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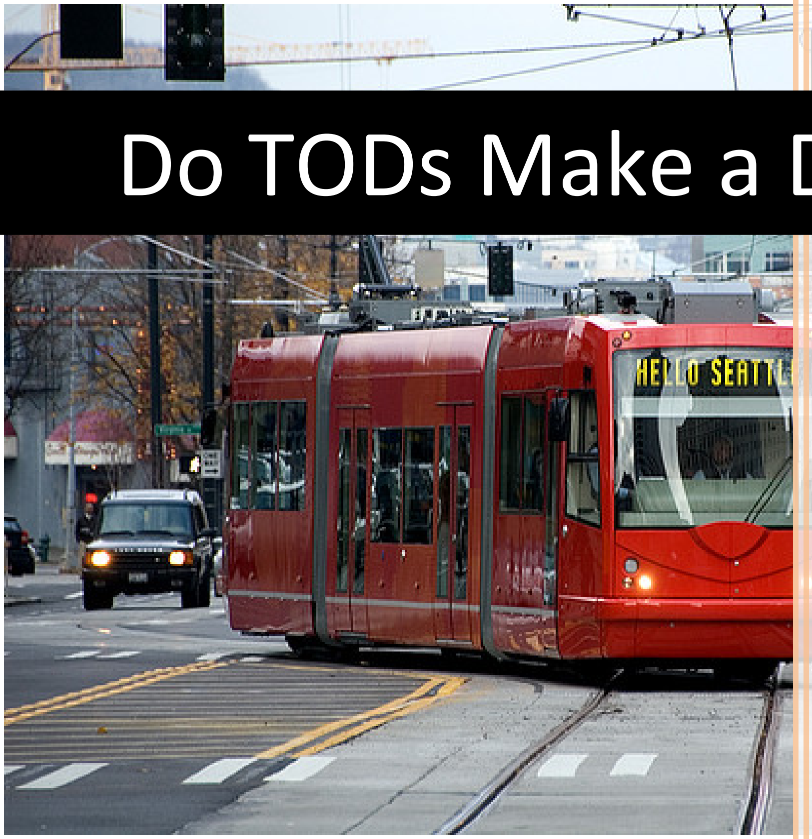
South Lake Union Streetcar
Seattle, Washington



Do TODs Make a Difference?

Portland State UNIVERSITY

OTREC OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM

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Disclaimer

PROJECT TITLE

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

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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 residence 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 section.

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 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. 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 then 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 viable as transit corridors. This meant that corridors 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 Transit Oriented Development (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 is classified using the North American Industrial Classification System (NAICS), and data is available for each Census Block at the two-digit summary level. Data was 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/. The data was downloaded 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 Transit Oriented Development (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 build 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.

