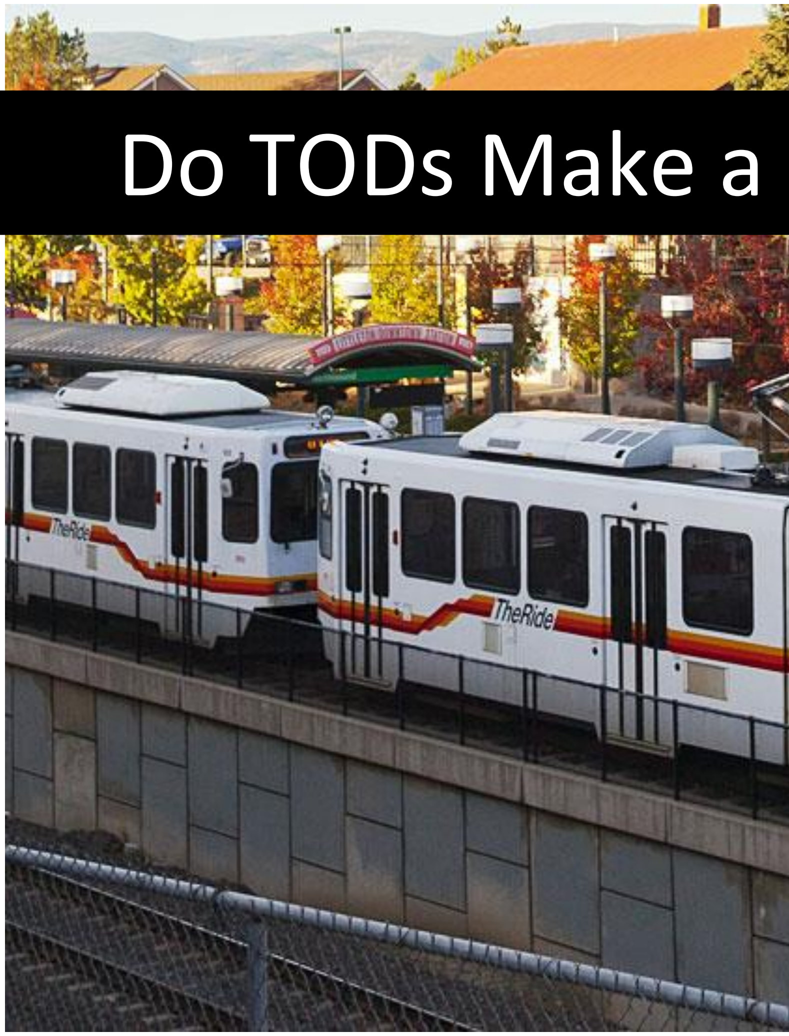
Light Rail Transit

Denver, Colorado

Do TODs Make a Difference?



NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

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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2-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.

3-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.

