DART Light Rail

Dallas, Texas

Do TOD's Make a Difference?

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

Report Structure

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

2-DATA AND METHODS

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

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

Selection of Treatment corridor

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

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

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

Creation of Comparable Corridors

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

Comparable Corridors Criteria

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

Keeping the comparable corridor in the same metropolitan 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 used was matched.

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

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

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

Data Source and Extent

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

There is a vast difference between TOD, and Transit Adjacent Development (TAD). The latter refers to any development happens to occur within the Transit Station Area (TSA), or 0.5-mile buffer around a fixed guide-way transit station, while the former refers to land uses and built environment characteristics hospitable to transit. This analysis assumes that while the existing development during the year of initial operations (YOIO) may not be TOD, land uses respond to changes in transportation conditions over time, phasing out TAD and replacing it with TOD. On this basis, the TOD is conflated with TSA for the purpose of this analysis.

Data Processing

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

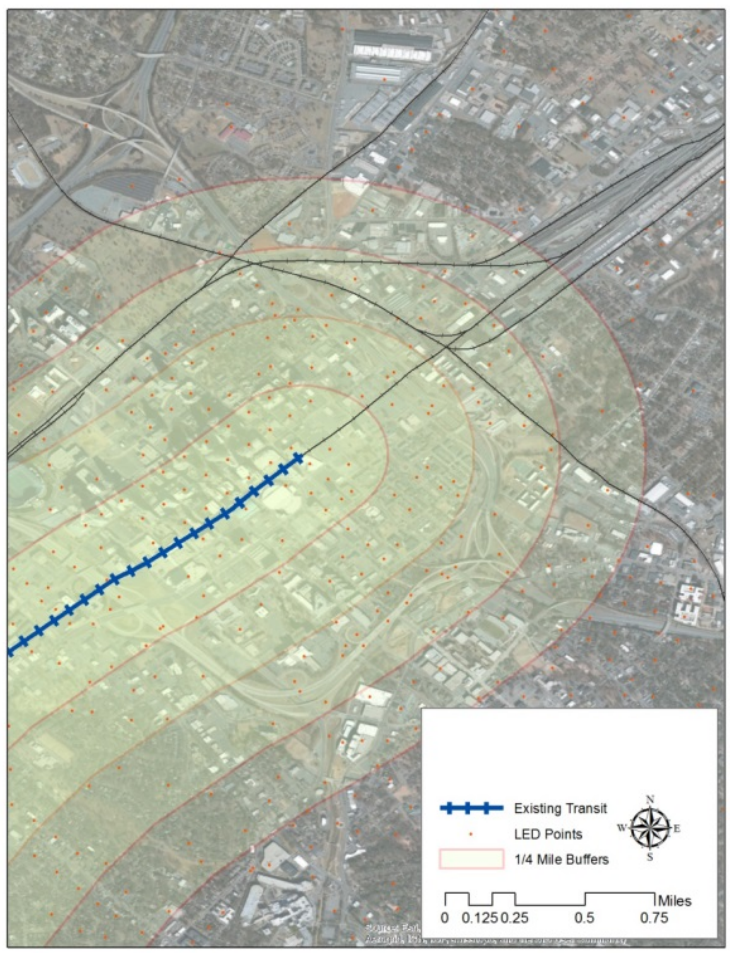

Figure 1: Example corridor, buffers, and LED census block points

Study Area

This study examines the red line of the Dallas DART system. It is a 29.3-mile light rail corridor that travels from Parker Road in Plano to Westmoreland. It opened for service in June 1996. The comparable corridor follows an existing railroad corridor (one of the few not used for later DART lines). Unlike most LRT lines, the DART system initially ran through downtown, rather than using it as a terminus. Figure 2 shows the transit and comparable corridors as well as the location of LED points.

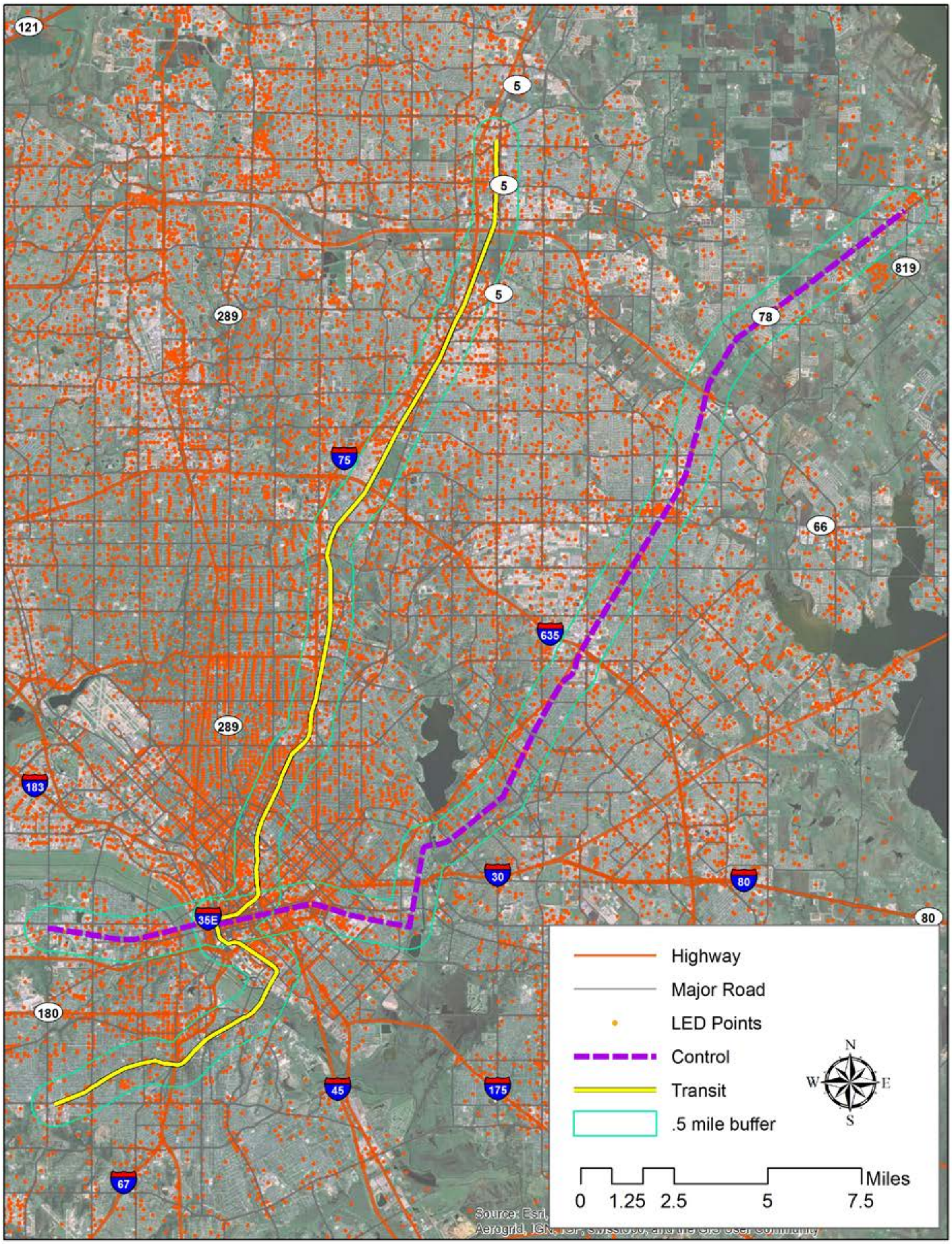

Figure 2: Transit and comparable corridor locations

3-EMPLOYMENT CONCENTRATION

Introduction

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

Data & Methods

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

Results

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

Industry	Location Quotient			Changes
	2002	2002-2011	2011	Δ 2002-2011
Utilities	4.56		3.28	-1.28
Construction	0.57		0.59	0.02
Manufacturing	0.47		0.69	0.22
Wholesale	0.57		0.48	-0.09
Retail	0.62		0.54	-0.08
Transportation	0.40		0.48	0.08
Information	1.49		1.82	0.33
Finance	2.04		1.72	-0.32
Real Estate	0.99		1.16	0.18
Professional	2.08		1.85	-0.24
Management	1.03		0.93	-0.09
Administrative	1.00		0.80	-0.19
Education	1.08		0.98	-0.10
Health Care	0.65		0.83	0.18
Arts, Ent. Rec.	1.37		1.27	-0.10
Lodging & Food	1.00		0.88	-0.13
Other Services	0.89		0.74	-0.14
Public Admin	3.02		3.03	0.01

Table 1: Location quotients comparison for transit corridor

Because the DART line began operations in 1996, the location quotients should already have begun to reflect any impacts from transit in 2002, and those impacts should only become more apparent over time. For the transit corridor, the most significant increases in location quotient occur in the Information industry, followed by the Manufacturing industry. The Health Care and Real Estate industries also realize significant increases in location quotients. In contrast, the location quotient for many industries falls significantly, most notably for Utilities.