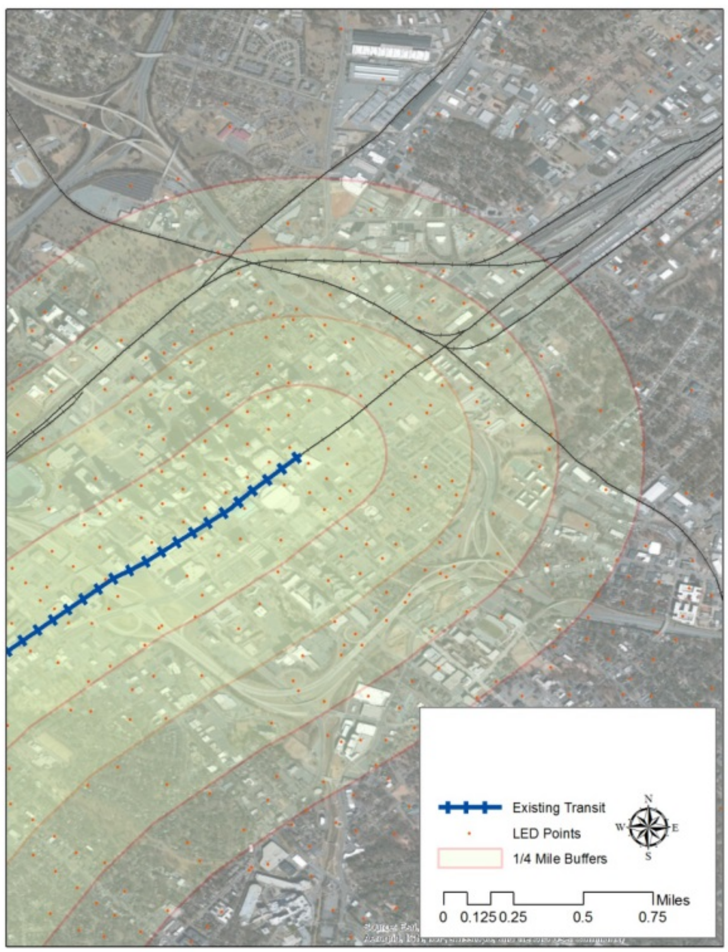

Figure 1: Example corridor, buffers, and LED census block points

Study Area

This study examines the South Lake Union Streetcar in Seattle. It is a 1.3

mile long streetcar corridor that began service on December 12, 2007. The corridor was chosen for analysis because it was a key part of a redevelopment project. The comparable corridor was chosen because it is similar in length to the South Lake Union Streetcar and it is the site of a future streetcar line.

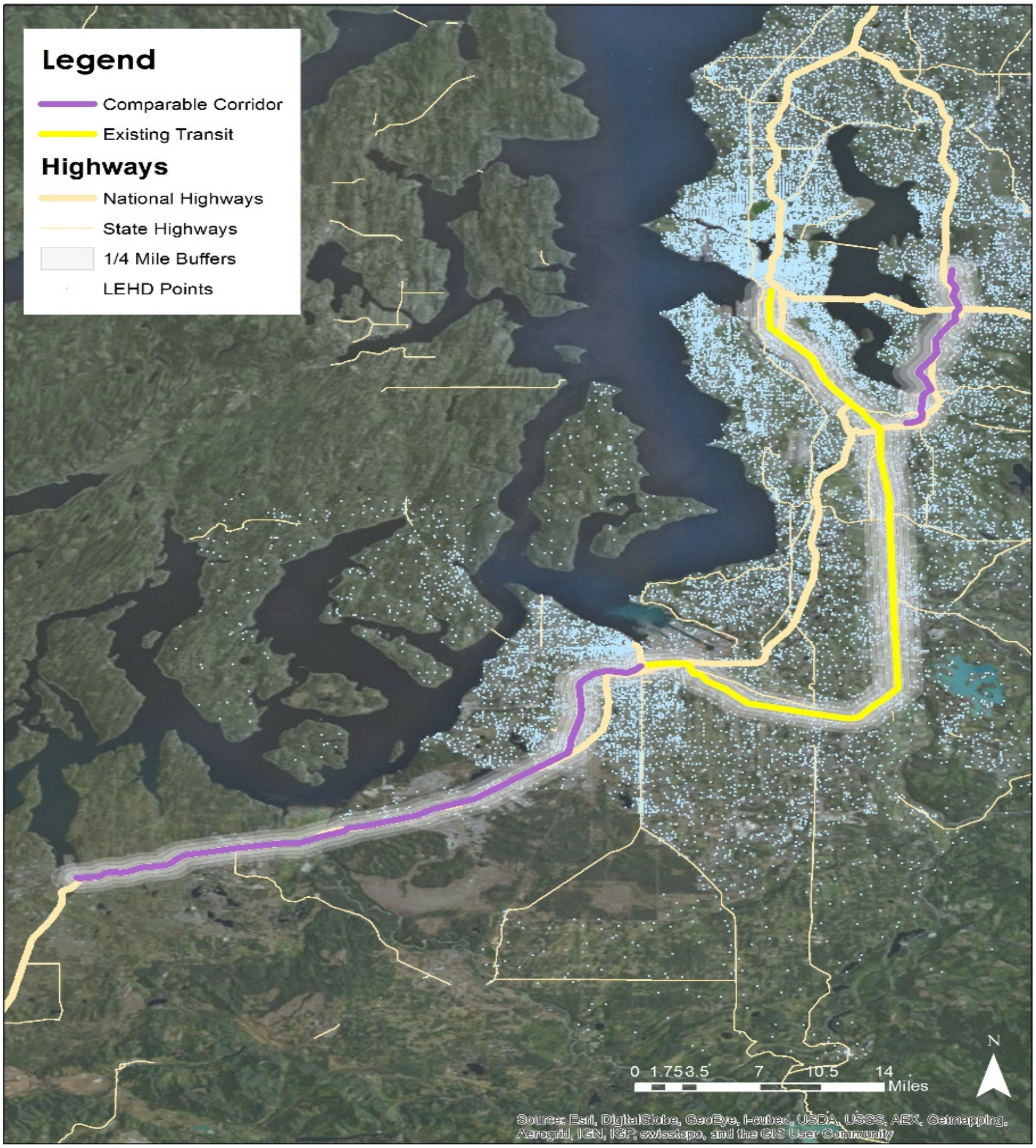

Figure 2: Transit and comparable corridor locations

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.