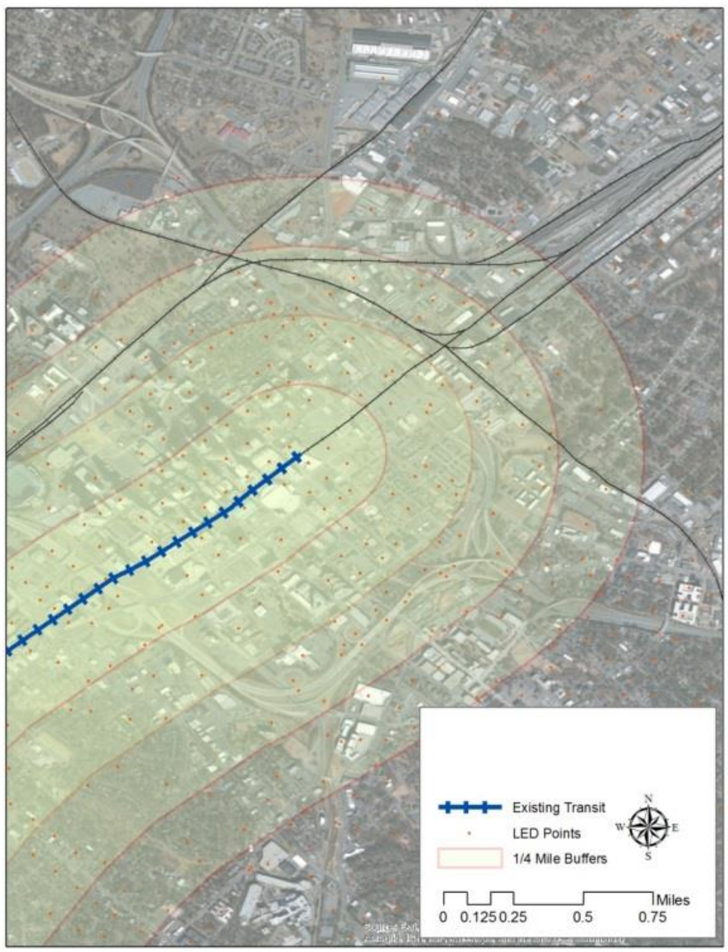

Figure 1: Example corridor, buffers, and LED census block points

Study Area

This study examines Denver's D Line (sometimes known as the green line), a light rail line that is part of the Denver metro region's RTD (Regional Transportation District) network. The D Line was the first light rail line of the RTD system and was opened on October 7, 1994, with extensions starting operations in 2000 and 2002. The existing transit line was chosen because it had an extensive development period, and because of its position along a major freeway. The comparable corridor was chosen due to its existing railroad right-of-way and the corridor is planned for use as a future commuter rail line. In addition, the land use is suburban. Figure 2 shows the transit and comparable corridors as well as the location of LED points.

