University Transportation Research Center - Region 2

Final Report

An analysis of the agglomeration benefits of transit investment: A Case Study of Portland and Dallas

Performing Organization: Rutgers University

September 2013

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The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

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The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

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UTRC's Technology Transfer Program goes beyond what might be considered "traditional" technology transfer activities. Its main objectives are (1) to increase the awareness and level of information concerning transportation issues facing Region 2; (2) to improve the knowledge base and approach to problem solving of the region's transportation workforce, from those operating the systems to those at the most senior level of managing the system; and by doing so, to improve the overall professional capability of the transportation workforce; (3) to stimulate discussion and debate concerning the integration of new technologies into our culture, our work and our transportation systems; (4) to provide the more traditional but extremely important job of disseminating research and project reports, studies, analysis and use of tools to the education, research and practicing community both nationally and internationally; and (5) to provide unbiased information and testimony to decision-makers concerning regional transportation issues consistent with the UTRC theme.

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16. Abstract

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Results show that newly formed firms tend to cluster around stations in the Portland region but not in the Dallas region. The difference between the two regions holds for different firm sizes, and different industrial sectors. In all cases, there is a much stronger association with transit proximity and new firm birth in the Portland region compared to the Dallas-Ft. Worth region. In both regions, births of larger firms tend to be associated with greater proximity to transit stations, perhaps reflecting the greater agglomeration benefits that they receive. Different planning and zoning criteria in Portland versus those in Dallas may explain the relative success of Portland in achieving clusters of new firms near transit.

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ABSTRACT

The objective of this paper is to examine whether new firms are more likely to form near rail transit stations. Two relatively new light-rail systems, one in Portland, Oregon and the other in Dallas, Texas form the basis of the analysis. A geo-coded time-series database of firm births from 1991 through 2008 is analyzed using all firm births, firm births of various sizes, and firm births of specific industry sectors. A random effects negative-binomial model is used to examine associations between proximity to rail stations and other spatially defined variables.

Results show that newly formed firms tend to cluster around stations in the Portland region but not in the Dallas region. The difference between the two regions holds for different firm sizes, and different industrial sectors. In all cases, there is a much stronger association with transit proximity and new firm birth in the Portland region compared to the Dallas-Ft. Worth region. In both regions, births of larger firms tend to be associated with greater proximity to transit stations, perhaps reflecting the greater agglomeration benefits that they receive. Different planning and zoning criteria in Portland versus those in Dallas may explain the relative success of Portland in achieving clusters of new firms near transit.

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EXECUTIVE SUMMARY

As many metropolitan areas develop new transit systems or expand existing systems, a major impetus is to spur economic development within the region. Rail transit is particularly promoted as a source of economic growth and development. A variety of mechanisms may lead to economic growth, and one that has recently been evaluated is how and whether transit causes or intensifies agglomerations of employment and population in cities. A related question is whether policies to encourage transit-oriented development may also lead to agglomeration economies by intensifying firms and employment within station areas.

We examined the birth of new firms near newly developed rail stations in Portland, Oregon, and Dallas-Ft. Worth. We used the National Establishment Time Series (NETS) dataset, derived from Dun & Bradstreet records of firms. The data include firm size, industrial category, birth and death dates, and location at the block level. We used the NETS data to develop a geographically specific dataset including firm location relative to the rail transit networks in each region. Because the NETS data are a time series over 18 years, we were able to evaluate how firm births within the regions have changed over time and how births may be influenced by proximity to the rail network, with attention to firms of various sizes and in specific industry sectors from 1991 through 2008. We used a random-effects negative-binomial regression model to examine associations between proximity to rail stations and to control for a large set of other spatially correlated variables such as distance to downtown, access to freeways, and socioeconomic characteristics of Census tracts.

We find that newly formed firms do tend to cluster around stations in the Portland region, but new firm births in the Dallas region are not nearly as correlated with rail station access. The difference between the two regions holds for different firm sizes, and different industrial sectors. Agglomeration benefits are apparent as births of larger firms have stronger associations with transit proximity and this occurs in both regions. The stronger effect for firm births in the 5+ employee category suggests that the nature of agglomeration benefits with respect to new firm births may be related to labor market accessibility rather than to other mechanisms such as information spillovers, but this tentative conclusion requires further verification.

While both the Dallas-Ft. Worth and Portland regions have relatively new light-rail (and commuter rail) systems, there are substantial differences in how these systems are associated with the birth of new firms. Why there is a difference between these two cities is important for urban and transportation planners to understand. Since new firms may be an important driver of regional growth, and clustering of these firms can lead to external agglomeration benefits, firm births are an important piece of the transit-agglomeration puzzle.

Based on our previous case-study research, Portland has adopted more stringent policies than Dallas-Ft. Worth in focusing development near rail stations and within the CBD, including restrictions on off-street parking for new development and an urban growth boundary that restricts development on the metropolitan fringe. These policies have led to more infill development, some of which naturally occurs near rail stations both in the CBD and elsewhere. In contrast, Dallas has no comprehensive planning around transit and there is ample parking in the CBD. With respect to firm births, fully maximizing the economic benefits of a transit network may require coordinated planning effort and supportive policies.

I. INTRODUCTION

Over the last 20 years many cities and regions in the US have built new rail capacity, especially light-rail serving the central business district (CBD) from outlying suburbs. These are often justified on the basis of economic growth and are aimed at shifting drivers to using public transit. While these goals may or may not be achieved, many areas also try to focus new development around new transit stations, both in the CBD and further out. There is evidence that new transit capacity can lead to agglomerations of economic activity and consequent increases in economic productivity (Chatman and Noland 2013). As part of this process, it is likely that new firms will locate near transit stations, either to take advantage of agglomeration externalities, to provide easy access for their labor force, or to take advantage of the amenities that might be provided near stations. New firm formation is seen as a potential necessary condition for economic growth, as well as for innovation (Santarelli and Vivarelli 2007, 455-488; Reynolds 1994, 429-442), and thus may be an unmeasured benefit of new transit systems.

The objective of this paper is to evaluate new firm formation around stations of two relatively new light-rail systems, one in Portland, Oregon and the other in Dallas, Texas. This is examined in the context of agglomerations forming around these systems, or clustering of firms to take advantage of the accessibility provided by the new light-rail systems. The analysis examines the impact on all new firms, those of various sizes, and a variety of different sectors. The analysis aims to show the variations that occur but also to highlight the differences found in our two metropolitan case studies, which are substantial. The results suggest that policy actions to accommodate agglomerative tendencies can unlock additional benefits from new transit systems.

II. PREVIOUS LITERATURE

A recent review by (Santarelli and Vivarelli 2007, 455-488) describes the factors believed to be associated with the birth of new firms and subsequent economic growth. The process of entrepreneurship, in which an individual starts a new firm is linked to the knowledge and networks that individual has gained from being employed in a specific sector, or sometimes via familial connections. Most new firms fail, and thus provide little in the way of economic growth for a region; overconfidence on the part of entrepreneurs leads to these "entry mistakes" and leads to the churn and turbulence that is seen in the economy. Some have argued that many entrepreneurs are non-productive, taking advantage of rent-seeking activities that may damage more productive competitors (Coyne, Sobel, and Dove 2010, 333-346).

Agglomeration economies are important for new firm formation. The main factors are the concentration of industries and the knowledge spillovers that occur. According to (Santarelli and Vivarelli 2007, 455-488) this is most important for "high-tech" sectors which are highly specialized; these sectors are also more likely to foster innovation and be successful compared to more traditional manufacturing and service sector firms. One example that isolates specific agglomeration effects is a model estimated by (van Oort and Bosma 2013, 213-244). They attempted to separate the effects of inventiveness and entrepreneurship from agglomeration effects. Inclusion of various proxies that measure the inventiveness of a region (number of patents) and entrepreneurial capacity (a survey of intent of individuals to start firms) finds that these pick up the effect of agglomeration (employment density) and both are associated with new firm formation.

Early work that investigated the determinants of firm births was an international comparison funded by the European Commission (Reynolds, Storey, and Westhead 1994, 443-456). Much of this was motivated by a belief that new firms nurtured economic growth. The cross-national studies used regional data for six countries and searched for similar effects. The main drivers of new firm birth were found to be growth in population, proxying as a measure of demand growth; and, population density, urbanization, and more smaller firms, all proxying as measures of agglomeration. Transportation capacity is embedded in local government expenditures which do not show consistent associations across different countries.

A study of Finnish data sought to compare results with the 1994 set of studies

(Kangasharju, 2000). A five year panel regression analysis was conducted and found the most significant variable was size of existing firms; theoretically this is based on assuming that existing firms are "seedbeds for future entrepreneurs", that is places where they pick up the skills to start their own firm (Kangasharju 2000, 355-373). Another study examined the birth of manufacturing firms in Texas (Sutaria and Hicks 2004, 241-262). They found that more large firms lead to more firm births; but rather than arguing that these firms spin off entrepreneurs, they argue that they are established to service larger firms.

