in the distribution of each of the categories in proximity to the transit corridor. LED employment data are also classified by industry using the North American Industrial Classification System (NAICS) at the two-digit summary level.

ArcGIS was used to create a series of buffers around each corridor in 0.25 mile increments. Those buffers were then used to select the centroid point of the LED block groups within those buffers, and summarize the totals. Because the location of census block points varies from year to year (for reasons of non-disclosure), it was necessary to make a spatial selection of points within the buffer for each year, rather than using the same points each year. For this analysis, on the 0.5 mile buffer was used.

Results

Overall jobs-housing balance for the existing transit and comparable corridor are presented below in Table 6 for each year. The ratio column indicates the ratio of workers who are employed within the corridor to the number of workers residing in the corridor. The year-on-year change for ratios is also presented. Sparklines at the bottom show the trend for each column. Years for which the transit system is in operation are shaded.

Overall Balance

The jobs-housing ratio at the metropolitan level represents a balanced level of jobs to workers. Comparing that value to the jobs-housing ratio for each corridor demonstrates how far out of balance both corridors are. Ideally, the addition of transit (years of operation highlighted in pink) should make the jobs-housing ratio more similar to the metropolitan level ratio.

Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	1,629	1,595	1.02	32.4	35.1	0.92	0.00	46.9	24.0	1.96	0.00	2002
2003	1,629	1,595	1.02	32.4	35.1	0.92	0.00	46.9	24.0	1.96	0.00	2003
2004	1,629	1,595	1.02	32.4	35.1	0.92	0.00	46.9	24.0	1.96	0.00	2004
2005	1,730	1,693	1.02	33.3	37.1	0.90	-0.03	47.1	24.2	1.94	-0.01	2005
2006	1,818	1,778	1.02	32.9	39.2	0.84	-0.06	50.8	26.8	1.90	-0.05	2006
2007	1,842	1,805	1.02	31.9	36.6	0.87	0.03	48.7	26.5	1.84	-0.06	2007
2008	1,821	1,787	1.02	30.4	34.9	0.87	0.00	45.9	25.0	1.83	-0.01	2008
2009	1,676	1,626	1.03	27.0	30.1	0.90	0.03	43.5	22.4	1.94	0.11	2009
2010	1,661	1,622	1.02	27.0	29.8	0.91	0.01	40.8	20.9	1.95	0.01	2010
2011	1,708	1,653	1.03	27.9	25.8	1.08	0.17	40	19.4	2.07	0.11	2011
Trend												Trend

Table 6: Jobs-housing balance for all income categories

The overall jobs-housing ratio for both the transit corridor is relatively job-rich, with a jobs-housing ratio twice that of the metropolitan area. While becoming more balanced prior to the advent of transit in 2008, the transit corridor becomes notably more job-rich afterward. However, that is largely a result of a steep decline in the number of workers resident in the corridor. Both workers and workers resident in the corridor decline, but the number of workers who reside in the corridor declines faster.

While the comparable corridor shows the same pattern of robust growth until the Great Recession and sharp decline afterward, employment proves resilient, with a notable increase in employment in 2011. It was job-poor in 2010, but become slightly job-rich in 2011. After the advent of transit, the only year with significant differences between the two corridors is 2009.

Income Balance

Jobs-housing balance by earnings category improves on the overall jobs-housing balance, as the overall jobs-housing ratio provides only a rough metric of the degree to which residents are matched to places of work within a corridor. Matching low income residents to high income workplaces will not increase job accessibility. Comparing the jobs-housing ratio by income category makes it possible to gauge not just the overall improvement in jobs-housing balance, but which earnings categories benefit the most from proximity to transit. To determine the degree to which an earnings-specific match is accomplished, **Table 7** compares the jobs-housing balance to the earnings category.

Low Income												
Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	467	452.17	1.03	12.9	11.1	1.16	0.00	17.0	8.0	2.12	0.00	2002
2003	467	452.17	1.03	12.9	11.1	1.16	0.00	17.0	8.0	2.12	0.00	2003
2004	467	452.17	1.03	12.9	11.1	1.16	0.00	17.0	8.0	2.12	0.00	2004
2005	480	463.91	1.03	12.6	11.5	1.10	-0.06	16.8	7.6	2.21	0.09	2005
2006	479	464.63	1.03	11.7	11.4	1.03	-0.07	17.1	8.0	2.14	-0.08	2006
2007	464	450.41	1.03	10.7	10.0	1.08	0.05	15.3	7.7	1.99	-0.15	2007
2008	450	438.09	1.03	10.1	9.4	1.07	0.00	14.0	7.2	1.96	-0.03	2008
2009	406	387.76	1.05	8.3	7.7	1.08	0.00	12.9	6.1	2.10	0.14	2009
2010	387	373.34	1.04	8.6	7.8	1.09	0.02	12.2	5.8	2.08	-0.02	2010
2011	399	384.31	1.04	8.9	6.9	1.29	0.20	11.9	5.6	2.13	0.04	2011
Trend												Trend