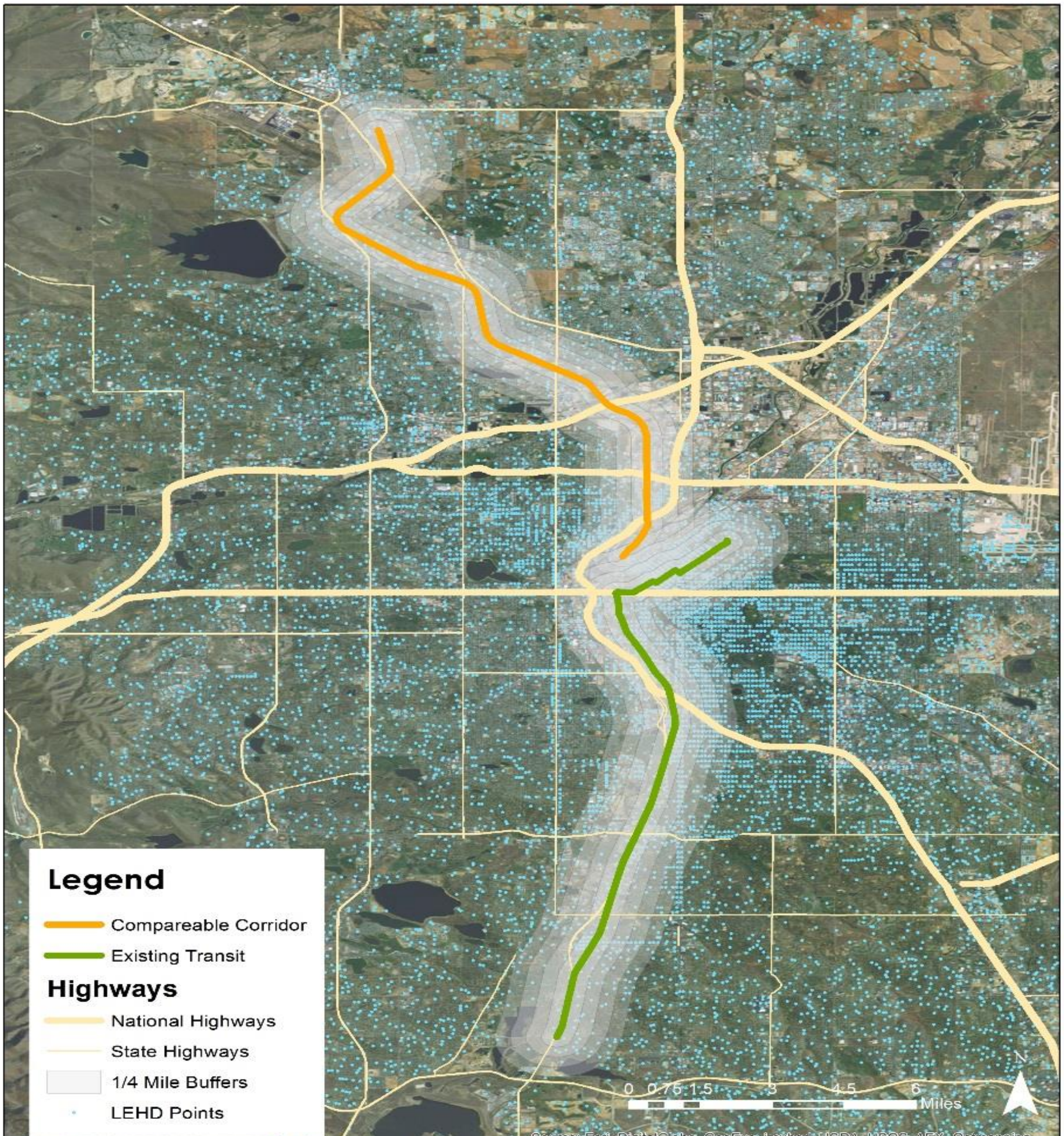

Figure 2: Transit and comparable corridor locations

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.

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 Denver D Line light rail corridor was already in operation in 1994 (our data spans 2002-2010), we are unable to compare 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 (2002-2010) is shown along with the differences between their LQ values. The difference between 0.25 and 0.5 mile buffers are also shown.

NAICS Sectors	Quarter-Mile Buffer			Half-Mile Buffer			Differences between 0.25 & 0.50 mile buffers
	Comparable	Existing	Corridor Differences	Comparable	Existing	Corridor Differences	
	2002-2010	2002-2010	2002-2010	2002-2010	2002-2010	2002-2010	
Utilities	0.18	5.15	4.97	0.15	3.44	3.29	1.68
Construction	1.22	0.85	-0.37	0.96	0.76	-0.2	-0.17
Manufacturing	1.19	0.9	-0.29	0.96	0.72	-0.24	-0.05
Wholesale	1.33	0.75	-0.58	1.63	0.78	-0.85	0.27
Retail	1.78	0.5	-1.28	1.12	0.41	-0.72	-0.56
Transportation	0.48	0.3	-0.18	1.16	0.34	-0.82	0.64
Information	0.57	1.92	1.35	0.58	1.49	0.91	0.44
Finance	0.66	1.69	1.03	0.64	1.39	0.75	0.28
Real Estate	1.15	0.7	-0.45	0.94	0.86	-0.07	-0.38
Professional	1.03	2.01	0.99	1.29	1.83	0.54	0.45
Management	0.85	1.78	0.94	0.93	1.5	0.57	0.37
Administrative	1.38	1.34	-0.04	1.18	1.18	0.00	-0.04
Education	0.23	0.32	0.09	0.57	0.72	0.15	-0.06
Health Care	0.44	0.33	-0.11	0.44	0.3	-0.14	0.03
Arts, Ent., Rec	0.54	0.86	0.32	1.05	1.05	0.00	0.32
Lodging, Food	1.1	1.05	-0.05	1.75	1.03	-0.72	0.67
Other services	1.08	1.04	-0.04	1.06	0.9	-0.16	0.12
Public Admin	1.46	1.14	-0.32	0.64	2.76	2.11	-2.43