We define location quotient (LQ) "as a ratio of ratios" following Miller, Gibson and Wright (1991: 66):

$$\mathrm{LQ} = \frac{\left(\frac{e_i}{\sum e}\right)}{\left(\frac{E_i}{\sum E}\right)}$$

where:

e_i = Employment in industry i in corridor
$\sum e$ = Total employment in corridor
E_i = Employment in industry i in the metropolitan area
$\sum E$ = Total employment in the metropolitan area

The analysis then compares the location quotients of each industry between each corridor for 0.25 mile and 0.5 mile buffers around each corridor. Because the Seattle Streetcar corridor was not in operation until 2007 (our data only spans 2002-2010), we are unable to completely capture the employment concentrations before and after its existence. Our analysis will focus on whether there were higher concentrations of employment opportunities along the transit line within each of the two buffer distances during the analysis period.

Both the existing and comparable corridors are located in pre-existing, built-up urban areas, so additional growth must occur through redevelopment of existing urban land. Therefore, 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.

Results & Discussion

The location quotients for 0.25 and 0.5 mile buffers for both the existing transit and comparable corridors are shown in Table 1. For each corridor, the average location quotient for each analysis period (2008-2010) is shown along with the differences between their LQ values. The difference between 0.25 and 0.5 mile buffers are also shown.

NAICS Sector	Quarter-Mile Buffer			Half-Mile Buffer			Differences between 0.25 & 0.50 mile buffers
	Comparable	Existing	Corridor Differences	Comparable	Existing	Corridor Differences	
	2008-2010	2008-2010	2008-2010	2008-2010	2008-2010	2008-2010	
Utilities	0.00	0.01	0.01	4.80	0.06	-4.74	4.75
Construction	1.72	0.49	-1.23	0.60	0.45	-0.15	-1.08
Manufacturing	0.38	0.12	-0.26	0.14	0.19	0.05	-0.31
Wholesale	0.40	1.45	1.05	0.23	1.05	0.82	0.23
Retail	0.66	0.69	0.02	0.92	0.56	-0.36	0.38
Transportation	0.81	0.31	-0.49	0.91	0.24	-0.67	0.18
Information	0.32	1.03	0.70	0.50	0.88	0.39	0.32
Finance	0.40	1.72	1.32	1.23	2.32	1.09	0.24
Real Estate	0.89	0.79	-0.10	0.69	1.56	0.88	-0.97
Professional	1.47	2.70	1.23	1.63	2.65	1.02	0.21
Management	1.61	2.34	0.74	0.80	2.14	1.34	-0.60
Administrative	1.10	1.69	0.59	0.59	1.58	0.99	-0.41
Education	0.14	0.18	0.04	0.06	0.13	0.07	-0.03
Health Care	1.31	0.48	-0.83	2.04	0.44	-1.59	0.76
Arts, Ent., Rec	1.39	0.50	-0.90	0.53	0.74	0.21	-1.11
Lodging, Food	0.95	1.04	0.09	0.56	1.15	0.59	-0.50
Other services	0.82	3.18	2.36	0.62	3.12	2.50	-0.14
Public Admin	5.19	0.21	-4.98	5.66	0.51	-5.15	0.17

Table 1: Location quotients comparison for existing transit and comparable corridors

Overall, we observe a gain of employment concentration in most industry sectors close to the Seattle South Lake Union streetcar line. As shown in the last column of Table 1 above, only industry sectors such as Arts, Entertainment & Recreation, Construction and Real Estate registered larger negative changes in the location quotient and show a lower concentration closest to the streetcar line, and other sectors such as Utilities, Wholesale, Retail, Information, Health Care, and Professional were increasing in job concentration around the transit line.

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. A careful study of the differences in location quotient in Table 1 above reveals different patterns of economic development and employment concentration with the quarter-mile and half-mile buffers, for both the Existing and Comparable corridors. Within the quarter-mile buffer, Other Services, Wholesale, Professional, Finance, Management and Administrative showed the greatest increases in the Existing streetcar corridor compared to the Comparable corridor. On the other hand, within the same quarter-mile buffer, Public Administration, Construction, Arts, Entertainment & Recreation and Health Care industries experienced greater loss of job concentration.