Medium Income												
Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	673	658	1.02	1.3	16.6	0.08	0.00	16.2	11.1	1.47	0.00	2002
2003	673	658	1.02	1.3	16.6	0.08	0.00	16.2	11.1	1.47	0.00	2003
2004	673	658	1.02	1.3	16.6	0.08	0.00	16.2	11.1	1.47	0.00	2004
2005	705	689	1.02	1.3	17.5	0.08	0.00	16.3	11.4	1.43	-0.03	2005
2006	734	714	1.03	1.3	18.1	0.07	0.00	17.8	12.3	1.45	0.01	2006
2007	732	714	1.03	1.3	16.8	0.08	0.01	17.2	12.2	1.41	-0.04	2007
2008	710	694	1.02	1.2	15.7	0.08	0.00	15.7	11.5	1.37	-0.04	2008
2009	661	638	1.04	1.1	13.7	0.08	0.00	15.0	10.4	1.44	0.07	2009
2010	639	620	1.03	1.1	13.5	0.08	0.00	13.9	9.5	1.46	0.02	2010
2011	647	620	1.04	1.09	11.82	0.09	0.01	13.6	8.7	1.56	0.10	2011
Trend												Trend

High Income												
Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	489	485	1.01	6.3	7.4	0.86	0.00	13.7	4.9	2.79	0.00	2002
2003	489	485	1.01	6.3	7.4	0.86	0.00	13.7	4.9	2.79	0.00	2003
2004	489	485	1.01	6.3	7.4	0.86	0.00	13.7	4.9	2.79	0.00	2004
2005	545	541	1.01	7.3	8.1	0.90	0.04	14.0	5.3	2.65	-0.14	2005
2006	605	599	1.01	8.2	9.7	0.84	-0.06	15.9	6.5	2.46	-0.19	2006
2007	646	641	1.01	8.2	9.8	0.84	-0.01	16.1	6.6	2.46	0.01	2007
2008	661	655	1.01	8.1	9.8	0.83	-0.01	16.1	6.4	2.52	0.06	2008
2009	610	601	1.02	8.1	8.7	0.94	0.11	15.6	5.9	2.65	0.13	2009
2010	635	628	1.01	7.7	8.5	0.91	-0.03	14.8	5.6	2.65	0.00	2010
2011	662	648	1.02	8.0	7.0	1.13	0.22	14.5	5.0	2.88	0.23	2011
Trend												Trend

Table 7: Jobs-housing balance by income category

The transit corridor is job-rich for all three income categories, but least so for middle income, which is slightly jobs-rich with a jobs-housing ratio of about 1.5. For all income categories, the jobs-housing ratio rises after the advent of transit. For low and medium income workers, the strongest rise is in 2009, but for high income workers, the jobs-housing ratio rises an astonishing .23 in 2011. Confounding any of these trends is that for all incomes, the corridor shows steady losses in both workers and numbers of workers resident in the corridor.

The number of both high and low income workers in the comparable corridor is about half that for the transit corridor, while the number of medium income is a bare fraction. The comparable

corridor also experiences a substantial increase in the jobs-housing ratio for 2011, indicating that the increase in the transit corridor is unlikely to be a result of transit. Again, any interpretation is confounded by the falling numbers of workers in the corridor; improvements in the jobs-housing ratio appear to be caused by reduction in employment, rather than increases in the number of workers residing in the corridor.

Industry Balance

Industry balance provides a more refined understanding of the match between place of residence and place of work. Comparing the jobs-housing ratio by industry category makes it possible to determine which industries benefit the most from proximity to transit. The industry balance for the transit corridor is presented in Table 8. The jobs-housing ratio has been broken into two data series by the year of the advent of transit.

If any population is making extensive use of transit, they would be expected to be both working and living in the transit corridor. If so, the number of people in any given industry both working and living in the corridor should increase over time, bringing the jobs-housing ratio for the corridor closer to the ratio for the metropolitan area.