Previous studies also examined the impact of unemployment and the change in unemployment on firm births. One argument is that more unemployment spurs individuals to start their own firm since jobs are unavailable; alternatively, unemployment signals a lack of demand and less new firm birth. The international studies found ambiguous results (Reynolds, Storey, and Westhead 1994, 443-456). (Sutaria and Hicks 2004, 241-262) find evidence in Texas of unemployment increases reducing firm births, while (Kangasharju 2000, 355-373) argues the opposite. (Santarelli and Vivarelli 2007, 455-488) suggest instead that firms may be formed when there is a gap between current wages and expected profits from being self-employed; current wages may be low because of a weak economy.

These firm formation studies model the rate of new firm formation, specifying either new firms per population or labor force size or new firms per existing firms. This allows simple ordinary least squares (OLS) or fixed effect panel models to be estimated. More recent studies assume that the firm formation process follows a Poisson distribution (Holl 2004, 341-363; Holl 2004, 693-712; Holl 2004, 649-668) and (Melo, Graham, and Noland 2010, 133-143).

There is a large literature that has examined how location choice (including the choices that new firms make) is influenced by accessibility. This dates back to early models of city growth and urban form that rely on a trade-off between access and the value of land, and thus what activities are economically best suited for development on that land (Anas, Arnott, and Small 1998, 1426-1464). The literature that explicitly examines the link from accessibility to new firm formation is sparse. The location choice literature assumes a discrete process of parcel selection and is based on conditional logit models that assume a random utility model (Shukla and Waddell 1991, 225-253; Waddell et al. 2007, 382-410). Recent work suggests that Poisson count models have an equivalent log-likelihood function to the conditional logit and therefore provide the same random utility assumptions (Guimarães, Figueirdo, and Woodward 2003, 201-204). The benefit is that rather than sampling from a large number of potential location choices one can achieve more efficient estimates using the entire dataset.

(Kim et al. 2008, 123-151) estimated a location choice model with a zip-inflated negative binomial count model. This model was focused on employment numbers, not the number of firms locating in each spatial unit. The count model leads to larger prediction errors (this is attributed to some high counts in the data that probably would not occur if firm counts were modeled). They conclude that the count model provides "more insights into the nature of employment dispersion and clustering" than a conditional logit and also avoids problem of *Independence of Irrelevant Alternatives* of discrete choice models.

Several studies have used count methods to examine firm births and have specifically focused on the role that transportation infrastructure plays. (Holl 2004, 341-363; Holl 2004, 693-712; Holl 2004, 649-668) modeled firm births in both Spain and Portugal by with a count model, specifically the fixed effect poisson and negative binomial models specified by (Hausman, Hall, and Griliches 1984, 909-938).

In an analysis of Spanish data, (Holl 2004, 341-363) estimates a Poisson fixed effects model using municipality level data from 1980-1994. The focus is on the birth of manufacturing firms and the association with proximity to the motorway network, much of which was built during this time frame. Motorway access is seen as important for manufacturing firms that seek to minimize their transportation costs. The association with straight-line distance to the motorway corridor is estimated using dummy variables for distance bands; results show that more firms are born closer to the motorway. Using similar data for Portugal, (Holl 2004, 693-712) estimates negative binomial fixed effects models for both the manufacturing and service industries. Proximity to the motorway is again statistically significant in the model that includes all sectors, but varies a bit in sub-sector models. Diversity of firms was also found to lead to more firm births, implying that knowledge comes from outside the 'own' sector, i.e., urbanization economies (Duranton and Puga 2001, 1454-1477; Jacobs 1969).

In (Holl 2004, 649-668) an analysis is done that compares relocations of existing firms with new firm births in the manufacturing sector. A count data fixed effects model is used. A market access measure (based on a gravity model) and distance to motorway measure (dummy variables) are tested. The hypothesis is that new firms are more reliant on local market conditions than relocations and that transport access matters less for new firms. This hypothesis is confirmed, although motorways are significant for both births and relocations. Firm diversity leads to more firm births as also noted in(Holl 2004, 693-712).

(Melo, Graham, and Noland 2010, 133-143) also analyze Portuguese data for a variety of different sectors. Using a cross-sectional negative-binomial model with municipality-level data, they include a variable for railway density and motorway density with spatial lags, something that other studies have not accounted for. Both own and lagged transportation variables are associated with new firm formation, with elasticities ranging from 0.07 to 0.27 with spatial spillover elasticities ranging from 0.24 to 0.67.

Our analysis builds on this prior literature by using a detailed block-level analysis for the Portland, Oregon and Dallas-Ft. Worth, Texas regions. A large panel data set encompassing 18 years over which both regions built out significant new light-rail infrastructure allows us to examine whether new firms are more likely to locate in proximity to stations.

III. BACKGROUND ON PORTLAND AND DALLAS

The Dallas region has two rail systems and a significant bus network and we include both in our analysis. The two rail services are the Dallas Area Rapid Transit (DART), a light-rail network, and the Trinity Railway Express (TRE), a commuter rail line. Both systems opened in 1996. DART Red and Blue lines opened in 1996, Green line in 2009 and Orange line opened in 2012 (though these lines were all extended after the initial segments were opened and the system is still being expanded) (Dallas Area Rapid Transit). The current system is 85 route-miles and serves 61 stations with 90,224 passenger trips on an average weekday (FY2012) (Dallas Area Rapid Transit). The TRE is a single-line commuter rail service serving downtown Dallas and Fort Worth and stations in-between. The route is 34 miles and has 10 stations. Average weekly FY 2012 ridership was 8,077 (Dallas Area Rapid Transit). Average weekly FY 2012 bus ridership is 131,567 passengers.

In the Portland metro region, there are three rail systems, the Portland streetcar, MAX light rail, and Westside Express Service (WES) Commuter Rail line. Our analysis only includes the MAX light rail network as the WES commuter rail opened in 2009. The first MAX light rail line, the blue line, opened in initially in 1986 and was expanded in 1998. The Red (airport) line opened in 2001, Yellow line in 2004, and Green line in 2009 (TriMet). In total, the MAX system serves 85 stations along 52 route miles. In FY2011, MAX average 126,800 weekday boardings (compared with an average of 190,3000 weekday trips on Tri-Met buses and 1,450 trips on WES) (TriMet).

A case study of planning in the Dallas region found no significant planning to encourage station area development (Chatman et al. 2012). This may because the Dallas rail transit systems, DART and TRE opened relatively recently, in 1996. There is also no evidence of significant changes in the zoning designed to accommodate densification of firms near the rail corridors. Transit oriented development (TOD) near rail stations has been limited (Mockingbird Station and downtown Plano are exceptions). While there has been increased firm densification along some rail corridors north of Dallas, others, such as those extending south from the urban core travel through large sections zoned residential and have limited potential for densification under the current planning regimes.

Within the urban core, several factors may limit firm densification near transit. First, much of the recent development in downtown Dallas has been conversion of office space to residential uses given what some believe to be an oversupply of office space. Second, a large portion of land in the downtown core is devoted to supplying parking. Yet, according to case study research, many developers perceive parking as undersupplied(Chatman et al. 2012).

In contrast, the Portland regional planning organization, Metro, has focused on densification of the urban area and encouraging development near transit. The most widely known and broad ranging policy is the Urban Growth Boundary (UGB). Additionally, the operator of the light-rail lines, Tri-County Metropolitan Transit District (Tri-Met), has pursued TOD projects along the light-rail stations since the 1980s (Jun 2008, 100-107). Finally, parking policies in Portland are also supportive; the city of Portland has eliminated minimum parking requirements near high frequency transit stations (Mukhija and Shoup 2006, 296-308), and the CBD has long had a maximum parking limit.

Although both cities have developed light-rail networks in recent years, Dallas and Portland are quite different. In the American Community Survey (ACS) 2007 -- 2011 (5-Year Estimates), the three counties in the Dallas region are home to 4.9 million residents and 1.8 million households. The population in the three Portland counties in our study is much smaller, only 1.6 million persons and 645,000 housing units. Dallas residents are majority minority while almost three-quarters of Portland's population identify as Non-Hispanic White (45.3 versus 74.7 percent). A greater share of Dallas residents are Non-Hispanic black (16.1 versus 3.2 percent) and almost three times as many residents identify as Hispanic in the Dallas study area (29.9 versus 11.5 percent). The share of Non-Hispanic Asian residents is similar (5.8 percent in Dallas and 6.5 percent in Portland). While the median household incomes are similar ($58,000 for Dallas versus $57,000 for Portland), the average household in Dallas is larger (2.8 versus 2.5 persons).