For the 0.5 mile buffer around the Existing Transit corridor, there are notable increases in the Other Services, Management, Finance, and Professional industries when compared to the Comparable corridor. On the other hand, these sectors lost the most jobs: Utilities, Public Administration and Health Care. It is reasonable that we do not observe many significant impacts in employment concentration for the analysis of the South Lake Union streetcar line during the analysis period, particularly because the streetcar operated at slower speeds due to its shared right-of-way and lower ridership (only reaching 2000 riders per weekday after 2011).

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 changes is determined by other factors.

In theory, employment in different NAICS sectors should be variable depending on the NAICS code, as some NAICS 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, large 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, in attempt to identify 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 (Metro Share) 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 (Industry Mix) 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 (Transit Share) 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.

The formula below was used for the shift-share analysis:

Shift-Share = Metro Share + Industry Mix + Transit Share

where:

Metro Share = $C_i^0 . \left(\frac{M^1}{M^0}\right)$

Industry Mix = $\left\{C_i^0 . \left(\frac{M_i^1}{M_i^0}\right)\right\}$ – Metro Share

Transit Share = $C_i^0 . \left(\frac{C_i^1}{C_i^0} - \frac{M_i^1}{M_i^0}\right)$

where:

C_i^0 = Number of corridor jobs in industry (i) at the beginning of the analysis period (0)
C_i^1 = Number of corridor jobs in industry (i) at the end of the analysis period (1)
M^0 = Total Metro jobs at the beginning of the analysis period (0)
M^1 = Total Metro jobs at the end of the analysis period (1)
M_i^0 = Metro jobs in industry (i) at the beginning of the analysis period (0)
M_i^1 = Metro jobs in industry (i) at the end of the analysis period (1)

Results & Discussion

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 changes in employment by sector within a 0.5 mile buffer of the transit corridor between 2007 and 2010. The second batch of columns shows the changes in employment by sector in the Seattle metropolitan area. The third batch of columns shows the results of the shift-share analysis, and apportions the source of employment change between the three categories of Metro Share, Industry Mix and Transit Shift.

NAICS Sector	Half Mile Buffer			Metro			Shift-Share Sources of Employment Change		
	2007	2010	% Change	2007	2010	% Change	Metro Share	Industry Mix	Transit Shift
Utilities	37	35	-5.4%	6,354	7,255	14.2%	-1%	6	-20%
Construction	3,878	2,767	-28.6%	110,833	72,459	-34.6%	-29	-1,313	6%
Manufacturing	3,114	2,238	-28.1%	176,238	158,481	-10.1%	-24	-290	-18%
Wholesale	7,440	7,425	-0.2%	84,735	78,990	-6.8%	-56	-448	7%
Retail	9,212	7,544	-18.1%	171,221	162,356	-5.2%	-70	-407	-13%
Transportation	1,800	1,266	-29.7%	69,695	64,811	-7.0%	-14	-113	-23%
Information	9,087	6,363	-30.0%	68,390	92,411	35.1%	-69	3,260	-65%
Finance	14,734	11,460	-22.2%	66,685	59,473	-10.8%	-112	-1,482	-11%
Real Estate	4,367	4,606	5.5%	34,215	31,419	-8.2%	-33	-324	14%
Professional	26,388	26,306	-0.3%	110,464	113,929	3.1%	-200	1,027	-3%
Management	3,811	6,098	60.0%	28,735	27,921	-2.8%	-29	-79	63%
Administrative	13,333	11,719	-12.1%	95,178	81,156	-14.7%	-101	-1,863	3%
Education	1,307	1,490	14.0%	127,360	131,445	3.2%	-10	52	11%
Health Care	6,928	7,883	13.8%	177,329	197,217	11.2%	-52	829	3%
Arts, Ent., Rec.	2,533	2,208	-12.8%	34,606	36,658	5.9%	-19	169	-19%
Lodging, Food	12,840	12,246	-4.6%	125,124	119,517	-4.5%	-97	-478	0%
Other Services	9,655	29,589	206.5%	67,500	93,091	37.9%	-73	3,734	169%
Public Admin	2,078	4,052	95.0%	52,401	66,310	26.5%	-16	567	68%
Total	132,542	145,295	9.6%	1,607,063	1,594,899	-0.8%	-1,003	2,847	10%

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

The entire Seattle metro area lost employment during the analysis period, with greatest losses occurring in Construction, Administrative, Finance, Manufacturing, Real Estate and Transportation sectors. However, despite the overall loss in employment in the Seattle area, there was about 9.6% total gain in employment within the 0.5 mile buffer, concentrated in Other Services, Public Administration, Management, Education and Health Care sectors. The shift-share analysis itself shows different trends.