Industries with changing location quotients in response to transit should also have a consistent time series trend as they react to enduring conditions in the corridor rather than temporary spikes. The sparklines make it possible to disregard changes in Manufacturing, which spike in 2011. The Information industry displays a far more consistent rising trend, as does Transportation and Health Care. In contrast, Finance, Professional and Administrative all show steady declines.

For both the transit and comparable corridors, changes in location quotient for the time period after the advent of transit are shown in Figure 3. Only some industries benefit from proximity to the transit corridor. Industries that benefit from proximity to transit should experience larger increases in location quotient in the transit corridor than in the comparable corridor. The y-axis is numeric change in location quotient.

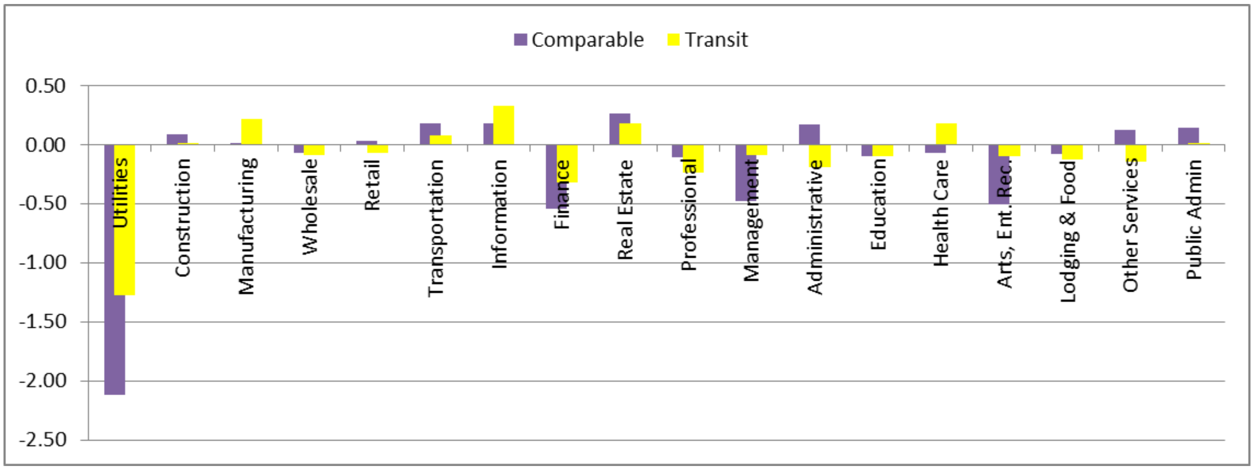

Figure 3: Changes in location quotient by corridor for the time period after the advent of transit

The location quotients for all industries vary significantly by corridor. The location quotient declined for most industries in the transit corridor, but increased strongly for a few corridors. Contrast with the comparable corridor confirms the success of the Manufacturing industry, as well as Information and Health Care, all of which do better in the transit corridor. The relative difference between the two corridors also makes notable the relative success of the Finance, Management, and Arts/Entertainment/Recreation industries in the transit corridor. While they decline in the transit corridor, they decline even more in the comparable corridor. The Utilities industry deserves its own note, for reasons of magnitude. While the Utility industry does extremely poorly inside the transit corridor, it does even more poorly within the comparable corridor.

Discussion & Implications

Attributing causal effect to transit lines is always problematic. Designing successful transit networks is largely a game of connect-the-dots, linking together major employment centers with employee housing along congested corridors. Many stations are co-established with new campuses for major institutions, so increases in the Health Care industry can be explained.

Manufacturing and Transportation employment is associated with low-density industrial land, rather than transit oriented development. More typically, industrial development is displaced by denser, higher value land uses when transit is developed nearby. Closer investigation typically reveals that such uses represent Transit ADJACENT Development rather than Transit ORIENTED Development. The built environment changes slowly.

The rise in the location quotient for Real Estate is curious, as there is no theoretical reason it should respond so positively to transit. It may be merely be a spatial confounder as the transit line runs through downtowns and major commercial real estate offices located in downtowns.

4-EMPLOYMENT GROWTH BY SECTOR

Introduction

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

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

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

Data and Methods

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

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

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

Results

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

NAICS Sector	Metro				Transit Corridor				Sources of Employment Change		
	2002	2011	# Change	% Change	2002	2011	# Change	% Change	Metro Share	Industry Mix Share	Corridor Effect
Utilities	15,917	15,170	(747)	-5%	7,662	4,837	(2,825)	0%	1185	(360)	(3,650)
Construction	148,629	139,104	(9,525)	-6%	9,004	7,963	(1,041)	-12%	1393	(577)	(1,856)
Manufacturing	313,372	270,729	(42,643)	-14%	15,537	18,093	2,556	16%	2403	(2,114)	2,267
Wholesale	164,806	175,777	10,971	7%	9,964	8,276	(1,688)	-17%	1541	663	(3,892)
Retail	322,013	325,424	3,411	1%	20,963	17,103	(3,860)	-18%	3242	222	(7,324)
Transportation	133,245	143,553	10,308	8%	5,571	6,640	1,069	19%	862	431	(224)
Information	110,094	82,816	(27,278)	-25%	17,330	14,631	(2,699)	-16%	2680	(4,294)	(1,085)
Finance	149,416	187,627	38,211	26%	32,157	31,339	(818)	-3%	4973	8,224	(14,015)
Real Estate	59,636	59,017	(619)	-1%	6,213	6,671	458	7%	961	(64)	(438)
Professional	160,038	208,993	48,955	31%	35,186	37,515	2,329	7%	5442	10,763	(13,876)
Management	14,625	36,703	22,078	151%	1,585	3,329	1,744	110%	245	2,393	(894)
Administrative	178,352	232,470	54,118	30%	18,755	18,156	(599)	-3%	2901	5,691	(9,190)
Education	195,500	270,521	75,021	38%	22,331	25,722	3,391	15%	3454	8,569	(8,632)
Health Care	228,404	336,137	107,733	47%	15,607	27,071	11,464	73%	2414	7,361	1,689
Arts, Ent. Rec.	35,158	42,586	7,428	21%	5,075	5,265	190	4%	785	1,072	(1,667)
Lodging & Food	199,663	250,556	50,893	25%	21,184	21,410	226	1%	3276	5,400	(8,450)
Other Services	76,795	82,370	5,575	7%	7,184	5,958	(1,226)	-17%	1111	522	(2,859)
Public Admin	53,118	86,050	32,932	62%	16,954	25,375	8,421	50%	2622	10,511	(4,712)
Total	**2,558,781**	**2,945,603**	**386,822**	**15%**	**268,262**	**285,354**	**17,092**	**6%**	**41,488**	**54,413**	**(78,809)**

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

The entire metropolitan area enjoys an increase in employment of 15 percent. The transit corridor does half as well, with an increase in employment of about 6 percent. This still represents an increase of over 17,000 jobs. In numeric terms, the Health Care industry enjoys the largest increase, followed by Public Administration and then Education, together adding about 23,000 jobs. In addition, Health Care enjoys a substantial percent increase. The other industries with notable percent increases are Management and Public Administration. Numerous industries experience dramatic changes in employment, losing thousands of jobs, representing double-digit changes in employment.