Despite the extensive transit systems in both regions, mode split (based on ACS data) for the commute trip is very different. Dallas residents travel to work by autos at much higher rates (96.2 versus 84.2 percent) and use transit and non-motorized modes much less than residents of Portland. Some 5.6 percent of Portland residents use transit to get to work compared with only 0.7 percent in Dallas and 4.1 percent of Portland residents use bicycles or walk to work compared with 1.1 percent of Dallas residents.

IV. DATA

To analyze the relationship between firm births and proximity to transit stations, we used the National Establishment Time-Series (NETS) database, a longitudinal database of firm locations, births, deaths, moves, sales, number of employees and industry classification from 1990 through 2009 (this data was purchased from Walls & Associates). We obtained data for three counties surrounding Portland, OR (Clackamas, Multnomah and Washington counties) and Dallas, TX (Dallas, Tarrant, and Collin counties). Because the NETS database does include reliable information on firm births for the initial year or firm deaths for the final year, we limit our analysis to the years 1991 through 2008. The NETS database categorizes firms according to the North American Industry Classification System (NAICS) two-digit codes.

After excluding firms with missing location data and firms we were unable to geocode, the resulting dataset for Portland contains information on between 57,000 and 130,000 firms per year and includes about 172,000 firm births and 103,000 firm deaths across all years. For Dallas, the dataset contains information on between 180,000 and 390,000 firms per year and includes about 570,000 firm births and 365,000 firm deaths across all years. The data was aggregated to Census Block level, thus we counted firm births and deaths in each Census block. There were 28,004 blocks in the Portland region times 18 years giving 504,072 records and 60,586 blocks in the Dallas region times 18 years giving 1,090,458 records.

For this analysis, we also analyzed various subsets of the data to examine different sized firms. First, we created two subsets of the data that excluded small firms, one with only firms with greater than one employee and another dataset with only firms with greater than five employees. Second, we created a subset that only included smaller firms, those with five or fewer employees. Table 1 summarizes the total number of firms for each of the datasets for Portland and Dallas. In the Portland database, 29.4 percent of firms are single employee firms and 75.9 percent of all firms have five or fewer employees. For Dallas, 25.1 percent of all firms are single employee firms and 75.1 percent have five or fewer employees.

Table 1. Number of Firms by year

	Portland				Dallas			
	All firms	Emp > 1	Emp > 5	Emp <= 5	All firms	Emp > 1	Emp > 5	Emp <= 5
1991	57,639	44,596	16,959	40,680	177,411	152,241	49,004	128,407
1992	58,163	44,395	16,952	41,211	171,939	144,609	49,465	122,474
1993	61,243	46,447	17,882	43,361	194,372	163,031	53,814	140,558
1994	66,090	49,799	18,607	47,483	191,600	158,690	54,578	137,022
1995	69,839	52,429	19,559	50,280	188,842	153,070	56,826	132,016
1996	72,726	54,181	20,229	52,497	191,971	153,531	58,013	133,958
1997	78,108	57,363	21,010	57,098	209,929	165,122	60,154	149,775
1998	80,768	58,310	21,679	59,089	219,743	170,295	61,938	157,805
1999	82,987	58,609	21,961	61,026	221,378	167,788	62,864	158,514
2000	83,141	58,301	22,393	60,748	222,665	166,572	64,776	157,889
2001	85,637	60,404	22,798	62,839	237,742	178,916	66,672	171,070
2002	98,477	72,569	22,959	75,518	270,495	207,674	68,119	202,376
2003	106,870	73,278	22,700	84,170	292,844	207,959	67,564	225,280
2004	107,330	72,958	22,708	84,622	298,420	209,751	67,495	230,925
2005	109,115	72,420	22,715	86,400	319,113	220,441	67,673	251,440
2006	116,177	76,955	23,208	92,969	338,932	233,041	68,984	269,948
2007	121,065	81,394	23,551	97,514	351,823	243,533	69,640	282,183
2008	130,676	86,298	23,468	107,208	390,403	264,475	69,264	321,139
Total	1,586,051	1,120,706	381,338	1,204,713	4,489,622	3,360,739	1,116,843	3,372,779

Figure 1 and Figure 2 show the number of firms for each of the five datasets for Portland and Dallas. The graphs show steady growth in the mid-1990s and rapid growth in the early and late 2000s prior to the most recent recession. The growth rate for smaller firms is much greater than for larger firms. For Portland, those firms with more than five employees increase by 38% between 1991 and 2008, while those firms with less than five employees increase by 164%. For Dallas the growth rates are 41% and 150%, respectively.