After controlling for metropolitan growth and shift in the industry mix, the effect of the transit corridor on employment was significantly positive. The sectors that benefited most from transit within the 0.5 mile buffer (as shown by the transit shift column) included Other Services, Public Administration and Management.

Analysis of the Corridor Share Effect is presented for both the transit and comparable corridors in Table 3. This analysis is intended to confirm that the corridor share effects attributed to transit are specific to the transit corridor, and not the result of another effect. Namely, the Transit Advantage shows the change in employment due to the Corridor Share Effect (Transit Shift minus Control Shift).

NAICS Sector	Control Shift	% Shift	Transit Shift	% Shift	Transit Advantage
Utilities	-121.21	-0.02	-7.25	0.00	113.97
Construction	523.40	0.01	231.69	0.00	-291.71
Manufacturing	-130.20	0.00	-562.25	0.00	-432.05
Wholesale	25.75	0.00	489.43	0.01	463.68
Retail	641.21	0.00	-1191.05	-0.01	-1832.26
Transportation	235.76	0.00	-407.86	-0.01	-643.63
Information	-428.29	0.00	-5915.68	-0.06	-5487.39
Finance	-33.83	0.00	-1680.51	-0.03	-1646.68
Real Estate	-208.42	-0.01	595.86	0.02	804.28
Professional	69.27	0.00	-909.73	-0.01	-979.00
Management	-92.49	0.00	2394.96	0.09	2487.45
Administrative	-379.86	0.00	350.27	0.00	730.13
Education	-51.56	0.00	141.08	0.00	192.64
Health Care	-6180.68	-0.03	178.00	0.00	6358.68
Arts, Ent., Rec.	224.13	0.01	-475.20	-0.01	-699.33
Lodging, Food	132.97	0.00	-18.62	0.00	-151.59
Other Services	-698.76	-0.01	16273.54	0.17	16972.30
Public Admin	-2830.79	-0.04	1422.43	0.02	4253.22
Total	**-9303.59**	**-0.10**	**10909.12**	**0.19**	**20212.71**

Table 3: Shifts by corridor and comparison between corridors

Drawing any conclusion for the Seattle South Lake Union streetcar line is difficult due to confounding factors. The corridor shift associated with the transit and comparable corridors are substantially different for most industries. The corridor effect for the transit corridor is stronger for Other Services, Management, Public Administration and Real Estate, while the comparable (control) corridor does better in the Retail, Construction, Transportation and Arts, Entertainment & Recreation sectors.

Without more rigorous controls, it is difficult to attribute all of the corridor effect to the South Lake Union streetcar line. Based on the results of the shift-share analysis, there are industries that are strongly attracted to this particular transit corridor. The percent change, shift-share, and contrast with the comparable corridor all indicate that proximity to the South Lake Union streetcar line appeared to be more attractive to Other Services, Health Care, Public Administration, Management, Administrative and Real Estate. While the comparable corridor in Seattle experienced job loss during the 2007 to 2010 period as a result of the Great Recession, the existing transit corridor gained a substantial number of jobs attributed to the Corridor Share Effect.

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; it provides alternate transportation options during conditions that impair other modes: weather, construction projects, or accident-induced delay; finally, it 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, reducing unemployment duration and the unemployment rate.

Data and Methods

The degree of resilience of a NAICS sector to shocks in the local economy was assessed by using difference-in-difference (DID) analysis because this specification requires fewer time periods and controls for the counterfactual effect by using the comparison corridor. In its simplest specification, the DID method allows changes in employment to be estimated before and after the Great Recession of 2007 while accounting for differences between comparable and transit corridors. The DID functional form is shown below:

$$\Delta Emp = \beta_0 + \delta_0 Post07 + \beta_1 Exist + \delta_1 (Post07 * Exist) + \varepsilon$$

where:

$\Delta\mathrm{Emp}$= Change in Total employment
β_0= Intercept (Pre-treatment employment of comparable corridor)
$\mathrm{Post07}$= Dummy (1 if value is after 2007, 0 if not)
Exist= Dummy (1 if value is in the existing corridor)
δ_1= Differences-in-Differences estimate

Results & Discussion

Figure 4 below shows the changes in employment by sector estimated using the DID methodology (δ_1). The analysis shows decline in employment in Other Services and Construction after the Great Recession, and gains in Retail, Education, Lodging and Food, Transportation, Wholesale, Administrative, Management, Arts, Entertainment & Recreation and Utilities.