Table 1: Location quotients comparison for Transit and comparable corridors

Overall, we observe that most NAICS industry sectors moved closer to the Denver D Line LRT. As shown in the last column in Table 1 above, while NAICS sectors such as Utilities, Wholesale, Transportation, Information Finance, Professional, Management, Health Care, Arts, Entertainment, & Recreation, Lodging, Food, and Other services experienced increases in concentration in the quarter-mile buffer zone around the Denver LRT line while other sectors (e.g. Construction, Manufacturing, Retail, Real Estate, Administrative, Education, Public Admin) appeared to decrease in concentration in these areas closest to the light rail 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. For the 0.25 mile buffer around the Existing Transit corridor, the location quotient for Utilities, Information, Finance, Professional, Management, Education, and Arts, Entertainment & Recreation all saw substantial increases. Within the same buffer, Construction, Manufacturing, Wholesale, Retail, Transportation, Real Estate, Administrative, Health Care, Lodging, Food, Other services, Public Administration, lost jobs. For the 0.5 mile buffer around the Existing Transit corridor, the location quotient for Utilities, Information, Finance, Professional, Management, Education, and Public Administration registered increases. All the other industries lost jobs, except for Administrative, and Arts, Entertainment and Recreation.

Because many light rail stations may be co-established with new campuses for major institutions, increases in the location quotient for Education could be expected. In addition, the employment concentration increases in the Arts, Entertainment & Recreation sector also makes sense since the Denver D Line LRT passes through downtown Denver as well as its theater district and convention center. The clustering of professional services (such as Finance and Professional sectors) and others that utilize office space (Utilities and Information) may be shifting closer to light rail stations while others that have larger space requirements (Manufacturing and Construction) may be gradually moving a bit further away from the stations to remain profitable.

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		
	2007	2010	% Change	2007	2010	% Change	Metro Share	Industry Mix	Transit Shift
Utilities	3,144	3,607	14.7%	6,738	7,181	6.6%	-125	232	8%
Construction	8,243	5,242	-36.4%	84,112	58,361	-30.6%	-66	-2,457	-6%
Manufacturing	5,856	4,663	-20.4%	73,194	67,365	-8.0%	-47	-419	-12%
Wholesale	6,673	6,352	-4.8%	71,054	66,656	-6.2%	-54	-359	1%
Retail	6,687	6,295	-5.9%	127,571	128,395	0.6%	-54	97	-7%
Transportation	2,197	1,289	-41.3%	49,034	39,892	-18.6%	-18	-392	-23%
Information	10,986	7,820	-28.8%	52,653	47,188	-10.4%	-88	-1,052	-18%
Finance	10,756	12,076	12.3%	68,492	69,514	1.5%	-86	247	11%
Real Estate	2,882	2,589	-10.2%	27,625	24,643	-10.8%	-23	-288	1%
Professional	22,718	22,048	-2.9%	103,009	107,406	4.3%	-183	1,152	-7%
Management	4,862	5,480	12.7%	25,253	27,421	8.6%	-39	456	4%
Administrative	12,682	13,201	4.1%	86,181	77,875	-9.6%	-102	-1,120	14%
Education	8,290	9,744	17.5%	91,579	97,827	6.8%	-67	632	11%
Health Care	4,649	5,206	12.0%	122,671	145,042	18.2%	-37	885	-6%
Arts, Ent., Rec.	2,864	2,785	-2.8%	21,970	22,292	1.5%	-23	65	-4%
Lodging, Food	13,293	14,200	6.8%	108,264	107,057	-1.1%	-107	-41	8%
Other Services	4,059	4,092	0.8%	36,411	36,169	-0.7%	-33	6	1%
Public Admin	19,706	23,111	17.3%	54,641	70,437	28.9%	-158	5,855	-12%
Total	150,547	149,800	-0.5%	1,210,452	1,200,721	-0.8%	-1,185	3,499	0%

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

The entire Denver metro area lost employment in Construction, Manufacturing, Wholesale, Transportation, Information, Real Estate, Administrative, Lodging, Food, and Other Services, during the analysis period. There was about 0.5% total loss in employment within the 0.5 mile buffer, concentrated in Construction, Manufacturing, Wholesale, Retail, Transportation, Information, Real Estate, Professional, and, Arts, Entertain & Recreation 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 neutral and rather evenly distributed among the sectors. The sectors that gained from the transit within the 0.5 mile included Utilities, Wholesale, Finance, Real Estate, Management, Administrative, Education, Lodging, Food, and Other Services.