Figure 1. Portland firms by year

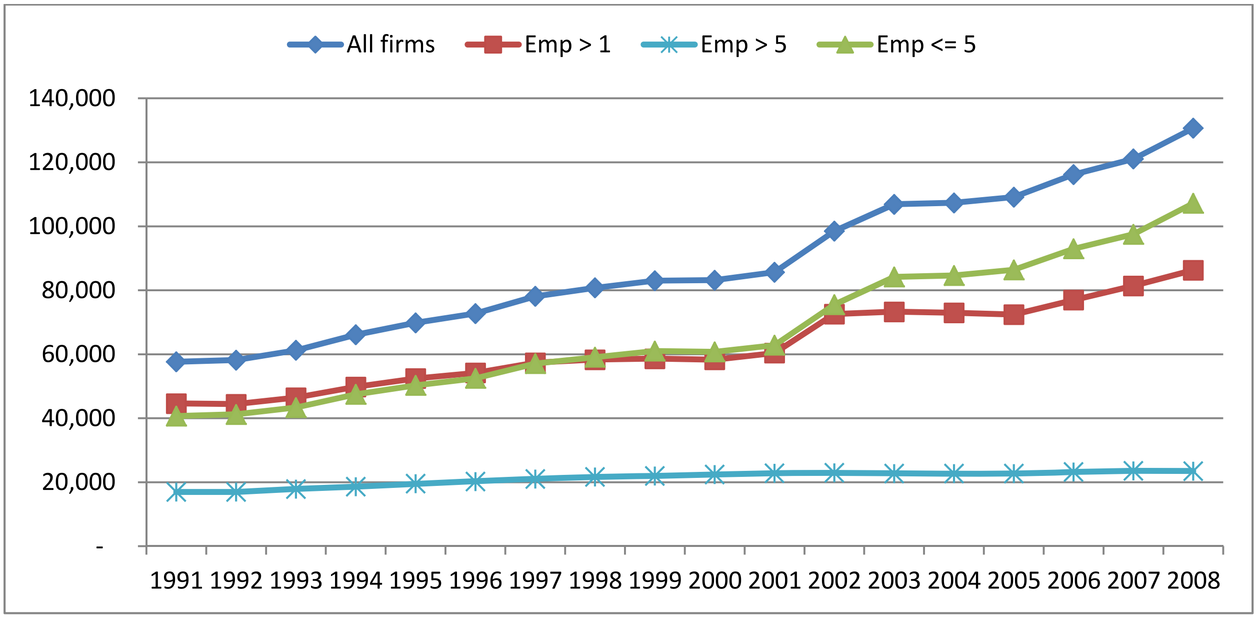


Figure 2. Dallas firms by year

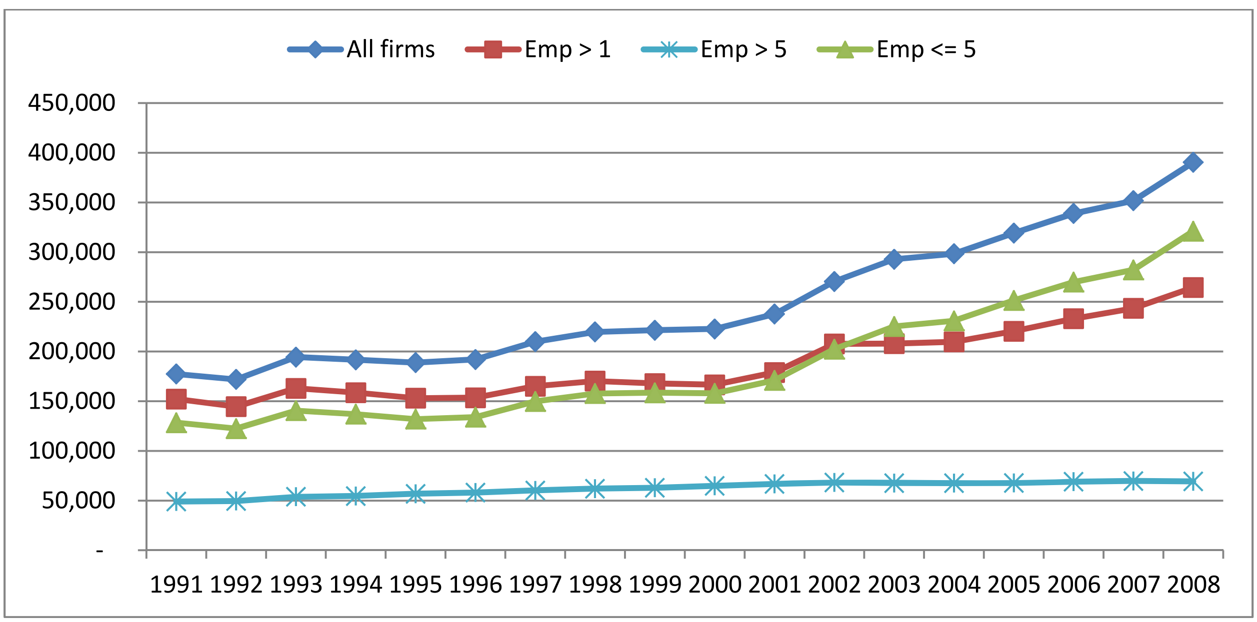


Figure 3 and Figure 4 show firm births per year as a percentage of the number of firm births in 1990 and show that larger firms did not have the same spikes in firm births. Instead, we see a decrease in firm births for larger firms in the 2000s. Much of the growth in firms over the time period of our sample can be attributed to smaller firms. The net increase in firms (accounting for both firm births and deaths) for Portland is 69,008 of which only 890 are firms employing more than five employees (1.29% of the total). For Dallas the net increase is 205,684 of which 4,390 are larger firms (2.13% of the total). While most firms are born small and few grow to larger sizes, smaller firms are often seen as incubators of innovation (Santarelli and Vivarelli 2007, 455-488); thus, our analysis examines associations between transit proximity and the birth of different sized firms.

Figure 3. Portland firm births compared with births in year 1990

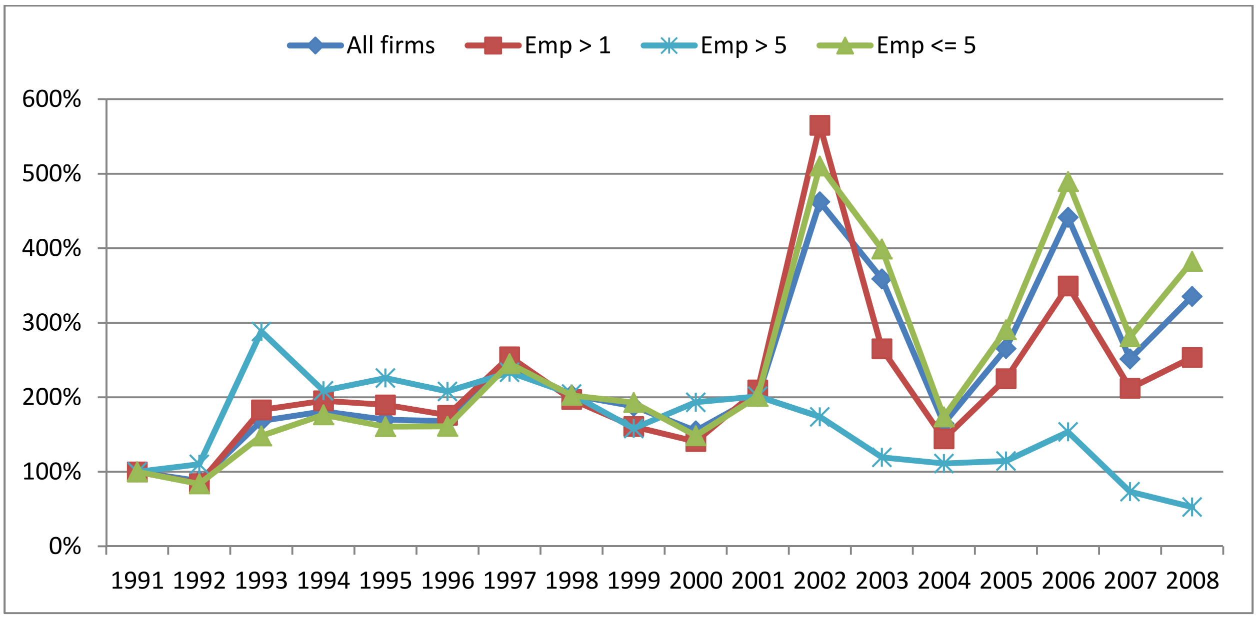
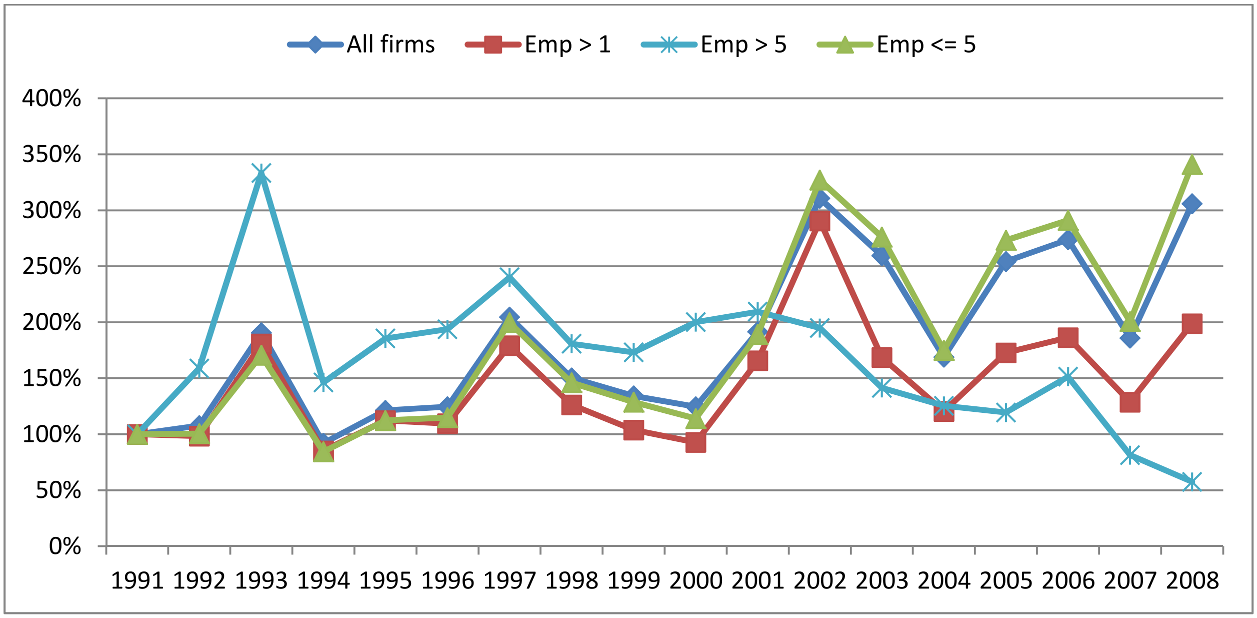


Figure 4. allas firm births compared with births in year 1990



We also examine whether there are differences in firm births and proximity to transit for different industry classifications. We focus on six NAICS categories, which are:

1. Manufacturing (NAICS codes 31-33)
2. Retail Trade (NAICS codes 44-45)
3. FIRE: Finance and Insurance (NAICS codes 52) and Real Estate and Rental and Leasing (NAICS code 53)
4. Professional, Scientific, and Technical Services (NAICS codes 54)
5. Health Care and Social Assistance (NAICS codes 62)
6. Arts, Entertainment, and Recreation (NAICS codes 71)

Table 2 and Table 3 summarize the number of firms and number of firm births for these NAICS categories for both Portland and Dallas from 1991 to 2008. Much of the literature on firm birth and formation has focused on the manufacturing sector, as has the literature on agglomeration economies. We suspect that manufacturing may be less sensitive to transit proximity, mainly because large scale manufacturing may require more space than other industrial sectors. Service oriented industries may be more likely to form and grow near transit. Also, many areas seeking to encourage transit-oriented development often attract retail trade and arts, entertainment, and recreational firms. Thus, there is a good rationale for analyzing specific industry categories.