After using Shift-Share analysis to disaggregate the cause of change in employment, different patterns emerge. The industry mix in the corridor is the major driver of employment growth, although the corridor enjoys the benefits of general metropolitan growth as well. But the negative corridor effect is very large. The corridor effect has its only positive effect for the Health Care industry. Other industries that appear to suffer especially from the corridor effect are the Finance and Professional industries.

Information about the corridor effect is presented for both the transit and comparable corridor in Table 3. Differences between the corridors are also presented. It is intended to confirm that the corridor effects attributed to transit are specific to the transit corridor, and not the result of another effect. The 'Corridor Benefit' relates the change in employment totals to the Corridor Effect. It is calculated as the corridor effect divided by the absolute value of employment change. A value of 1 indicates that almost all the change can be attributed to the corridor effect, while a value of 0 means that the corridor has almost no effect.

Industry	Comparable			Transit			Transit Advantage		
	# Change	Corridor Effect	Corridor Benefit	# Change	Corridor Effect	Corridor Benefit	Difference, # Change	Difference, Corridor Effect	Difference, Corridor Benefit
Utilities	-2920	-3753	-1.3	-2825	-3650	-1.3	95	103	0.0
Construction	-473	-1077	-2.3	-1041	-1856	-1.8	-568	-779	0.5
Manufacturing	-1846	-2013	-1.1	2556	2267	0.9	4402	4280	2.0
Wholesale	-972	-2056	-2.1	-1688	-3892	-2.3	-716	-1837	-0.2
Retail	-198	-1538	-7.8	-3860	-7324	-1.9	-3662	-5786	5.9
Transportation	1119	-404	-0.4	1069	-224	-0.2	-50	181	0.2
Information	-2427	-1519	-0.6	-2699	-1085	-0.4	-272	434	0.2
Finance	-3582	-10358	-2.9	-818	-14015	-17.1	2764	-3657	-14.2
Real Estate	532	144	0.3	458	-438	-1.0	-74	-582	-1.2
Professional	1515	-6365	-4.2	2329	-13876	-6.0	814	-7511	-1.8
Management	223	-1366	-6.1	1744	-894	-0.5	1521	473	5.6
Administrative	3290	-43	0.0	-599	-9190	-15.3	-3889	-9147	-15.3
Education	1151	-4979	-4.3	3391	-8632	-2.5	2240	-3653	1.8
Health Care	3268	-5838	-1.8	11464	1689	0.1	8196	7527	1.9
Arts, Ent. Rec.	-880	-2235	-2.5	190	-1667	-8.8	1070	568	-6.2
Lodging & Food	-29	-3753	-129.4	226	-8450	-37.4	255	-4697	
Other Services	384	-503	-1.3	-1226	-2859	-2.3	-1610	-2356	-1.0
Public Admin	7384	-4370	-0.6	8421	-4712	-0.6	1037	-343	0.0
Total	**5539**	**-52025**	**na**	**17092**	**-78809**	**na**	**11553**	**-26784**	**na**

Table 3: Shifts by corridor and comparison between corridors

That the corridor effect is specific to transit can be discerned by contrasts with the comparable corridor. The corridor benefit aids in comparison by providing a metric that is independent of the magnitude of employment. The corridor effect is provided for both as a reference. The corridor benefit for the transit corridor is positive only for the Manufacturing industry. Contrast with the comparable corridor mitigates the status of the transit corridor somewhat. While the corridor effect is negative for Manufacturing and Health Care, it is less negative for the comparable corridor. Differences in the corridor benefit show the same relationship for the Retail and Management industries.

Discussion & Implications

The Health Care and Education industries have been mainstays of not only urban redevelopment, but also of new transit lines. While it has long been theorized that retail and office development are transit oriented, empirical evidence suggests that this is incorrect. Rather, the main beneficiaries of transit oriented development appear to be campus style developments, such as hospitals and schools. Entertainment venues are also (erratically) big winners for proximity to transit. In effect, every land use characterized by high parking ratios, and thus big parking lots, is attracted to transit. Transit not only enables such uses to manage peak loads for parking, it reduces their land costs, and makes it possible to locate in central urban locations. Retail appears to be an exception to this rule. Retail is not commonly thought of as low density, but even in dense urban environments, multistory retail is rare. Even in great pedestrian environments, with every block face wrapped in retail, the density of retail fails to compare with that of a mid-rise office building. Contrary to planning lore, retail may not be compatible with transit.