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	Comparable	% Shift	Transit	% Shift	Transit Advantage
Utilities	2.41	0.00	256.29	0.04	253.88
Construction	145.05	0.00	-477.39	-0.01	-622.45
Manufacturing	181.43	0.00	-726.64	-0.01	-908.07
Wholesale	-1354.99	-0.02	92.04	0.00	1447.02
Retail	-1301.26	-0.01	-435.19	0.00	866.07
Transportation	-927.13	-0.02	-498.39	-0.01	428.74
Information	184.67	0.00	-2025.73	-0.04	-2210.40
Finance	-149.69	0.00	1159.50	0.02	1309.20
Real Estate	296.98	0.01	18.10	0.00	-278.89
Professional	35.32	0.00	-1639.73	-0.02	-1675.05
Management	-195.69	-0.01	200.59	0.01	396.28
Administrative	-595.07	-0.01	1741.27	0.02	2336.34
Education	-2238.14	-0.02	888.41	0.01	3126.55
Health Care	97.07	0.00	-290.82	0.00	-387.89
Arts, Ent., Rec.	-133.07	-0.01	-120.98	-0.01	12.09
Lodging, Food	23.58	0.00	1055.20	0.01	1031.62
Other Services	101.19	0.00	59.98	0.00	-41.21
Public Admin	-331.23	0.00	-2291.75	-0.03	-1960.52
Total	**-6158.55**	**-0.08**	**-3035.23**	**-0.03**	**3123.32**

Table 3: Shifts by corridor and comparison between corridors

Drawing any conclusion for the Denver D Line LRT 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 Utilities, Wholesale, Retail, Transportation, Finance, Management, Administrative, Education, Arts, Entertainment & Recreation, Lodging, and Food, while the comparable (control) corridor does better in Information, Public Administration and Professional sectors.

Without more rigorous controls, it is difficult to attribute all of the corridor effect to the Denver light rail. The corridor was not arbitrarily chosen, but rather a process of ‘connecting the dots’ between major regional employment centers. The D Line connects downtown Denver with Englewood and Littleton.

Based on the results of the shift-share analysis, there are industries that are both strongly attracted to LRT transit corridors. The percent change, shift-share, and contrast with the comparable corridor all indicate that proximity to the Denver D Line appeared particularly attractive to Utilities, Wholesale, Finance, Management, Administrative, Education, Lodging, and Food industries.

Although the analyzed corridors in Denver experienced job loss during the 2007 to 2010 period as a result of the Great Recession, the number of jobs lost attributed to the Corridor Share Effect is significantly lower (or even shows positive growth) in the transit corridor as opposed to the comparable corridor. This effect is particularly striking within the Education and Wholesale industries which experienced large negative impacts to employment in the comparable corridor, but showed gains in employment in the transit corridor which are attributed to transit in the shift-share analysis.

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 Utilities, Construction, Wholesale, Transportation, Management, Administrative, and Lodging & Food, and gains in Manufacturing, Retail, Information, Finance, Real Estate, Professional, Education, Health Care, Arts, Entertainment, Recreation, Other Services and Public Administration.