Table 2. Number of Firms by NAICS

	Portland			Dallas		
	Mean	Max	Min	Mean	Max	Min
Manufacturing	5,664	6,759	4,648	14,433	18,054	11,665
Retail	10,617	14,346	7,169	39,007	53,944	27,017
FIRE	8,816	13,816	5,507	27,318	44,659	17,230
Professional, Scientific, and Technical Services	11,806	19,043	6,399	33,591	54,762	18,793
Health Care and Social Assistance	6,238	9,234	3,972	15,995	25,275	8,854
Arts, Entertainment, and Recreation	1,770	2,531	964	4,981	7,109	3,321

Table 3. Firm Births by NAICS

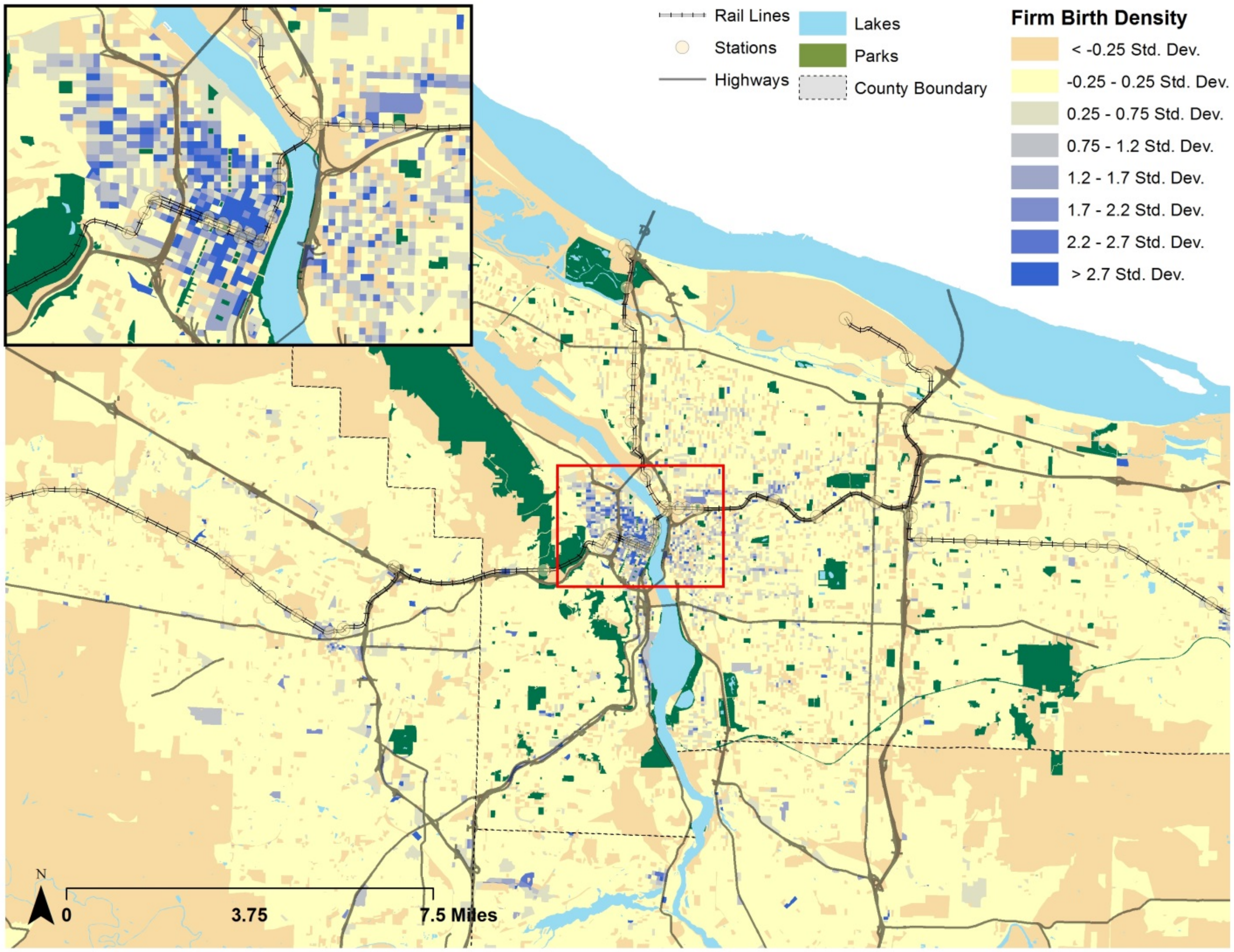
	Portland			Dallas		
	Mean	Max	Min	Mean	Max	Min
Manufacturing	411	582	220	1,292	838	1,935
Retail	1,154	2,488	425	5,057	2,596	9,515
FIRE	935	1,794	277	3,260	1,230	5,732
Professional, Scientific, and Technical Services	1,345	2,415	537	4,247	2,169	6,862
Health Care and Social Assistance	601	1,822	172	3,669	1,833	619
Arts, Entertainment, and Recreation	214	412	89	269	634	1,011

SPATIAL DATA

Firm data was linked to Census blocks allowing us to generate counts of firm births which are our key dependent variable in our statistical analysis (discussed further below). Figure 5 and Figure 6 map the density of firm births (per square mile) from 1991 through 2008 for Portland and Dallas along with the rail transit networks for each region.

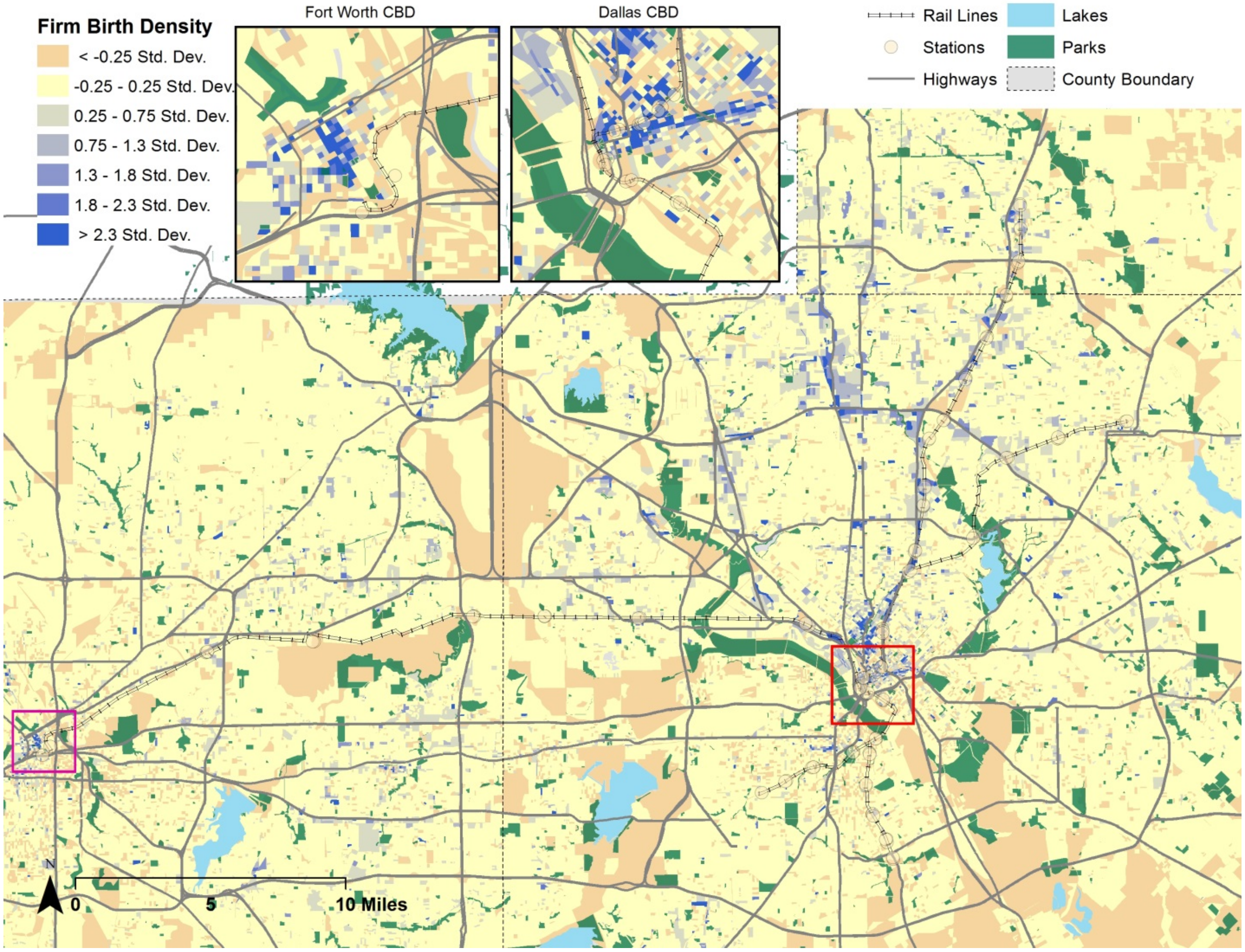
The map of Portland firm births (Figure 5) shows the concentration of firm births in the central city (see inset map). Within the central city, there are consistent increases in firm births throughout the downtown core and to a lesser extent across the Willamette River. In addition, there are increases in firm births west towards Beaverton and Hillsboro along the MAX light rail line and south from Beaverton.

Figure 5. Portland density of firm births per square mile (1991-2008)



Firm births in Dallas (Figure 6) are less concentrated. In both the Dallas and Fort Worth central cities, there is visible firm growth but this is balanced by significant firm growth elsewhere, particularly north of Dallas' CBD. Outside of the central city, much of the growth in the Dallas area is along freeway corridors some of which are adjacent to DART rail lines but most of the highway adjacent firm growth is not.