Industry	Comparable					Transit				
	2002	2002 to 2008	2008	2008 to 2011	2011	2002	2002 to 2008	2008	2008 to 2011	2011
Utilities	0.01		0.00		0.01	0.05		0.00		0.00
Construction	0.68		0.60		0.79	1.49		1.21		1.20
Manufacturing	0.36		0.38		0.29	0.59		0.71		0.70
Wholesale	0.62		0.40		0.52	1.16		1.04		1.03
Retail	1.51		1.55		1.74	2.21		1.79		1.90
Transportation	0.14		0.10		0.18	0.29		0.37		0.29
Information	1.93		2.19		3.31	4.65		2.44		1.84
Finance	0.64		0.49		0.74	1.27		1.07		1.13
Real Estate	1.78		0.37		0.62	0.98		0.88		1.08
Professional	0.77		0.75		0.79	1.37		1.07		0.98
Management	0.64		0.27		0.34	0.29		0.27		0.26
Administrative	0.91		0.91		0.99	1.03		0.93		1.15
Education	0.22		0.17		0.33	5.81		6.23		7.50
Health Care	1.70		1.93		2.29	1.62		2.08		2.61
Arts, Ent. Rec.	0.35		0.60		0.76	1.24		1.37		1.50
Lodging & Food	1.31		1.18		1.42	2.47		1.69		1.63
Other Services	1.21		0.98		0.77	1.88		1.89		1.78
Public Admin	0.04		0.05		0.14	3.77		4.22		4.18

Table 8: Job accessibility trends over time by industry sector and corridor

The transit corridor is job-rich for most industries, notably Education, Health Care, and Public Administration industries. Following the first year of transit operations (2008), the jobs-housing ratio notably worsens for Education and Health Care. The jobs-housing ratio improves for the Information and Real Estate Industries. The industries for which the trends in jobs-housing ratios are different before and after the advent of transit include Retail and Finance. For almost all other industries (including Education, Health Care, and Public Administration) the jobs-housing ratio was already increasing prior to the advent of transit.

Discussion & Implications

Because of the declines in both workers and workers resident in the corridor, it is difficult to assess the effect of transit on jobs-housing balance. Overall, the jobs-housing ratio tends to increase, indicating that transit tends to worsen jobs-housing balance. However, given the context of staggered reductions in employment in the corridor and workers living in the corridor, conclusions are difficult to draw.

The most substantial increase in the jobs-housing ratio occurs in 2009, but is caused by decline in residents, rather than employment. Beyond that it is difficult to differentiate the transit corridor from the comparable corridor.

Comparing the corridors by income shows neither employment or employees resident in the corridor have regained their 2002 levels. Indeed, for low and medium income, the total number of workers in the corridor, or working in the corridor in 2011 was half as many as in 2002. For high income, it was barely reaching the same level as 2002. To the extent that these numbers no longer represent a recessionary aberration, and are rather the 'new normal', it appears that jobs-housing ratio has increased for all income categories, but has increased the most for high income.

Ideally, comparing the jobs-housing ratio for different industries should show which industries are transit compatible, with transit compatible industries showing better matches. At the corridor scale, it seems unable to do so. A system-wide analysis may be necessary to determine the degree to which the transit system is matching worker's places of residence to their places of work. Retail represented a notable exception. Retail tends to be a low-income education, with correlates with transit ridership. The Main Street LINK is anchored at one end by the Metro Light Rail and at the other by the Superstition Spring Mall. The combination of low-income housing and transit accessible retail employment would make a viable living alternative for retail workers.

7-SUMMARY OF FINDINGS

Summaries of the results of the analysis for the five policy questions bellow.

Are TODs attractive to certain NAICS sectors?
Do TODs generate more jobs in certain NAICS sectors?
Are firms in TODs more resilient to economic downturns?
Do TODs create more affordable housing measured as H+T?
Do TODs improve job accessibility for those living in or near them?