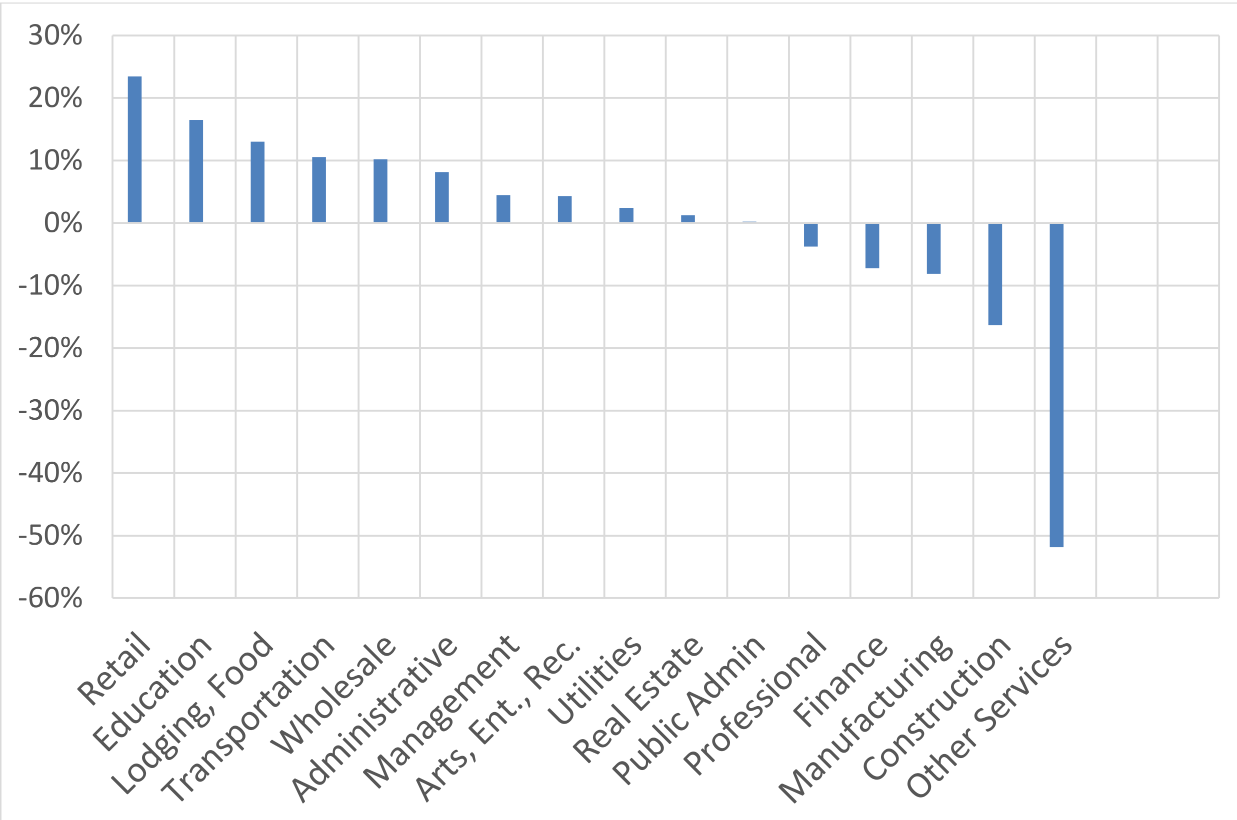

Figure 3: Changes in Employment for different industries

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. This analysis did not yield robust statistical results due to large standard errors, a manifestation of our small sample size. Although statistically significant effects could not be inferred from the data, meaningful changes were decipherable. The higher positive estimated coefficients for Retail, Education and Lodging and Food industry sectors point to stronger resilience along the transit corridor whereas Other Services and Construction yielded negative coefficient estimates, indicating a weaker rebound from the Recession.

Some caveats are necessary. Employment in any industry sector is variable over time, and the amount of variability increases with smaller geographic units of analysis. Because the geographic unit of analysis is small, the amount of fluctuation is larger. Changes might 'average out' over a larger unit of geographic aggregation have may have significant effects. 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. Finally, 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.

6-HOUSING AFFORDABILITY

Introduction

It is not always possible to maintain a supply of affordable housing for a growing population by adding additional 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. 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 have 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 Transit Oriented Development (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 & 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 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 are frequented by non-walk modes, including bicycle, bus, and automobile. The characteristics of the built environment within a mile buffer of station can still affect transit ridership (Guerra, Cervero, & Tischler 2011).

Data and Methods

This section describes the data and techniques used for the analysis. Unlike all other analyses contained in this report, this housing and transportation affordability 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 magnitude of effect for proximity to transit. The area within the smallest buffers should show the strongest reaction.