5-EMPLOYMENT RESILIENCE

Introduction

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

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

Data and Methods

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

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

Results

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

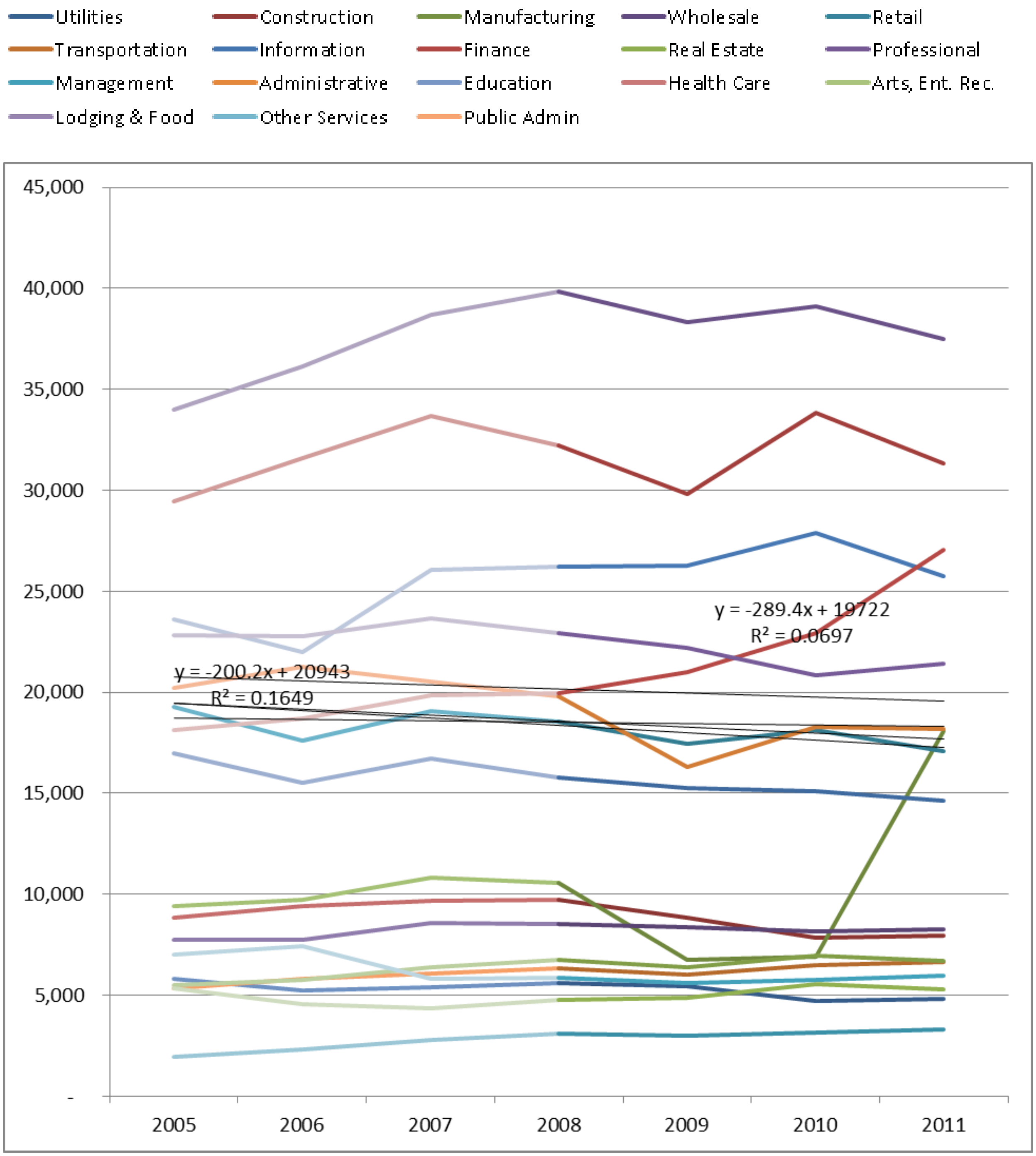

Figure 4: Regression trend lines and R-squared values for different industries

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

Resilience by industry is presented in Table 4. It highlights the resilience of different industries between 2002-2008 and 2008-2011. The trend number is the linear regression line on industry employment over time. Trend indicates whether total employment increases or decreases during each time period. A negative trend indicates sustained loss of employment while a positive trend indicates a sustained gain. The trend number is the slope of the regression line. However, industries with larger total employment will have larger slopes. To normalize trend numbers for comparison between industries, the trend percent is presented. It is calculated by dividing the trend number for a time period by the average employment for that period. Finally, the R^2 column indicates how strong a trend is. Industry sectors with a high R^2 demonstrate robust trends—trends in employment change that are consistent over time with less tendency to fluctuate.

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

Industry	2005-2008			2008-2011			Differences		
	Trend #	Trend %	R2	Trend #	Trend %	R2	Trend #	Trend %	R2
Utilities	-51	-1%	0.07	-301	-6%	0.77	-251	-5%	0.70
Construction	291	3%	0.89	-629	-7%	0.86	-920	-10%	-0.04
Manufacturing	456	4%	0.76	2270	21%	0.31	1814	17%	-0.46
Wholesale	318	4%	0.78	-86	-1%	0.66	-404	-5%	-0.12
Retail	-72	0%	0.02	-367	-2%	0.53	-295	-2%	0.52
Transportation	333	6%	0.99	135	2%	0.41	-198	-4%	-0.58
Information	-253	-2%	0.21	-352	-2%	0.96	-99	-1%	0.74
Finance	1027	3%	0.58	148	0%	0.01	-879	-3%	-0.57
Real Estate	452	7%	0.98	26	0%	0.02	-426	-7%	-0.96
Professional	2007	5%	0.98	-619	-2%	0.63	-2626	-7%	-0.35
Management	393	16%	0.99	84	3%	0.66	-310	-13%	-0.33
Administrative	-200	-1%	0.16	-289	-2%	0.07	-89	-1%	-0.10
Education	1182	5%	0.56	17	0%	0.00	-1165	-5%	-0.56
Health Care	664	3%	0.93	2321	10%	0.91	1657	7%	-0.01
Arts, Ent. Rec.	-193	-4%	0.34	211	4%	0.58	404	8%	0.24
Lodging & Food	108	0%	0.12	-584	-3%	0.70	-692	-3%	0.59
Other Services	-498	-8%	0.64	38	1%	0.11	536	8%	-0.53
Public Admin	1914	12%	0.80	2829	13%	0.74	915	1%	-0.06
Total	8087	3%	0.86	4703	2%	0.33	-3385	-1%	-0.53

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

Prior to 2008, only a few industries had falling employment. The Professional and Public Administration industries were growing, while the Management industry posted large percent increases.

During the 2008 to 2011 period, many industries had falling employment, but a number of industries continued to have strong positive trends. Numerically, the Health Care, Public Administration and Manufacturing industries all had positive employment trends. All three industries also had strong positive Trend %, and Health Care had a very strong R^2 value.

Difference between the pre- and post- recessionary periods should reveal which industries are resilient. Resilient industries should have positive trends for both periods. By this criterion, very few industries are resilient, with the notable exception of the Health Care and Manufacturing industries.

In addition to resilient industries, there are industries that are emergent. They represent a phase shift or transition away from pre-recession industrial ecology and toward a new and different one. Emergent industries are characterized by flat or falling trends prior to the recession, but large positive trends following the recession. Only the Other Service industry fits this pattern.

Comparing R^2 values of different industries before and after the Great Recession makes it possible to determine the consistency of trends. Trend numbers represent a line fitted to the data points, an averaging value of sorts, which only track general trends. R^2 is a kind of meta-measure of that measure. It indicates that the trend consistency declines for all industries with positive growth rates before and after the recession, indicating erratic trends.

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

Industry	Differences						Differences in Differences		
	Transit			Comparable					
	Trend #	Trend %	R2	Trend #	Trend %	R2	Trend #	Trend %	R2
Utilities	-251	-5%	0.70	-529	-11%	-0.42	278	6%	1.13
Construction	-920	-10%	-0.04	-704	-10%	0.03	-215	0%	-0.07
Manufacturing	1814	17%	-0.46	-778	-10%	-0.01	2592	27%	-0.45
Wholesale	-404	-5%	-0.12	-363	-9%	-0.04	-41	4%	-0.08
Retail	-295	-2%	0.52	66	0%	-0.60	-361	-2%	1.12
Transportation	-198	-4%	-0.58	-462	-6%	-0.95	264	3%	0.37
Information	-99	-1%	0.74	301	3%	-0.39	-400	-4%	1.13
Finance	-879	-3%	-0.57	-1028	-7%	-0.02	148	5%	-0.55
Real Estate	-426	-7%	-0.96	-16	-1%	-0.09	-410	-6%	-0.87
Professional	-2626	-7%	-0.35	-11	0%	-0.42	-2614	-7%	0.06
Management	-310	-13%	-0.33	-441	-37%	0.14	131	24%	-0.47
Administrative	-89	-1%	-0.10	713	7%	0.22	-802	-8%	-0.31
Education	-1165	-5%	-0.56	120	1%	-0.40	-1286	-6%	-0.16
Health Care	1657	7%	-0.01	245	1%	-0.23	1412	6%	0.22
Arts, Ent. Rec.	404	8%	0.24	337	12%	-0.24	66	-4%	0.49
Lodging & Food	-692	-3%	0.59	-48	-1%	0.05	-644	-3%	0.54
Other Services	536	8%	-0.53	84	2%	0.35	453	6%	-0.88
Public Admin	915	1%	-0.06	697	0%	-0.08	218	1%	0.02
Total	-3385	-1%	-0.53	-1870	-1%	-0.62	-1515	0%	0.09

Table 5: Comparison of resilience by corridor

Comparison of the two corridors suggests that the transit corridor is significantly less resilient than the comparable corridor overall, suffering much worse as a result of the Great Recession. However, the transit corridor has the advantage in a large number of industries. The Manufacturing and Management industries do much better in the transit corridor, as does Health Care. The comparable corridor also highlights the Other Services industry as doing atypically well.

Discussion & Implications

Trend comparisons aside, the time series data of resilient industries should have a characteristic profile after the recession: U-shaped, with a decline followed by a recovery. Examining the chart of regression trend lines is very helpful, but regardless of overall trends, resilient industries are immediately visible.

The Great Recession hit different places at different times, and the effects have lasted longer in some places than in others. Contrary to expectations, 2008 is rarely the nadir in employment. For some industries, the nadir occurs in 2009 even 2010. Industries that declined in 2007-2008 were doomed to decline from 2008-2009. They might be deemed 'Fragile' industries. Against the slightest headwind, they collapse. A 2008-2009 positive trend was often a conflicted indicator. Most industries with one did badly from 2009 to 2010, indicating an industry specific recovery phasing broader economic headwinds. Curiously, a 2007 inflection point is actually a good sign. It may be that for such industries, the deadwood has been pruned before being battered by the Great Recession. Industries with uniform positive trends for post-recessionary periods are rare, and often have static employment.

There are, of course, regional and industry specific patterns. Typically, industries dependent on public funding lag the rest of the economy by a year. Funded by tax receipts, cutbacks occur only in the year after, as data about the previous year’s economic performance affect budgeting.

Savaged by the Great Recession, employment in most industries declined between 2008 and 2011. Not all industries recovered equally, however, and neither overall economic performance nor pre-recessionary trends for the metro provide guidance for the success of any particular industry.