Q1: Attractiveness to NAICS sectors (Location quotient)

Transit corridor

- Substantial Increases: Real Estate, Health Care, and Arts/Entertainment/Recreation
- Substantial Reductions: Information

Advantage of transit corridor over comparable corridor

- Does better than the transit corridor in Information, Construction, and Public Administration
- Did worse than the transit corridor for Administrative & Healthcare

Q2: Do TODs generate more jobs in certain NAICS sectors? (Shift-share analysis)

Numeric Change in Transit corridor

- Employment in transit corridor falls more severely than metropolitan area.
- Substantial numeric increases: Health Care
- Substantial percent increases: Real Estate, & Arts/Education/Recreation
- Substantial numeric reductions: Construction and Information, all others.
- Substantial percent reductions: Construction and Information

Effect of corridor, as per Shift-Share

- Health Care, Administrative, and Real Estate positively affected by corridor.
- Increases in Health Care attributable to industry growth
- Negative corridor effect on Retail industry is severe.

Advantage of transit corridor over comparable corridor

- The effect of corridor location in transit corridor inferior to comparable corridor for many industries.
- The difference in corridor effect favors the transit corridor for Health Care and Administrative.

Q3: Are firms in TODs more resilient to economic downturns? (Interrupted Time Series)

Transit corridor

- Positive trends prior to 2008: Utilities, Transportation, Education, Health Care
- Positive trends after 2008: Health Care and Real Estate
- Improved trends: Real Estate, Lodging/Food.

- Erratic trend after 2008: Lodging/Food
- Resilient Industries: Health Care

Advantage over comparable corridor:

- Professional and Administrative employment is more resilient in transit corridor.
- Health care as resilient in comparable corridor

Q4: Do TODs create more affordable housing measured as H+T? (Housing affordability)

Unlike other analyses in this report, this analysis measures changes in more than just the .50mile buffers. The magnitude of the effect of transit should be proportional to proximity to transit.

Transit corridor in 2009

- H+T costs for the transit corridor are less than the metropolitan average.
- Housing costs are actually lower near transit.
- Transportation costs are constant, regardless of distance to transit.

Transit corridor changes in H+T costs 2000-2009

- H+T costs for the transit corridor change less than the metropolitan average.
- Housing costs change more than transportation costs.
- Changes in transportation costs are constant with distance to transit
- Changes in housing costs vary with distance to transit; the greater the distance to transit, the less change.
- Housing costs changes negative within 1.25 miles of transit.

Advantage over Comparable Corridor

- The increase in H+T cost is greater for the comparable corridor for all distances.
- Changes in H+T for comparable corridor are never negative.

Q5: Do TODs improve job accessibility for those living in or near them?

Jobs accessibility was operationalized as the balance between number of workers and number of workers residing in the corridor, using the jobs-housing ratio as a comparison. The jobs-housing ratio for the metro was used as the preferred ratio. The differences were compared for all workers in the corridor, for workers by earnings, and for workers by industry.

Transit corridor

- For the transit corridor, the number of workers either living or working in the corridor declines precipitously after 2006.
- Job rich at start of study period, with jobs-housing ratio about twice that of the metropolitan area.
- Jobs-housing ratio roughly constant over the course of the study period.
- Increase in jobs housing ratio can largely be attributed to a decrease in the number of residents.
- The jobs-housing ratio for low income workers improved in 2009.

- The jobs-housing ratio for high-income workers is very similar to the comparable corridor.
- The advent of transit does not appear to have substantially improved job accessibility for any industry.
- The jobs-housing ratio moved closer to balance for the Retail and Real Estate industries.

Advantage over Comparable Corridor

- Improvement in jobs-housing balance occurs for Real Estate in comparable corridor as well.
- Jobs-Housing ratio for retail diverges from balance for in the comparable corridor.

8-REFERENCES

Arrington, G.B. and Robert Cervero. 2008. Effects of TOD on Housing, Parking, and Travel. TCRP Report 128. Washington, DC: Transportation Research Board.

Bartholomew, K. & Ewing, R. 2011. Hedonic price effects of pedestrian- and transit-oriented development. Journal of Planning Literature, 26(1), 18-34.

Cervero, Robert, et al. 2004. TCRP Report 102: Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects. Washington, DC: Transportation Research Board.

US Census Bureau. Table 643, Annual Total Compensation and Wages and Salary Accruals Per Full-Time Equivalent Employee, by Industry: 2000 to 2009. < http://www.census.gov/compendia/statab/cats/labor_force_employment_earnings/compensation_wages_and_earnings.html>

Center for Neighborhood Technology. 'About the Index'. http://htaindex.cnt.org/about.php

CTOD. 2011. Transit and Regional Economic Development. Chicago, IL: Center for TOD.

CTOD. 2009. Mixed-Income Housing Near Transit. Chicago, IL: Center for TOD.