Data Source and Geography

This study uses the Location Affordability Index (LAI), developed under the aegis of the Sustainable Communities, an inter-agency partnership between the Housing and Urban Development, US Department of Transportation, and the Environmental Protection Agency, to analyze housing affordability around the transit corridor. The LAI designed as a statistical model that estimates the total cost of housing plus transportation at different locations, controlling for a number of factors known to influence transportation and housing costs, such as household income and number of workers. Furthermore, the LAI model provides total housing and transportation cost estimations for eight different household profiles, representing different family structures and types. For this analysis, we chose to utilize the estimates for type 1 households (hh_type1), which represents the Regional Typical household, with average household size, median income, and an average number of commuters per household for the region[1].

The unit of analysis for the LAI dataset is the 2010 Decennial Census Block Group. The data extent is the Census 2010 Core-Based Statistical Area (CBSA). When transit lines crossed the boundary into adjacent statistical areas, both statistical areas were included.

Data Processing

The LAI data[2] for the Seattle metropolitan area was downloaded in CSV (Comma Separated Values) format, and was joined to GIS (geographical information system) shapefiles of the 2010 Decennial Census Block Groups[3] for our analysis.

However, Census Block Groups represent an unacceptably large geography for transit relevant analysis. Instead of attributing a whole block group to be within a buffer zone if its centroid was within the buffer threshold, we devised an alternative method with geographically-weighted characteristics. Those buffers were then used to clip the block groups. The characteristics of each block were then weighted by geographic ratio (the ratio of the area of the block group to 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 index was devised. Because the metropolitan area contains all census blocks, not just urban blocks, weighting the blocks by area was deemed inappropriate. 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 value for the metro area was calculated by weighting the block group characteristics by Census 2012 block group

[1] The full methodology for the LAI can be found at: http://lai.locationaffordability.info/methodology.pdf. A full data dictionary can be found at: http://lai.locationaffordability.info/lai_data_dictionary.pdf.
[2] LAI data location: http://www.locationaffordability.info/lai.aspx?url=download.php
[3] 2010 Decennial Census GIS files: https://www.census.gov/geo/maps-data/data/tiger.html

population. This weighted average is intended to provide a reference for what are normal values for the metropolitan area.

This analysis makes use of seven characteristics from the location affordability index: housing costs as a percentage of income and transportation costs as a percentage of income, for owners, renters, and all households in the region. Additionally, it makes use of the median income to translate percentages into dollar amounts.

Results & Discussion

Overall, the analysis revealed that locating closer to transit is not necessarily associated with affordability. Table 4 shows that as a household is located within an existing transit corridor, the portion of their income spent on housing and transportation declined by 3.66% and -0.66%, after controlling for housing and transportation costs within the comparable corridor in quarter-mile and half-mile buffers (using a difference-in-difference approach).

Corridor	2010		
	Comparable	**Existing**	**Difference**
Quarter-Mile	30.13	33.79	3.66
Half-Mile	34.44	33.78	-0.66
Differences	-4.31	0.01	4.32

Table 4: Affordability by Corridor

It was surprising to find that housing and transportation costs increased for those households living closer to the transit line. Since travelers self-select to live in TODs "due to habit, personal taste, or happenstance" (Cervero, 1994, p. 177), we thought housing and transportation costs would have declined with proximity to transit. This could be the result of households still driving even though transit was available, which may be reasonable since the South Lake Union streetcar line does not aim to provide commuting benefits. Also, the transit lines may not be accessible to destinations and housing around transit lines could be relatively expensive.

7-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. Transit Oriented Development (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 work 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 et al., 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 or 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 overall job accessibility. In addition to providing total number of employees per Census Block, the LED employment data is 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 is 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 & Discussion

Generally, job-housing imbalance seemed to increase with proximity to the transit line due to the combined effect of loss of jobs and inadequate housing. At the half-mile radius of the transit line, the average ratio of workplace to residence was at 8.6:1 (see Table 5), representing a 38% decline from the 0.25 mile corridor. This picture reflects rapid growth in employment and residential developments as one gets farther from the streetcar. For example, between 2002 and 2011, moving from the 0.25 mile buffer to a 0.5 mile buffer showed more than doubling of employment and residential growth. The variation of job-housing for different income groups was also very clear. It was found that low income earners were increasingly located in communities with very high job concentrations.