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 and 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 0.5-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.

Resilience is a poorly understood and poorly operationalized concept. Measurement attempts remain ad-hoc. 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. Employment level is likely the stronger standard. For national recessions, the number of months it takes a nation to return to a pre-recessionary level of GDP is a gauge of the resilience of the economy. Applying a similar measure to most industries is difficult, as employment in many had not recovered to pre-recessionary levels in 2011. Extrapolating post-recessionary trends would make it possible to estimate the date of return, but with some uncertainty. An evaluation of resilience, however, requires employment loss for this approach, and some industries fail to decline. These industries are robust, and an effective metric for resilience would need to be able to detect both as positive outcomes.

Equal or better trends after the recession are also a bit of a red herring. Many industries do ‘less badly’ after the Great Recession, without doing well in any meaningful way. A positive post-recessionary trend is an unmitigated good, and highlights yet another outcome of the economic shock delivered by the Great Recession: Industries doing very badly suddenly doing much better. As conditions shift, creative destruction in some industries clears the way for growth in different industries.

Contrary to expectations, a high R^2 value for the post recessionary period is actually a conflicted indicator—consistently declining industries have high R^2 values, while the ideal U-shaped pattern in total employment associated with resilience is characterized by a very low R^2 value.

6-HOUSING AFFORDABILITY

Introduction

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

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

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

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

Data and Methods

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

Data Source and Geography

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

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

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

Data Processing

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

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

Results

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

1. Housing, Transportation, and H+T dollar costs for the transit corridor
2. Change in H+T costs for transit corridors
3. Change in H+T costs for transit and comparable corridors

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

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

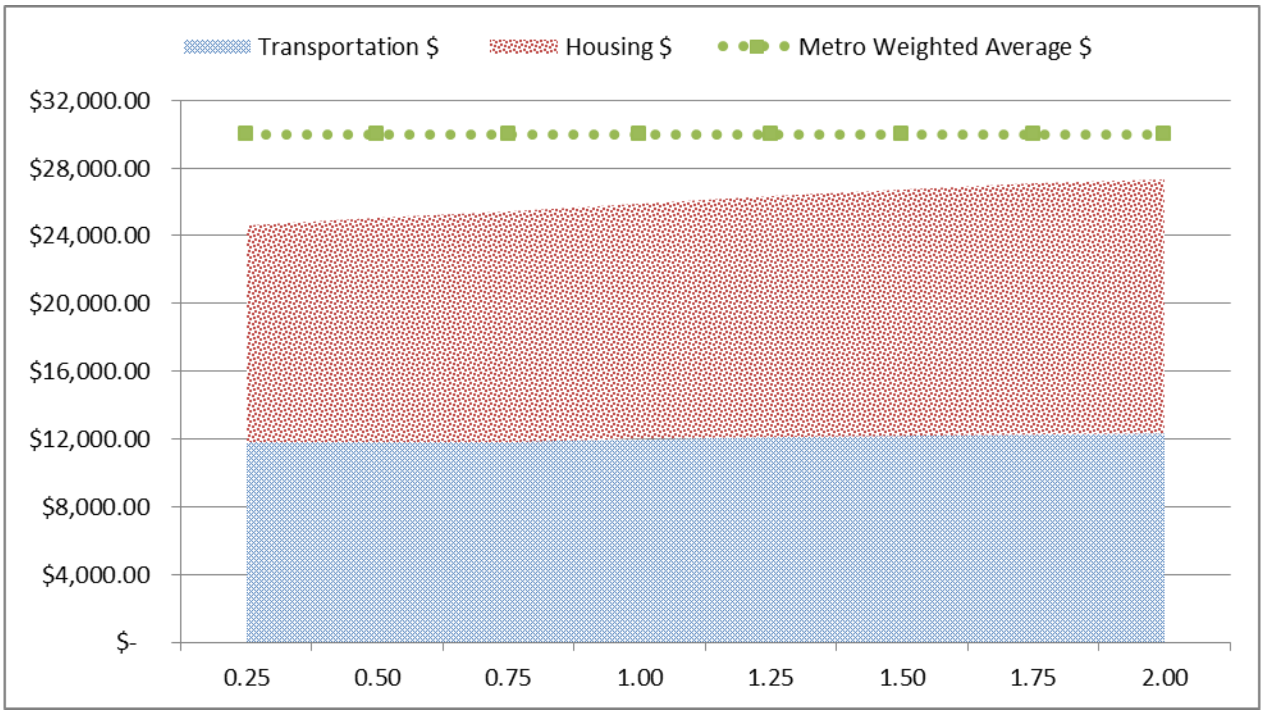

Figure 5: Housing, transportation, and H+T costs for the transit corridor, 2009, by buffer distance

As the above graph shows, H+T costs near the transit line are lower than the metropolitan average. Housing costs are lower nearer to the transit line. Differences in transit costs are slightly lower nearer the transit corridor.

Percentage point changes in housing, transportation, and H+T costs are shown below in Figure 6. The changes represent the difference in the percentage of income calculated to be necessary for housing and transportation expenditures. A stacked graph has been used to display the disaggregated effects of housing and transportation on H+T affordability. The vertical axis shows the change in percentage points needed to meet housing and transportation costs. The horizontal axis shows how the total varies by buffer distance from the transit corridor. The time series analysis is intended to show if changes in H+T cost respond to proximity to transit.

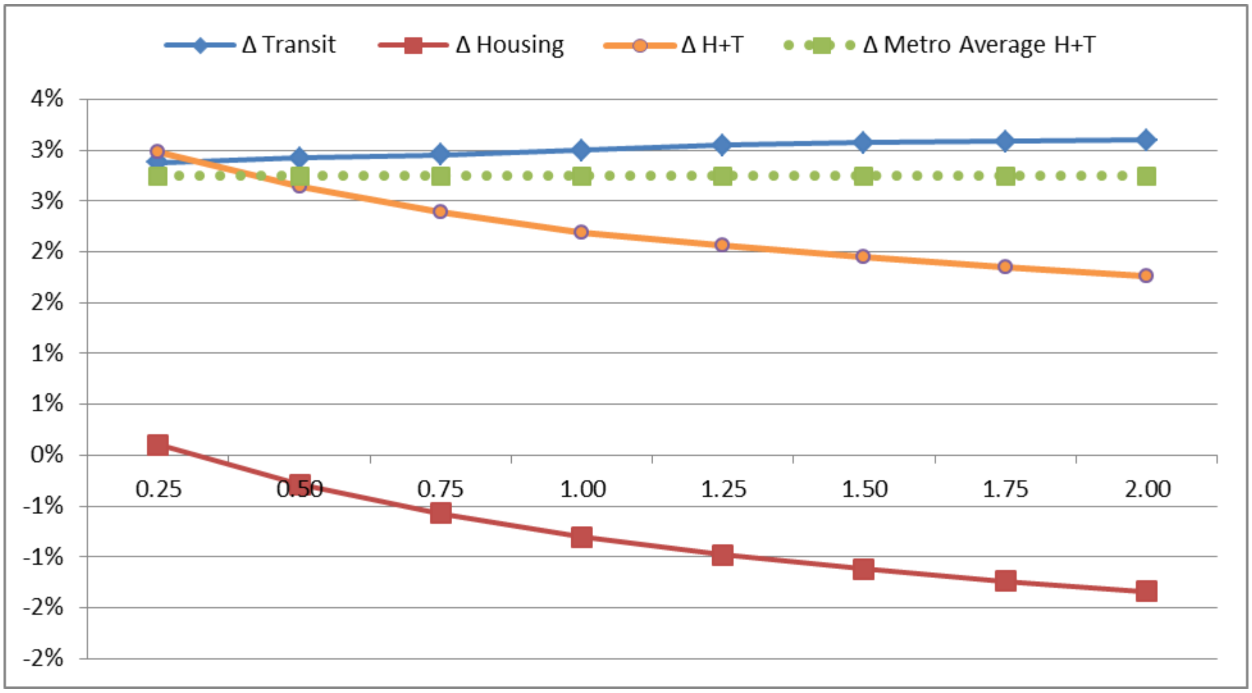

Figure 6: Change in housing and transportation costs, 2000-2009, for transit corridor, by buffer distance

The changes in H+T costs for the transit corridor are notably dissimilar to the metropolitan area average. Changes in H+T costs vary with distance to the transit corridor. Changes in the transportation costs in the transit corridor are larger than changes in housing costs, but still vary significantly with distance from the transit corridor by a fraction of a percent. Changes in housing costs display a consistent pattern in relation to proximity to the transit corridor. While housing costs actually fall for the transit line, they fall the least with proximity to the transit line. The changes in housing costs near the transit corridor are not fully offset by the difference in transportation costs, so H+T costs for the transit corridor increase more with proximity to the corridor.