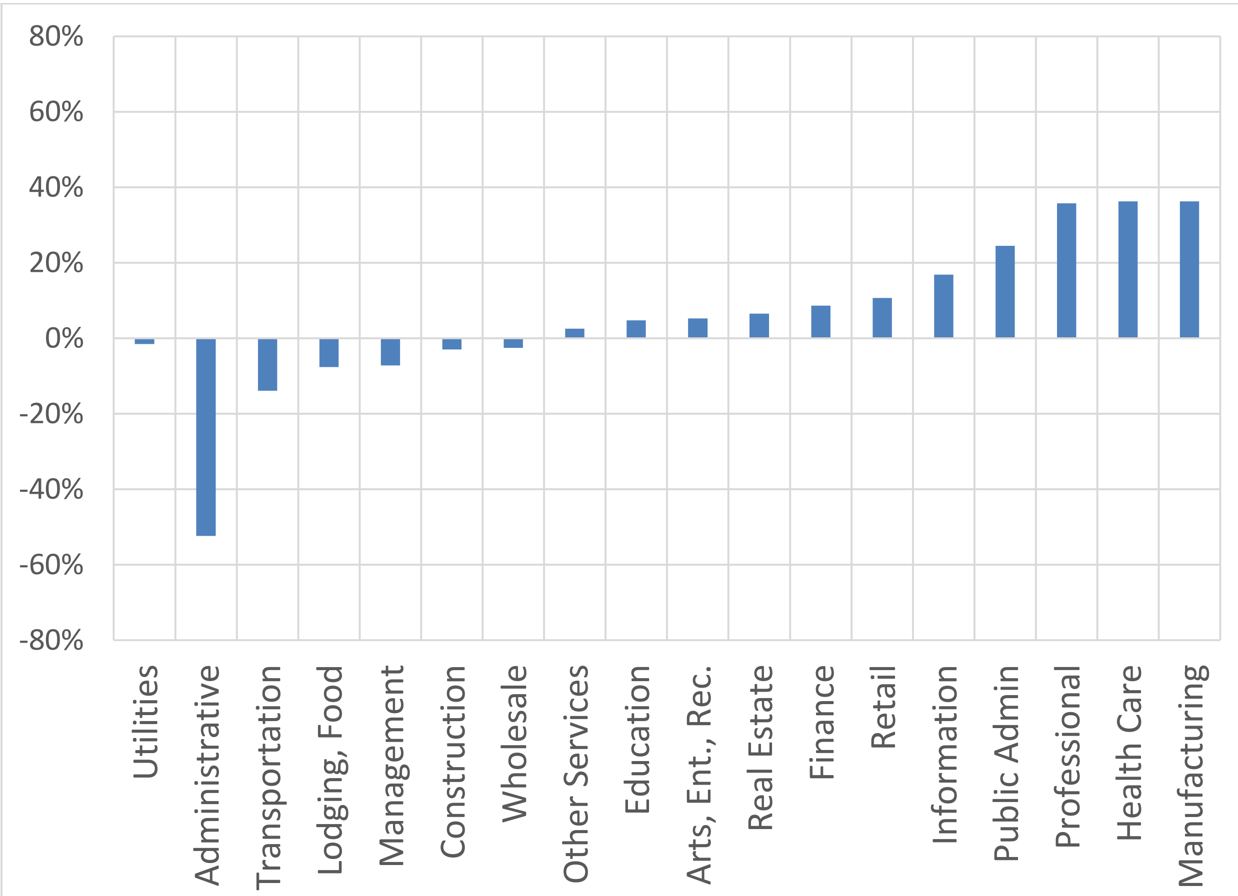

Figure 3: Changes in Employment for different industries

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 Manufacturing, Health Care and Professional industry sectors point to stronger resilience along the transit corridor whereas Administrative and Transportation 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 Denver 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 population. This weighted average is intended to provide a reference for what are normal values for the metropolitan area.

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[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

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 does not provide conclusive evidence regarding housing affordability along transit lines. Table 4 shows that those households who live within a quarter-mile or half-mile radius of the selected Denver LRT corridor spend 3.7% to 4.6% less on housing and transportation compared to households in the corresponding comparable corridor.

Corridor	2010		
	Comparable	**Existing**	**Difference**
Quarter-Mile	41.85	38.15	-3.70
Half-Mile	42.44	37.80	-4.64
Differences	-0.59	0.35	0.94

Table 4: Affordability by Corridor

It was not surprising to find that housing and transportation costs declined for those households living closer to the Denver LRT transit line since travelers self-select to live in TODs "due to habit, personal taste, or happenstance" (Cervero, 1994, p. 177). We do not observe a significant reduction in housing and transportation costs as households reside within a tighter zone of the existing transit line, whereas the effects are also insignificant when compared with the comparable corridor.

6-JOB ACCESSIBILITY

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, jobs-housing imbalance seemed to increase with proximity to the transit line due to the combined effect of loss of jobs and housing. At the half-mile radius of the transit line, the average ratio of workplace to residence was at 5.5:1 (see Table 5), representing a 30% increase from the job-housing balance from the 0.25 mile corridor. This picture reflects the deterioration in employment and residential developments as one gets closer to the LRT line from say a quarter-mile. For example, between 2002 and 2011, moving from the half-mile buffer to a quarter-mile buffer showed employment and residential loss of 96% and 156% respectively. Further, it appears higher income households were living in communities with an above average number of jobs.