CTOD. 2012. TOD Database. http://toddata.cnt.org/

Fan, Y., Guthrie, A., and Levinson, D. 2012. Impact of light rail implementation on labor market accessibility: A transportation equity perspective. Journal of Transport and Land Use, 5(3).

Glaeser, Edward L., Matthew E. Kahn, and Jordan Rappaport. 2008. Why do the poor live in cities? The role of public transportation. Journal of Urban Economics 63, no. 1: 1-24.

Kolko, Jed. 2011. Making the Most of Transit: Density, Employment Growth, and Ridership around New Stations. San Francisco, CA: Public Policy Institute of California.

NAHB. 2010. The Economic Impact of Low Income Housing Tax Credit Development Along Transit Corridors in Metro Denver. Washington, DC: National Association of Home Builders.

Nelson, Arthur C. 2011. The New California Dream. Washington, DC: The Urban Land Institute.

Schuetz, Jenny and Jed Kolko. 2010. Does Rail Transit Investment Encourage Retail Activity? Project 11-04. Los Angeles, CA: University of Southern California, Metrans Transportation Center.

Tobler W., (1970) "A computer movie simulating urban growth in the Detroit region". *Economic Geography*, 46(2): 234-240.

Victoria Transport Policy Institute (VPTI). Evaluating Transportation Resilience. Online TDM Encyclopedia, 31 March 2014. www.vtpi.org. Accessed 31 March 2014.

Victoria Transport Policy Institute (VPTI). Transportation Affordability. Online TDM Encyclopedia, 10 September 2012. www.vtpi.org. Accessed July 2, 2013.

Vinha, Katja Pauliina. 2005. The impact of the Washington Metro on development patterns. College Park, MD: University of Maryland.

9-APPENDIX A

LEHD

The Longitudinal Employer-Household Dynamics (LEHD) program is part of the Center for Economic Studies at the U.S. Census Bureau. The LEHD program produces new, cost effective, public-use information combining federal, state and Census Bureau data on employers and employees under the Local Employment Dynamics (LED) Partnership. State and local authorities increasingly need detailed local information about their economies to make informed decisions. The LED Partnership works to fill critical data gaps and provide indicators needed by state and local authorities.

Under the LED Partnership, states agree to share Unemployment Insurance earnings data and the Quarterly Census of Employment and Wages (QCEW) data with the Census Bureau. The LEHD program combines these administrative data, additional administrative data and data from censuses and surveys. From these data, the program creates statistics on employment, earnings, and job flows at detailed levels of geography and industry and for different demographic groups. In addition, the LEHD program uses these data to create partially synthetic data on workers' residential patterns.

All 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands have joined the LED Partnership, although the LEHD program is not yet producing public-use statistics for Massachusetts, Puerto Rico, or the U.S. Virgin Islands. The LEHD program staff includes geographers, programmers, and economists.

Source: http://lehd.ces.census.gov/

Shift-Share Calculations

	Local Economy				Reference Economy						
NAICS SECTOR	Initial Year	Final year	# Change	% Change	Initial Year	Final year	# Change	% Change	County Share (CS)	Industry Mix (IM)	Local Economy Effect (LEE)
Sector A	a	b	=(b-a)	=(b-a)/a	a2	b2	=(b2-a2)	=(b2-a2)/a2	=[(b2+d2+f2-(a2+c2+e2))/(a2+c2+e2)	=a*[(b2-a2)/a2]	=[(b-a)]-CS+IM for Sector A
Sector B	c	d	=(d-c)	=(d-c)/c	c2	d2	=(d2-c2)	=(d2-c2)/c2	=[(b2+d2+f2-(a2+c2+e2))/(a2+c2+e2)	=b*[(d2-c2)/c2]	=[(b-a)]-CS+IM for Sector B
Sector C	e	f	=(f-e)	=(f-e)/e	e2	f2	=(f2-e2)	=(f2-e2)/e2	=[(b2+d2+f2-(a2+c2+e2))/(a2+c2+e2)	=c*[(f2-e2)/e2]	=[(b-a)]-CS+IM for Sector C
Totals	a+c+e	b+d+f	=(b+d+f)-(a+c+e)	=[(b+d+f-(a+c+e)]/(a+c+e)	a2+c2+e2	b2+d2+f2	=(b2+d2+f2)-(a2+c2+e2)	=[(b2+d2+f2(a2+c2+e2)]/(a2+c2+e2)	na	na	Sum of LEE for Sectors A, B & C