Percentage point changes in housing, transportation, and H+T costs for the transit corridor, comparable corridor, and metro area are shown below in Figure 7. The vertical axis shows the change in percentage points needed to meet housing and transportation costs. The horizontal axis shows how the total varies by buffer distance from the transit corridor.

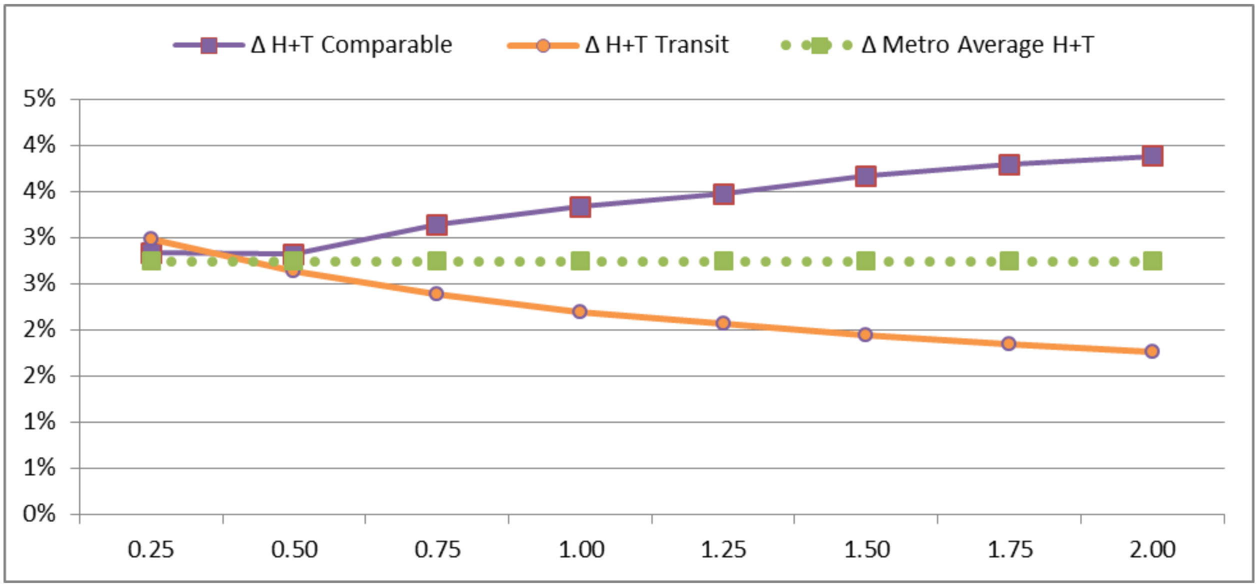

Figure 7: Changes in H+T, 2000-2009, for transit and comparable corridors, by buffer distance

The transit and comparable corridors display significantly different patterns in changes in H+T costs, so much so that the comparable corridor is almost the reverse of the transit corridor. For the transit corridor, H+T costs increase more with proximity to the transit corridor. For the comparable corridor, the reverse is true, so the increase in H+T costs is greatest furthest from the corridor. This suggests that the comparable corridor is burdened by some kind of nuisance effect.

Discussion & Implications

These results are incredibly exciting, as they confirm two theoretical assumptions about transit. Theoretically, the value of the additional accessibility generated by proximity to transit should be capitalized into property value, resulting in rising housing costs. The strongest response to transit should be in the areas closest to the transit station. The pattern of increases in housing costs matches this relationship. The increases in housing costs are greatest near the transit line. The cause of the increase can be attributed to rising housing costs suggesting that the value of the accessibility provided by the DART light rail is being capitalized into housing values. This can be partially explained by congestion in the Dallas metropolitan area, which is already some of the worst in the nation, and is predicted to worsen. Access to faster, cheaper and more reliable rapid transit becomes thereby more valuable.

The value of reliability is often understated. The primary transit market is typically thought of as low-income transit dependent households. But for rapid transit, there exists a second distinct market of workers with high enough incomes to both afford cars and access to desirable transit proximate locations, as an alternate if conditions favor its use. Rapid transit is less prone to delay from weather, accidents, or congestion. Travel time along a freeway corridor varies radically by conditions and by time of day. Many of the most congested corridors are barely sub-critical—even minor disruptions in traffic flow can trigger gridlock.

This suggests that rather than improving housing affordability, transit actually impair its. While this has been empirically demonstrated repeatedly, the extended hypothesis has been that reductions in transportation costs actually offset the increase in housing case. Evidence from DART suggests that while transportation costs do respond to proximity to the light rail, the effect is insufficient to counter the increase in housing values.

The continued rise in housing prices above the value of transportation costs can be explained by household and housing lifecycles. The effect of increasing H+T costs is compounded by tenure type. Housing affordability issues are most severe in locations where renting is the primary form of tenure. Renters, unlike owners, are not insulated against increases in housing costs. Rental tenure in America is characterized by short leases, so increases in property value can rapidly be capitalized into higher rents. Rising rents increase housing costs, resulting in the displacement of previous tenants, who are no longer able to afford the higher rents. In contrast, mortgage payments are fixed upon purchase, so that current homeowners are largely isolated from the effects of increases in housing costs. The primary cause of declining affordability for existing homeowners is increasing property taxes, of which homeowners pay only a fraction of the increase in value.

The percent of homeowners also acts to confound actual housing affordability conditions. In the past decade, the appreciation in home value has outstripped appreciation in wages so that many current homeowners could no longer afford to buy their own homes. While they are affordable for the current owners, their appreciated value makes them less affordable to prospective owners. Over time, this compounds housing affordability issues. Lower housing affordability means that fewer households are able to become homeowners, and must remain renters. Thus, they remain vulnerable to further increases in housing costs. As rents rise, so does the premium associated with home ownership, so that households are willing to pay more for property. Cities with high monthly rents also have high property prices for a reason.

Policy intervention is necessary to ensure that housing locations near transit stations remain affordable. Without measures to maintain housing affordability, areas around transit stations will see the displacement of low-income renters in favor of medium-income owners. There is a strong negative relationship between income and transit ridership, as low-income households are more likely to be transit dependent, so this process acts to reduce transit ridership. Changes in the distribution of tenure will also reduce the benefits of self-selection. Households locating near transit self-select for proximity to transit, and are thus the types of households most likely to make use of transit.

Over time, as household characteristics, such as place of work and size of household change, the utility of proximity to transit changes. A single person household is extremely likely to be able to make use of transit, while a two-worker family household is less likely to be able to do so. Unable to make use of transit, such households would then require multiple vehicles, resulting in transportation costs in line with the metropolitan norm. In a worst-case scenario, housing units around transit stations are owned by non-transit using households and yet suffer from higher average housing costs. In contrast, households in rental tenure are more likely to relocate in response to changing conditions, so that even if housing costs rise, transit ridership suffers less.

Long term, ensuring a supply of affordable transit oriented housing near stations will require policy intervention. The amount of affordable housing that is constructed is minimal. Most affordable housing results from the depreciation of former medium income housing. Constructing new housing as infill development requires higher density housing than the surrounding urban fabric, because the land value has increased in the interval since the initial development of the area. Constructing new affordable housing requires higher densities, due to the lower return per unit. In combination with parking requirements, new affordable housing is required to 'go vertical' to achieve sufficient density.