Years	LOW			MEDIUM			HIGH			
	Work	Home	Ratio	Work	Home	Ratio	Work	Home	Ratio	Avg
2002	31988	8465	3.78	58647	11698	5.01	68888	8324	8.28	5.60
2003	31008	8026	3.86	54157	11214	4.83	64279	8311	7.73	5.42
2004	28719	7897	3.64	50019	10595	4.72	66882	8974	7.45	5.30
2005	28842	8059	3.58	50154	10979	4.57	69907	9916	7.05	5.14
2006	28515	7871	3.62	48786	11339	4.30	74075	10643	6.96	5.07
2007	27066	7421	3.65	48986	10633	4.61	80482	10720	7.51	5.44
2008	26985	7206	3.74	47410	10605	4.47	74616	11023	6.77	5.17
2009	25589	6851	3.74	46056	10382	4.44	84748	11815	7.17	5.38
2010	24897	6353	3.92	44394	10097	4.40	86825	12010	7.23	5.49
2011	25421	6269	4.06	44302	9722	4.56	87470	12380	7.07	5.54

Table 5: Jobs-housing balance for income categories

Clearly, proximity to transit had negative 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. A careful scrutiny of these changes across the corridors revealed uneven developments. While locating closer to transit in 2000 and 2011 had a negative effect on incomes, the contrary was the case in 2009. This was primary as a result of the substantial income gains in 2009 existing corridors as opposed to heavy losses in 2000 and 2011.

Buffer	Comparable			Existing			Differences		
	2000	**2009**	**2011**	**2000**	**2009**	**2011**	**2000**	**2009**	**2011**
Quarter-Mile	58839	53276	52772	46399	46495	45304	-12440	-6781	-7468
Half-Mile	59294	54754	53540	48411	45735	46776	-10882	-9019	-6764
Differences	-455	-1478	-768	-2012	760	-1472	-1558	2238	-704

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 markedly better for those within any buffer zone around the existing transit corridor. However, employment accessibility does not necessarily improve as we move from the quarter-mile buffer to the half-mile buffer. Analyzing the difference between the half-mile versus quarter-mile buffer and then the difference between the existing corridor and the comparable corridor shows that being located closer to the LRT line improves employment accessibility by about 22%.

Buffer	2010		
	Comparable	**Existing**	**Difference**
Quarter-Mile	58038	109444	51406
Half-Mile	60947	103164	42217
Differences	-2909	6280	9189

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 poor; and (3) higher job accessibility. From these findings, it is possible to conclude that although transit access was associated with higher job accessibility, the jobs that became accessible as a result of the transit line were not paying enough to either attract higher income households or lift the poor into the median income range.

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

- Most attractive: Utilities, Professional
- Least attractive: Transportation, Education and Health Care

Transit advantage over comparable corridor

- Substantial: Utilities and Information
- Minor: Education, Arts, Entertainment and Recreation

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

Change in transit corridor

- Employment in light rail corridor shrank less than metropolitan area
- Substantial percentage increases: Education and Public Administration
- Substantial percentage reductions: Transportation and Construction

Shift-share analysis – Transit Shift

- Administrative, Education and Finance sectors not only showed positive employment growth that do not follow Denver metropolitan trends, shift-share analysis also shows largest contributions by transit

Transit advantage over comparable corridor

- Transit advantage is strongest for Education and Administrative
- Strong transit disadvantage exists for Public Administration and Information

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: Manufacturing, Health Care and Professional
- Negative signs of resilience: Administrative and Transportation

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 Denver light rail spend a smaller percentage on housing and transportation compared to the comparable corridor
- No significant impacts on affordability 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 increases as household income levels increase. High income households enjoy much higher jobs-housing ratio than other groups.
- Job accessibility has not significantly improved within each income group over the years. Overall job accessibility appears to be slowly increasing since 2006 as a general trend.
- Lower average household income within transit corridor.
- Existing transit corridor provides better job accessibility, although more higher income jobs exist within the corridor, indicating persistent jobs-housing imbalance

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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/