Years	LOW			MEDIUM			HIGH			
	Work	Home	Ratio	Work	Home	Ratio	Work	Home	Ratio	Avg.
2002	29479	2923	10.1	44416	4735	9.4	54025	4466	12.1	10.6
2003	28013	2779	10.1	41193	4725	8.7	54856	4913	11.2	10.0
2004	27880	2909	9.6	39911	4514	8.8	52682	5061	10.4	9.7
2005	26144	2837	9.2	39133	4562	8.6	61209	5473	11.2	9.8
2006	25089	2916	8.6	38773	4673	8.3	65666	6511	10.1	9.2
2007	26260	2848	9.2	37602	4597	8.2	68866	7017	9.8	9.2
2008	34047	2810	12.1	36892	4543	8.1	72724	7925	9.2	9.4
2009	37048	2773	13.4	34648	4592	7.5	71321	9811	7.3	8.3
2010	40501	2474	16.4	32633	4205	7.8	72253	8548	8.5	9.5
2011	42578	2665	16.0	31065	4541	6.8	72578	9781	7.4	8.6

Table 5: Jobs-housing balance for income categories

Clearly, proximity to transit had positive income effects over time (see Table 6 below). Within a quarter-mile of transit, there appeared to be retrogression of income over the years. Similarly, within the half-mile buffer of transit, incomes depreciated. However, the negative income effects were more pronounced in the half-mile buffers than the quarter-mile buffer. Therefore, on the whole, households locating closer to the transit line were relatively better-off.

Buffer	Comparable			Existing			Differences		
	2000	2009	2011	2000	2009	2011	2000	2009	2011
Quarter-Mile	26488	26869	29559	42250	40476	41725	15762	13607	12166
Half-Mile	32018	34041	35889	44999	43955	45286	12981	9914	9396
Differences	-5530	-7171	-6331	-2749	-3479	-3561	2781	3693	2770

Table 6: Household Median Income by distance band by year

The employment accessibility index of the Location Affordability project was used to measure the employment accessibility of households to transit. Generally, as shown in Table 7, access to employment is better for those within any buffer zone around the existing transit corridor. In addition, employment accessibility is comparable as we move from the quarter-mile buffer to the half-mile buffer, in both the existing transit and comparable corridors. This may indicate the highly developed nature of the analysis corridors.

Buffer	2010		
	Comparable	Existing	Difference
Quarter-Mile	219409	274093	54685
Half-Mile	206567	269595	63028
Differences	12842	4498	-8343

Table 7: Job Accessibility by Corridor

We reach the following conclusions regarding job accessibility close to the transit line: (1) uneven distribution of job and housing; (2) higher likelihood of being non-poor; and (3) lower job accessibility. From these findings, it is possible to conclude that the uneven distribution of jobs coupled with lower job accessibility was making it difficult for households to move up on the economic ladder because they may have to pay more for housing and transportation.

8-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

- Most attractive: Other Services, Professional
- Least attractive: Utilities, Manufacturing and Public Administration

Transit advantage over comparable corridor

- Substantial: Other Services, Finance, Professional
- Minor: Wholesale, Information, Administrative, Management

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

Change in transit corridor

- Employment in streetcar corridor gained much more than metropolitan area
- Substantial percentage increases: Other Services, Public Administration and Management
- Substantial percentage reductions: Information, Transportation, Manufacturing and Construction

Shift-share analysis – Transit Shift

- Employment in Other Services, Public Administration and Management are most positively impacted by transit

Transit advantage over comparable corridor

- Transit advantage is strongest for Other Services, Health Care and Public Administration
- Strong transit disadvantage exists for Information and Finance

Q3: Are firms in TODs more resilient to economic downturns? (Difference-In-Difference)

In this example, resilience is defined as the capacity to maintain a positive trend despite the economic shock of the 'Great Recession'. We utilized a difference-in-difference estimation to analyze resilience within each industry.

- Positive signs of resilience: Retail, Education and Lodging and Food
- Negative signs of resilience: Other Services and Construction

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

This report uses the Location Affordability Index (LAI), developed under the aegis of the Sustainable Communities, an inter-agency partnership between the Housing and Urban Development, US Department of Transportation, and the Environmental Protection Agency, to analyze housing affordability around the transit corridor in 2010.

- Households located close to the streetcar corridor spend a larger percentage on housing and transportation compared to the comparable corridor within the 0.25 mile buffer
- Affordability does not necessarily increase as households move closer to the transit line

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 and for workers by income levels.

- Jobs-housing ratio is much higher for low-income households than for high or medium income households.
- Jobs-housing ratio has been generally declining, but the ratio has been increasing significantly for low-income households
- Higher average household income within transit corridor, but with declining job accessibility for higher income households

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10-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/