Reducing or eliminating parking minimums near transit stations would be an effective policy. Reduced parking would lower per-unit cost of new affordable housing, and reduce the tendency to convert affordable transit oriented rental units to unaffordable transit indifferent owner-occupied units.

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. TOD is based on the premise that locating housing and employment in close proximity to transit stations will significantly enhance the accessibility of those locations. Because each transit line connects multiple stations, it creates a Transit Oriented Corridor (TOC) where people can live or work near any station and use the rapid transit system to access destinations at any other station along the corridor. Therefore, transit oriented development should significantly enhance employment accessibility along the corridor.

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

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

Data & Methods

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

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

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

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

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

Results

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

Overall Balance

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

Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	2,576	2,457	1.05	157.4	40.1	3.92	0.00	272.0	58.4	4.65	0.00	2002
2003	2,544	2,428	1.05	150.5	39.9	3.77	-0.16	259.4	55.7	4.66	0.00	2003
2004	2,580	2,473	1.04	148.2	38.3	3.87	0.10	258.7	54.9	4.72	0.06	2004
2005	2,653	2,572	1.03	143.8	40.1	3.59	-0.28	257.7	58.1	4.43	-0.28	2005
2006	2,761	2,677	1.03	149.4	41.8	3.57	-0.02	264.1	60.9	4.34	-0.09	2006
2007	2,843	2,763	1.03	157.1	42.7	3.68	0.11	280.3	60.1	4.66	0.32	2007
2008	2,918	2,821	1.03	157.1	43.2	3.64	-0.04	279.2	60.3	4.63	-0.03	2008
2009	2,855	2,758	1.04	146.8	43.9	3.34	-0.29	264.0	59.4	4.44	-0.19	2009
2010	2,871	2,768	1.04	161.7	44.4	3.65	0.30	281.5	59.1	4.76	0.32	2010
2011	2,974	2,865	1.04	161.8	38.8	4.18	0.53	289	60.3	4.79	0.03	2011
Trend												Trend

Table 6: Jobs-housing balance for all income categories

The overall jobs-housing ratio for both the comparable and transit corridors is job-rich. The transit corridor has 4 to 5 times as many jobs per worker than the metropolitan area. Because the DART line began operations in 1996, the jobs-housing ratio should already have begun reflect any impacts from transit in 2002, and those impacts should only become more apparent over time. Instead of a general movement toward parity, what the corridor shows is enormous constancy. The jobs-housing ratio never varies significantly. At its high it is 4.79, which is about 0.45 from its low of 4.34. But both the number of workers working and living in the corridor are very constant.

Even in the depths of the Great Recession, the change in either is never more than a few percentage points to the total. The number of workers residing in the corridor is also extremely stable, more so even then the number of employees. The pattern for other metro areas has been declines in the number of workers in the corridor being tracked by the number of workers living in the corridor, but lagged by a year.

Part of this stability is the result of the length of the corridor (almost 30 miles) and its location—not only does it reach downtown, but passes through, so it picks up central business district adjacent development for a substantial portion of the line. With a larger geography, changes along one part of the corridor are offset elsewhere.

The comparable corridor has a smaller number of jobs, and a much larger overall variance in the jobs-housing ratio. Most tellingly, however, is that the fluctuation in the number of workers living in the corridor, which declines sharply in 2011. Successful transit corridors with walk access to transit should lose workers in the corridor.

Income Balance

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

Low Income

Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	680	639	1.06	29.7	10.9	2.71	0.00	57.9	14.9	3.87	0.00	2002
2003	654	614	1.07	27.2	10.4	2.63	-0.08	55.4	13.9	3.98	0.11	2003
2004	657	620	1.06	27.4	10.0	2.75	0.12	56.6	13.6	4.17	0.18	2004
2005	667	642	1.04	26.5	10.3	2.58	-0.18	55.8	14.4	3.88	-0.28	2005
2006	683	656	1.04	25.1	10.4	2.42	-0.15	54.5	14.5	3.76	-0.13	2006
2007	682	656	1.04	26.2	10.3	2.54	0.12	54.7	13.9	3.93	0.17	2007
2008	676	647	1.05	25.6	10.1	2.54	0.00	52.4	13.3	3.93	0.00	2008
2009	649	619	1.05	22.6	10.4	2.18	-0.36	48.0	12.6	3.82	-0.10	2009
2010	621	595	1.04	23.0	9.8	2.34	0.16	48.1	12.1	3.98	0.16	2010
2011	640	619	1.03	22.9	8.5	2.68	0.35	46.1	12.2	3.77	-0.22	2011
Trend												Trend

Medium Income

Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	1,056	1,006	1.05	6.1	17.8	0.34	0.00	97.1	25.4	3.83	0.00	2002
2003	1,034	987	1.05	5.8	17.4	0.33	-0.01	91.8	24.2	3.79	-0.03	2003
2004	1,027	983	1.04	5.6	16.3	0.34	0.01	90.4	23.0	3.93	0.14	2004
2005	1,035	1,002	1.03	5.2	16.6	0.31	-0.03	85.9	23.7	3.63	-0.31	2005
2006	1,033	1,000	1.03	5.2	16.8	0.31	-0.01	86.9	23.9	3.63	0.01	2006
2007	1,041	1,008	1.03	5.2	16.8	0.31	0.00	88.5	22.5	3.94	0.31	2007
2008	1,046	1,007	1.04	5.0	16.6	0.30	-0.01	84.5	21.8	3.87	-0.07	2008
2009	1,030	991	1.04	4.7	17.0	0.27	-0.03	80.8	21.4	3.77	-0.10	2009
2010	1,014	970	1.05	4.9	16.6	0.30	0.02	81.9	21.0	3.91	0.14	2010
2011	1,033	987	1.05	4.81	14.39	0.33	0.04	80.8	20.6	3.92	0.01	2011
Trend												Trend

High Income

Year	Metro			Comparable				Transit				Year
	Work, 000's	Home, 000's	Jobs-Housing Ratio	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	Work, 000's	Home, 000's	Jobs-Housing Ratio	Year on Year Change	
2002	840	811	1.04	66.6	11.4	5.83	0.00	117.0	18.1	6.46	0.00	2002
2003	855	826	1.04	65.3	12.1	5.38	-0.45	112.1	17.6	6.37	-0.08	2003
2004	896	870	1.03	64.7	12.0	5.39	0.01	111.8	18.3	6.11	-0.26	2004
2005	952	928	1.03	65.4	13.2	4.95	-0.44	116.0	20.1	5.78	-0.33	2005
2006	1,045	1,021	1.02	72.6	14.7	4.93	-0.02	122.7	22.4	5.47	-0.31	2006
2007	1,121	1,099	1.02	78.9	15.6	5.05	0.12	137.1	23.7	5.78	0.31	2007
2008	1,196	1,167	1.02	81.3	16.6	4.91	-0.14	142.3	25.1	5.66	-0.11	2008
2009	1,177	1,149	1.02	77.5	16.5	4.70	-0.21	135.3	25.4	5.32	-0.34	2009
2010	1,236	1,203	1.03	89.7	17.9	5.00	0.30	151.5	26.1	5.81	0.49	2010
2011	1,302	1,259	1.03	90.8	15.8	5.74	0.74	162.2	27.5	5.90	0.09	2011
Trend												Trend

Table 7: Jobs-housing balance by income category

The transit corridor is job-rich for all three income categories, but particularly for high-income, where it has 5 to 6 times as many workers as working residents. The ratio is lower for medium-income and low-income workers. The trends for low-income and high-income workers are notably different from those in the metropolitan area. While the sparkline for the jobs-housing ratio for the metropolitan for low-income workers shows a bulge, the transit corridor shows a steady decline. The same is true for medium-income workers.