Figure 6. Dallas density of firm births per square mile (1991-2008)



Using Geographic Information System software, we calculated the straight-line distance to rail transit stations for each year in the data set based on station opening dates. The Portland light-rail system MAX began operating in 1986 with significant expansions in 1998, 2001 and 2004. The Dallas rail systems, DART and commuter rail system, Trinity Railway Express (TRE), opened in 1996 and we include both in this analysis. Extensions to these systems opened in 1997, 2000, 2001 and 2002. We exclude stations that opened in 2009 or after.

Because we are interested in the agglomeration effects near rail stations, we identified Census block centroids within a quarter, half and one-mile of stations. Table 4 and Table 5 summarize the distribution of firm births by distance to station (by firm size) for both Portland and Dallas (for Dallas, the table only summarizes data after 1996, when the rail systems opened). In both regions, larger firms are more likely than other firms to be born and located near stations, but in all cases there is general pattern of increasing firm birth density closer to the station.

Table 4. Portland density of firm births (per sq. mi.) by distance from station

	All Firms	Emp > 1	Emp > 5	Emp <= 5
Less than 0.25 mi.	211.2	155.6	30.7	180.5
0.25 to 0.5 mi.	100.7	69.6	12.2	88.5
0.5 to 1.0 mi.	58.2	37.2	5.6	52.6
Greater than 1 mi.	25.2	15.3	1.9	23.3
	38.0	24.6	3.7	34.3

Table 5. Dallas density of firm births (per sq. mi.) by distance from station (years 1996 and later)

	All Firms	Emp > 1	Emp > 5	Emp <= 5
Less than 0.25 mi.	174.5	128.7	24.1	150.4
0.25 to 0.5 mi.	56.6	38.1	5.2	51.4
0.5 to 1.0 mi.	70.1	47.3	5.8	64.3
Greater than 1 mi.	28.9	19.4	2.7	26.2
	32.2	21.7	3.1	29.2

Figure 7 and Figure 8 graph the changes in firm births for concentric distances from the station. In both cases, the spikes in firm births are in the early, mid and late 2000s.

Figure 7. Portland change in firm births by distance from station (all firms)

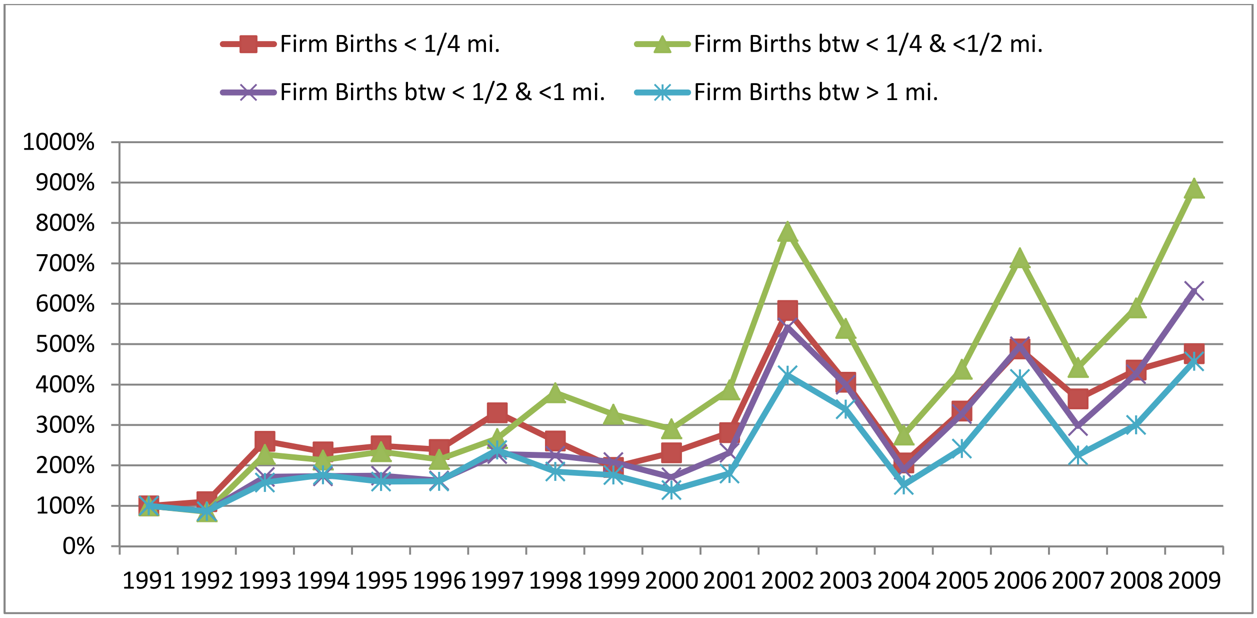
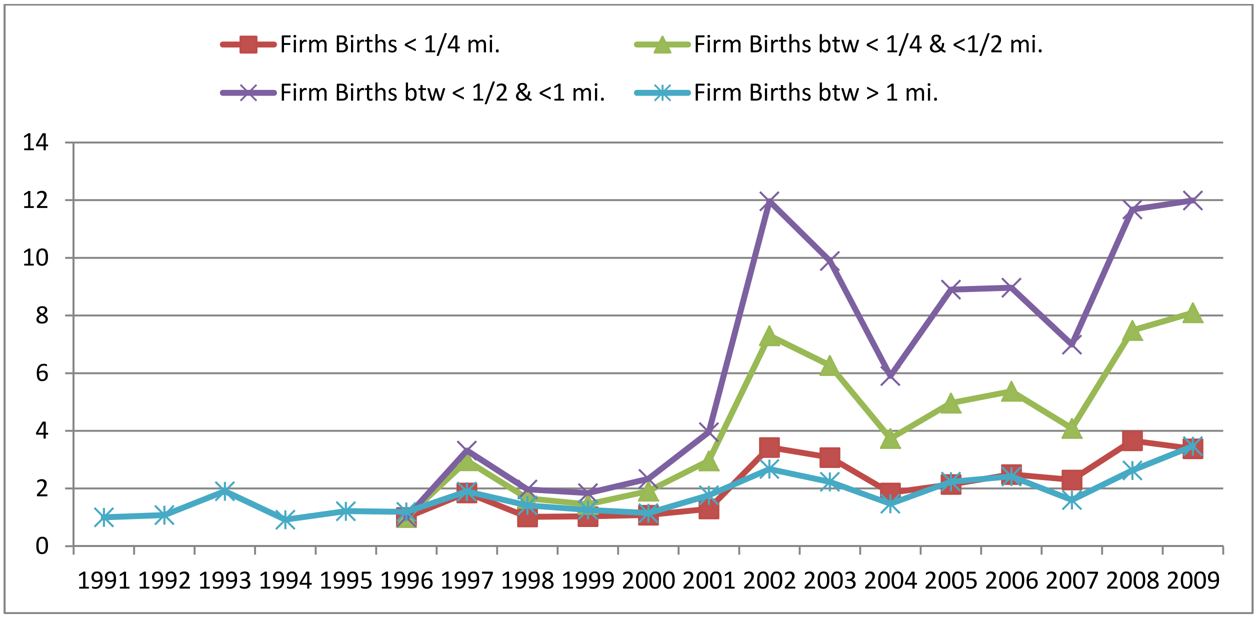

Firm Births < 1/4 mi.
Firm Births btw < 1/4 & <1/2 mi.
Firm Births btw < 1/2 & <1 mi.
Firm Births btw > 1 mi.
1000%
900%
800%
700%
600%
500%
400%
300%
200%
100%
0%
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

Figure 8. Dallas change in firm births by distance from station (all firms)



We also included several distance measures that do not vary by year: straight-line distance to the nearest highway, distance to the Central Business District (CBD) and accessibility measures. For Dallas, we calculated distance to both the Dallas and Fort Worth CBDs. Our accessibility measure is the access of firms to workers' residences.[1] Using data provided by the Dallas and Portland Metropolitan Planning Organizations (The North Central Texas Council of Governments and Metro), we calculated both transit and auto access to worker's residences based on peak period transit and auto travel times and worker residential locations for all Transportation Analysis Zones (TAZ). In the models, we use a ratio of transit access to auto access for the TAZ in which the Census block's centroid is located.

We also added basic demographic data from the 1990, 2000 and 2010 Censuses. We used the Longitudinal Tract Data Base which provides estimates for the 1970 through 2010 Censuses using 2010 Census Tract boundaries . Each block in our database is then associated with the Census Tract in which the Census block's centroid is located. For years in-between the decennial census, we calculated a straight-line interpolation of the Census data.

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[1] We used the same distance decay coefficient for both Dallas and Portland. In both cases, the $e^{-0.1*t_{ij}}$ where t_{ij} is the travel time in minutes from zone *i* to *j*.

V. METHODS AND ESTIMATION STRATEGY

Our key objective is to analyze the association of firm births with proximity to transit stations. Our working hypothesis is that firms will be more likely be born and locate in areas with good transit access. This represents an agglomeration of employment that is hypothesized to occur near transit. Our modeling approach does not allow us to make causal inferences, however, our panel dataset allows us to model the changes over time and across space.

Firm births within a Census block are discrete events. This suggests that count models are an appropriate method, in particular because there are a large number of blocks with no firm births (or zero counts). This ranges from 31% to 83% of all blocks in Portland and 24% to 78% of all blocks in Dallas, depending on the firm size modeled. Our final models are estimated as random effects negative binomial models (Hausman, Hall, and Griliches 1984, 909-938). We choose the negative binomial distribution over poisson given the restrictive assumption of equivalence between the mean and the variance of the poisson model. The negative binomial model relaxes this restriction and reports an overdispersion term. Empirical work often results in overdispersion in count models, mainly because models are imprecise and not fully specified, thus the overdispersion term accounts for much of this error.

We choose a random effects formulation as some of our data is time-invariant, precluding the use of fixed effects models. More practically, fixed effects models would not converge when tested mainly because of the large number of spatial units. To determine whether random effects models are preferred we tested models aggregated to the Census tract level, allowing both fixed effects and random effects models to be estimated. The Hausman test suggested that the random effects was preferable.

Our dependent variable is therefore the number of firm births in block *i* in year *t*. The independent variables include measures of distance to the nearest rail station, measures of other firm activity in that block, measures about the spatial location of that block, Census demographic data about the block during that year, and dummy variables for each year *t.* We use the area of each block (in square miles) as an offset variable for the model. This means that we are essentially constraining the parameter for area to be equal to one, or equivalently we are estimating firm births per unit area.

Our key variable of interest is various measures of distance to rail stations. First, we evaluated a model with a straight-line distance measure to the nearest rail station (which we capped at 10 miles, assuming that there would be no effect at such a large distance) and a dummy variable which is equal to one if the distance to the nearest station is greater than 10 miles or if there are no stations open in the region (which is the case for Dallas prior to 1996). Second, we evaluated a model that adds distance thresholds to test the effects of distance near the station, which we suspect may be non-linear. We constructed thresholds indicating whether the Census block is within a quarter-mile of the station, between a quarter and a half-mile, between a half and one mile, or further than one mile from the station.

To control for other firm activity in each block we include the total number of firms and firm deaths in block *i* in year *t*. We also included a number of variables measuring the spatial attributes of the block. We include a dummy variable indicating whether block *i* is within two miles of the center of the CBD (straight-line distance); for Dallas we include a measure for both Dallas and Fort Worth CBDs; a measure of employment density (employees per block per square mile); population per square mile (Census tract population per square mile); an accessibility ratio measure (transit accessibility to auto accessibility); distance to nearest highway (measured as a straight-line distance in miles). We include several measures of demographics from the Decennial Census. For each year, we include the percentage of the Census tract population who identify as Black and Hispanic, the median household income and rent, and the percent of the tract population with a college education. Finally, we include dummy variables indicating whether the years 1991 through 2008. We omit the first year, 1991, and use this as the reference category. Table 6 summarizes the variables in the model for the full Portland and Dallas data sets.

Table 6. Summary Stats for Model Variables

	Portland				Dallas			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Firm Births	0.34	2.14	0	141	0.52	3.28	0	425
Distance to Station								
Distance to station (in mi)	0.26	0.44	0	1	0.49	0.50	0	1
Station Distance >= 10 mi	4.98	3.74	0	10	7.13	3.46	0	10
<= 1/4 mi	0.03	0.17	0	1	0.01	0.09	0	1
1/4 to 1/2 mi	0.05	0.22	0	1	0.02	0.13	0	1
1/2 to 1 mi	0.10	0.30	0	1	0.04	0.19	0	1
> 1 mi (ref. cat.)								
Firm Variables								
Number of Firms	0.20	2.36	0	223	0.33	4.05	0	460
Number of firth deaths	3.15	16.96	0	1,064	4.12	23.16	0	2,204
Spatial Variables								
PDX CBD dist <= 2 mi	0.08	0.27	0	1				
DAL CBD dist <= 2 mi					0.02	0.16	0	1
FTW CBD dist <= 2 mi					0.03	0.17	0	1
Emp. Density (1,000 per sq. mi.)	3.82	41.37	0	4,317	3.17	50.94	0	10,257
Pop. Density ((1,000 per sq. mi.)	3.78	3.26	0	25	3.32	2.55	0	59
Accessibility Ratio	0.34	0.30	0	1	0.18	0.30	0	2
Dist. to highway (in mi)	1.03	1.77	0	16	0.76	0.77	0	6
Census Tract Data								
Percent Black	0.04	0.08	0	1	0.16	0.22	0	1
Percent Hispanic	0.07	0.06	0	1	0.22	0.21	0	1
Median HH Income (in 1,000s)	47.13	17.18	7	135	48.91	25.52	3	236
Median Rent	586	162	0	1,619	582.28	234.89	0	1,999
Percent College Ed	0.21	0.12	0	1	0.18	0.14	0	1
Year variables not shown								

VI. RESULTS

In each region, we analyzed models with the entire data set (all firms), subsets where we exclude smaller and larger firms, and for the six NAICS industrial sectors. We present two models for each analysis, one where we use straight-line distance measures to the nearest rail station and a second where we include distance thresholds as dummy variables. Results for Portland are discussed first, followed by Dallas, and then by a discussion comparing the two.

One thing to note in all our models is that parameter estimates are almost all statistically significant at a high level of confidence. This is primarily because of the size of our dataset. This makes inference difficult but also makes parameter estimation more precise given the small standard errors on our estimates. Thus, in interpreting the results, parameter values are important and in particular the size of the parameter estimates; those that are near zero are in most cases unimportant, while those with larger values are more important, in terms of their substantive association with the dependent variable.

PORTLAND

For Portland, our models suggest that firm births are positively correlated with proximity to rail stations though the results for all firm sizes. Table 7 presents the model results (In the interest of space, we omit the dummy variables for each year from the table of results).

The model results for the negative binomial regression using the entire data set (all firms), indicates that firm births decrease as the distance from the nearest rail station increases. In model A, without the distance thresholds, the coefficient for distance to station is -0.277 and -0.284 when distance thresholds are included. When distance thresholds are added, in model B, firm births in blocks that are within one-quarter to one-half miles from the nearest rail station are significant and positive (0.12); beyond one-half mile the coefficient is not statistically significant (i.e., it is equivalent to the reference category which is greater than one mile distant). This implies that, holding all else equal, blocks that are within one-quarter to one-half miles have 12.7 percent ($1.127 = e^{0.12}$) more firm births than blocks that are greater than one mile from the nearest rail station.

The proximity results for the models of other firm sizes suggest that firm size matters in whether firm births are associated with station proximity. In Model B for firms larger than one employee, the coefficient for distance to station is slightly smaller than the model for the entire dataset (-0.294 compared with -0.317), yet the distance thresholds for the buffers indicating that the block is within a quarter-mile or between a quarter and a half-mile are both significant and positive (0.267 and 0.164) and larger than in the model for all firms. This implies that, holding all else equal, blocks that are less than one-quarter mile from a station have 30.6 percent more firms born with more than one employee than blocks that are greater than one mile from the nearest rail station and blocks within one quarter to one-half mile have 17.8 percent more firms born with more than one employee than blocks that are greater than one-half mile from the nearest rail station. This result is more pronounced in the model with firms greater than five employees. In model B, the distance threshold variables indicating that the block is within a quarter-mile or between a quarter and a half-mile are both significant (0.794 and 0.517) and much larger than the other models. For firms with greater than five employees, blocks that are less than one-quarter mile from a station have 112 percent more firm births than blocks that are greater than one mile from the nearest rail station and blocks within one quarter to one-half mile have 68 percent more firm births than blocks that are greater than one mile from the nearest rail station. The coefficient measuring distance to the nearest station is -0.444 in model B for larger firms compared with -0.284 in the model of all firms. However, in model B the parameter for station distance greater than 10 miles is not statistically significant. These results suggest that proximity to the station is greater for firms that are born as larger firms. The distance parameters for the model with smaller firms (less than 5 employees) is similar to the model for all firms; this is mainly because the data is similar, as 76 percent of firms have five or fewer employees.

The coefficients for the firm variables, number of firm deaths and total number of firms, conform to our expectations. More firms are associated with more firm births (0.007), while more firm deaths are associated with fewer firm births (-0.005). This result holds for all firm sizes, although for larger firms greater than 5 employees, the number of firms in the block has a larger effect on firm birth (0.045) and firm deaths have a larger negative effect (-0.023).

Blocks within two miles of the CBD center and population density are associated with more firm births. This effect is more pronounced for larger firms and in this case is less pronounced for firms born with fewer than five employees. Employment density also has a positive association, although the coefficient is relatively small, so the effect is minor and much less than the effect of population density in all our models.