The sparkline for low-income workers in the transit corridor displays the same constancy as the metropolitan area as a whole, with low variance in the jobs-housing ratio and small year on year-on-year changes. For low-income workers, the corridor is job-rich, with 3 to 4 times as many workers with job as workers with homes. The general trend in the jobs-housing ratio is slightly downward. The sparkline for medium-income workers in the transit corridor displays the same constancy as the metropolitan area as a whole, with low variance in the jobs-housing ratio and small year on year-on-year changes. The general trend is flat or slightly rising. Reductions in both the number of workers in the corridor and number of workers with homes in the corridor contribute to this outcome. In contrast, the sparkline for high-income workers in the corridor is much less consistent, despite the higher number of overall workers. It shows the same decline toward parity with the metropolitan area, but as a result of a rising number of workers with homes in the corridor.

Industry Balance

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

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

Industry	Comparable 2002	Comparable 2002 to 2011	Comparable 2011	Transit 2002	Transit 2002 to 2011	Transit 2011	# Change	% Change
Utilities	26.14		22.83	17.82		17.34	-0.48	-3%
Construction	2.45		3.21	3.07		3.32	0.25	8%
Manufacturing	1.87		2.13	3.09		4.63	1.54	50%
Wholesale	2.20		1.89	3.22		2.76	-0.46	-14%
Retail	1.77		1.95	3.47		2.97	-0.50	-14%
Transportation	4.82		5.59	2.90		3.19	0.28	10%
Information	6.02		6.51	6.08		7.70	1.62	27%
Finance	6.53		5.29	7.16		6.70	-0.46	-6%
Real Estate	2.66		3.55	3.70		4.25	0.55	15%
Professional	6.12		6.06	6.30		6.25	-0.05	-1%
Management	3.90		2.78	3.42		4.11	0.70	20%
Administrative	2.46		3.20	4.10		3.45	-0.65	-16%
Education	4.08		3.82	4.84		4.62	-0.22	-5%
Health Care	3.87		3.84	3.08		3.87	0.78	25%
Arts, Ent. Rec.	6.44		5.08	6.14		6.39	0.25	4%
Lodging & Food	2.85		2.63	4.19		3.91	-0.28	-7%
Other Services	3.02		3.90	3.68		3.42	-0.26	-7%
Public Admin	13.58		18.83	11.48		15.96	4.48	39%

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

In 2002, the transit corridor is jobs-rich for all industries, so falling values for the jobs-housing ratio indicate an improvement in the jobs-worker balance, and increasing job accessibility. Atypically, values with red bars are actually good in this context. Thus, the most significant moves toward parity with the metropolitan area are by the Administrative industry, although the Wholesale and Retail industries experience valuable changes.

Evaluation of the sparklines makes a visual determination of the consistency of changing trends possible. Only the Administrative industry makes steady progress toward parity, although the Construction, Real Estate and Health Care all make steady progress away from greater parity.

Discussion & Implications

Overall, there is minimal support for the idea that proximity to transit improves the jobs-housing balance. The jobs-housing ratio by income does not suggest that transit improves jobs-housing balance, and indeed may aggravate it.

New transit lines are situated to maximize ridership. Maximizing ridership means focusing on density. The more origins and destinations near a transit station, the more likely it is to generate ridership. Employment tends to be concentrated, so that employment densities are almost always greater than residential densities. Thus, transit systems tend to be built in job-rich locations.

The jobs-housing ratio improves toward parity for some industries, but these are the same industries that earlier analysis characterized as experiencing large job losses. So it seems likely that the increase toward parity along the corridor is not a result of more residents matching their place of residence to their place of work, but rather a result of lower number of workers in that industry.

Ideally, comparing the jobs-housing ratio for different industries should show which industries are transit compatible, with transit compatible industries showing better matches. At the corridor scale, it seems unable to do so. The jobs-housing ratio is very far from parity for most industries. While improving the job-worker ratio along the corridor towards parity would be a positive result, the failure to do so may not capture the whole story. For many metro areas with a single high capacity transit line, all accessible destinations from transit must be in proximity to that line. But Dallas has a large network of rapid transit lines. Effectively gauging the effect on jobs-housing balance would require evaluating the jobs-worker balance over the whole transit network.

The larger the metropolitan area, the more places it is possible to both live and work. Thus, the less likely any given worker will be a resident of any given geography. For any growing and expanding metropolitan area, the match between workplace and residence would be expected to worsen over time. However, the addition of transit would be expected to counteract this, providing a mechanism to assort workers in a way that their residential location better matches their employment location.

For a transit system to substantially improve jobs-housing balance by bringing the jobs-housing ratio (by any criteria) into greater conformity with the metropolitan norm, the change in mobility and accessibility provided by that transit system must be sufficient to influence residence location choices for a substantial number of people. Given the limited area within walking distance of transit stations, this implies either very high residential density in proximity to transit stations, or some mechanism that concentrates enough workers to proxy for residential density, such as park and ride lots or transit centers fed by local bus service.

8-SUMMARY OF FINDINGS

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

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

Q1: Attractiveness to NAICS sectors (Location quotient)

Transit corridor

- Substantial Increases: Information and Manufacturing
- Notable Increases: Real Estate and Health Care
- Massive Reductions: Utilities
- Substantial Reductions: Finance and Professional

Transit advantage over comparable corridor

- Confirmed Advantage: Manufacturing, Information and Health Care
- Mitigated Decline: Finance and Management

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

Numeric Change in Transit corridor

- Employment in metropolitan area grew more than transit corridor
- Substantial numeric increases: Health Care, Public Administration and Education
- Substantial percent increases: Health Care, Education and Management
- Substantial reductions: Retail, Information, Utilities, and Wholesale

Effect of corridor, as per shift-share

- Corridor Effect positive only for Manufacturing and Health Care
- Strongest negative corridor effect for Professional and Finance
- Corridor benefit only meaningful for Manufacturing

Transit advantage over comparable corridor

- Difference in corridor benefit largest for Retail and Management
- Difference in corridor effect largest for Manufacturing and Health Care

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

In this example, resilience is defined as the capacity to maintain a positive trend despite the economic shock of the 'Great Recession'. The R^2 values measure the amount of variation in trends before and after the recession. More resilient industries will have more comparable R^2 values.

Transit corridor prior to Great Recession

- Major positive trends: Manufacturing, Public Administration and Health Care
- Consistent trends, as per R^2: Most industries had high trends
- Declining: Other Services, Arts/Entertainment/Recreation

Transit corridor after Great Recession

- Major positive trends: Manufacturing, Public Administration and Health Care
- Declining: Utilities and Construction

Transit Corridor Differences before and after Great Recession

- Biggest difference: Manufacturing and Health Care
- Resilient (positive trends before and after): Manufacturing, Public Administration and Health Care
- Emergent (strong negative before, strong positive after): Arts/Entertainment/Recreation and Other Services

Advantage over Comparable corridor:

- Better trends: Health Care, Public Administration and Construction.
- Did well by comparison: Manufacturing and Management

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

Unlike other analyses in this report, this analysis measures changes in more than just the 0.5-mile buffers. The magnitude of the effect of transit should be proportional to proximity to transit.

Transit corridor

- H+T costs for the transit corridor are less than the metropolitan average
- H+T costs fall with proximity, barring the area within 0.25 miles
- Transportation costs do not change with proximity to the corridor

Transit corridor changes in H+T costs 2000-2009

- H+T costs for the transit corridor change less than the metropolitan average for all distances except 0.25 mile buffer.
- Transportation costs change more than housing costs
- Transportation costs change nearly constant with distance, slight decline
- Change in housing cost negative for all buffers except 0.25 mile

Comparable corridor

- H+T costs in comparable corridor increase with distance to corridor
- Relationship of H+T costs to distance to corridor mirror opposite of transit corridor
- H+T costs of comparable corridor higher than metropolitan average

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

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

- Job rich at start of study period, with jobs-housing ratio greater than that of the metropolitan area
- Most job-rich for high income workers
- Very constant jobs-housing ratio throughout the study period, low variability
- Towards parity: Administrative, Wholesale and Retail industries
- Further from parity: Construction, Real Estate and Health Care

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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/

Shift-Share Calculations

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