Other spatial accessibility variables include the straight-line distance to the nearest highway; blocks that are closer to highways have more firm births (-

0.845); this coefficient also increases in absolute value as firm size increases reinforcing the result that access is important, even by driving. But transit access seems more important, as our generalized measure of accessibility, the ratio of transit access to highway access, is positive (0.872) implying more transit access relative to highway access is associated with more firm births. This parameter also increases as firm size increases.

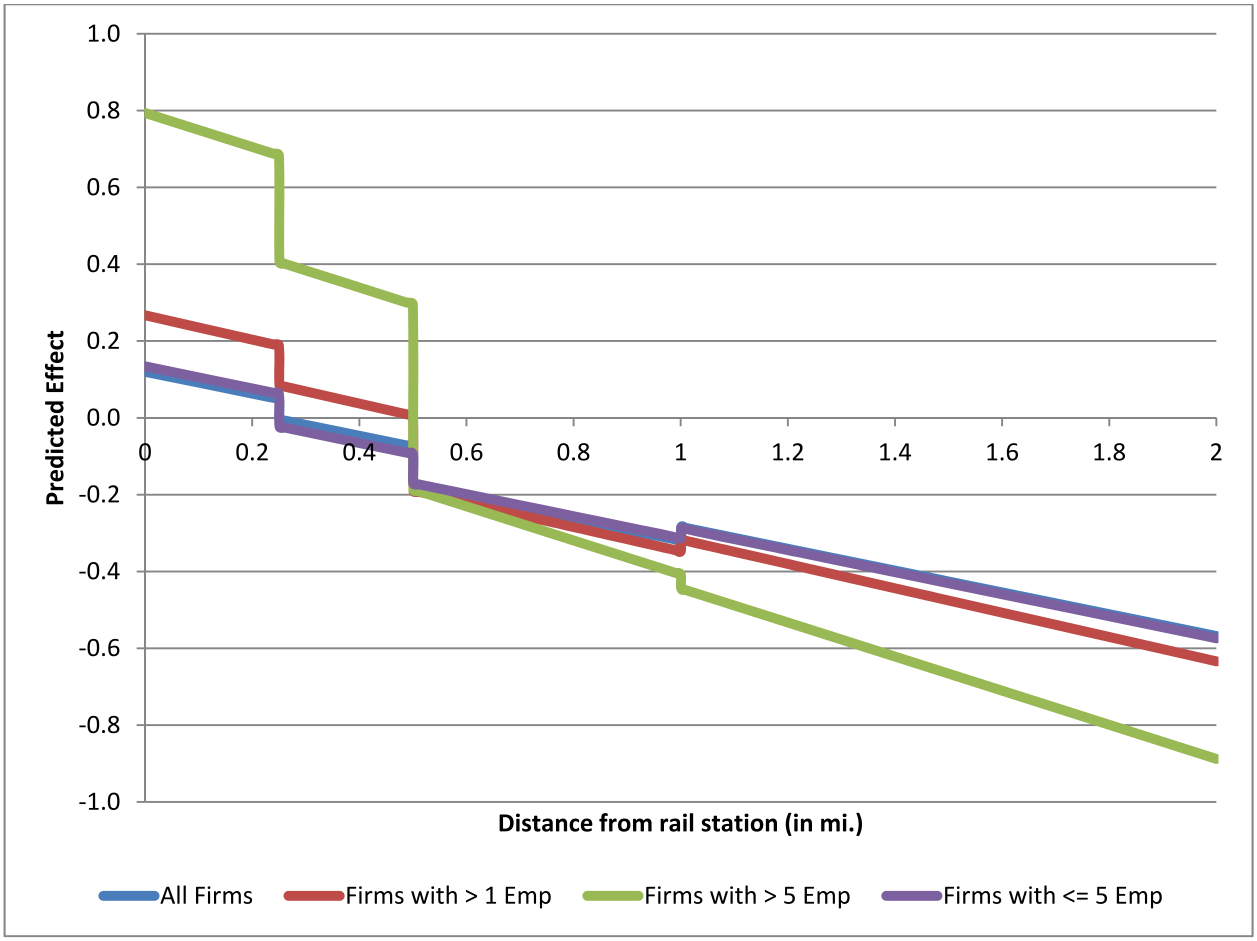
Not all our Census control variables are statistically significant, and some are substantively unimportant with low coefficient values. Percent black is insignificant, while percent Hispanic is statistically significant, but not in all the models. Median household income and median rent are near zero, and thus while statistically significant, really have a small association with firm births; the parameter for the model with larger firms is negative for median household income. Percent of the tract population with a college education has a relatively high parameter value and is statistically significant, suggesting that human capital is an important factor in the birth of new firms, or in their choice of location; this parameter is over double the value of the all firms model for the model of larger firms (1.110 vs. 2.870), suggesting human capital is most important for larger firms.

Table 7. Portland negative binomial model coefficients

	All Firms				Firms with > 1 Emp				Firms with > 5 Emp				Firms with <= 5 Emp			
	Model A		Model B		Model A		Model B		Model A		Model B		Model A		Model B	
Distance to Station																
Distance to station (in mi)	-0.277	***	-0.284	***	-0.294	***	-0.317	***	-0.348	***	-0.444	***	-0.281	***	-0.287	***
Station Distance >= 10 mi	-0.017	***	-0.016	***	-0.014	***	-0.009	**	-0.020	***	0.004		-0.017	***	-0.016	***
<= 1/4 mi			0.120	***			0.267	***			0.794	***			0.134	***
1/4 to 1/2 mi			0.067	**			0.164	***			0.517	***			0.049	
1/2 to 1 mi			-0.035				-0.031				0.036				-0.027	
> 1 mi. (ref. cat.)																
Firm Variables																
Number of firms	0.007	***	0.007	***	0.009	***	0.009	***	0.044	***	0.045	***	0.009	***	0.009	***
Number of firm deaths	-0.005	***	-0.005	***	-0.002	**	-0.002	***	-0.022	***	-0.023	***	-0.009	***	-0.009	***
Spatial Variables																
PDX CBD dist <= 2 mi	0.587	***	0.564	***	0.735	***	0.679	***	0.789	***	0.626	***	0.483	***	0.458	***
Emp. Density (1,000 per sq. mi.)	0.0002	***	0.0002	***	0.0002	***	0.0002	***	0.0003	***	0.0003	***	0.0002	***	0.0002	***
Pop. Density (1,000 per sq. mi.)	0.090	***	0.090	***	0.080	***	0.081	***	0.022	**	0.027	***	0.097	***	0.097	***
Accessibility Ratio	0.910	***	0.872	***	1.080	***	0.997	***	1.340	***	1.070	***	0.801	***	0.763	***
Dist. to highway (in mi)	-0.843	***	-0.845	***	-0.907	***	-0.911	***	-1.130	***	-1.160	***	-0.820	***	-0.821	***
Census Tract Data																
Percent Black	0.137		0.176		0.063		0.156		0.067		0.315		0.064		0.098	
Percent Hispanic	0.445	***	0.431	***	0.201		0.170		0.705	*	0.630	*	0.579	***	0.567	***
Median HH Income (in 1,000s)	0.004	***	0.005	***	0.003	***	0.003	***	-0.023	***	-0.023	***	0.003	***	0.003	***
Median Rent	0.000	***	0.000	***	0.000	***	0.000	***	0.001	***	0.001	***	0.000	***	0.000	***
Percent College Ed	1.090	***	1.110	***	1.050	***	1.110	***	2.630	***	2.870	***	1.230	***	1.260	***
Year variables not shown																
Constant	3.990	***	3.990	***	3.850	***	3.820	***	4.140	***	4.040	***	3.930	***	3.930	***
N	504,072		504,072		504,072		504,072		504,072		504,072		504,072		504,072	
Log-likelihood	-240,000		-240,000		-180,000		-180,000		-47,000		-47,000		-220,000		-220,000	
Chi2	57,425		57,509		42,047		42,154		8,512		8,584		60,939		61,010	

Figure 9 graphs the cumulative effect of straight-line distance and distance threshold coefficients as a function of distance from rail stations for each of the panel models[2]. Because the results for the model of all firms and the model of all firms with five or fewer employees are so similar, the graphs for these lines mostly overlap. The graph clearly shows the effect of being near a rail station on firm births is greatest for larger firms, particularly those with greater than five employees. This effect is positive and larger than for the other firms for distances from zero to a half-mile from a station. However, after a half-mile, there is a quick drop-off and the effect is negative (as it is for the other models).

Figure 9. Portland predicted effects of station distance variables



We also tested a reduced model with only the full set of distance to rail station variables, firm variables and dummy variables the year (excluding Census variables and other

[2] In each graph, we include all the distance variables not only the significant variables. We did separate graphs which included only the significant distance variables and the general patterns remains the same.

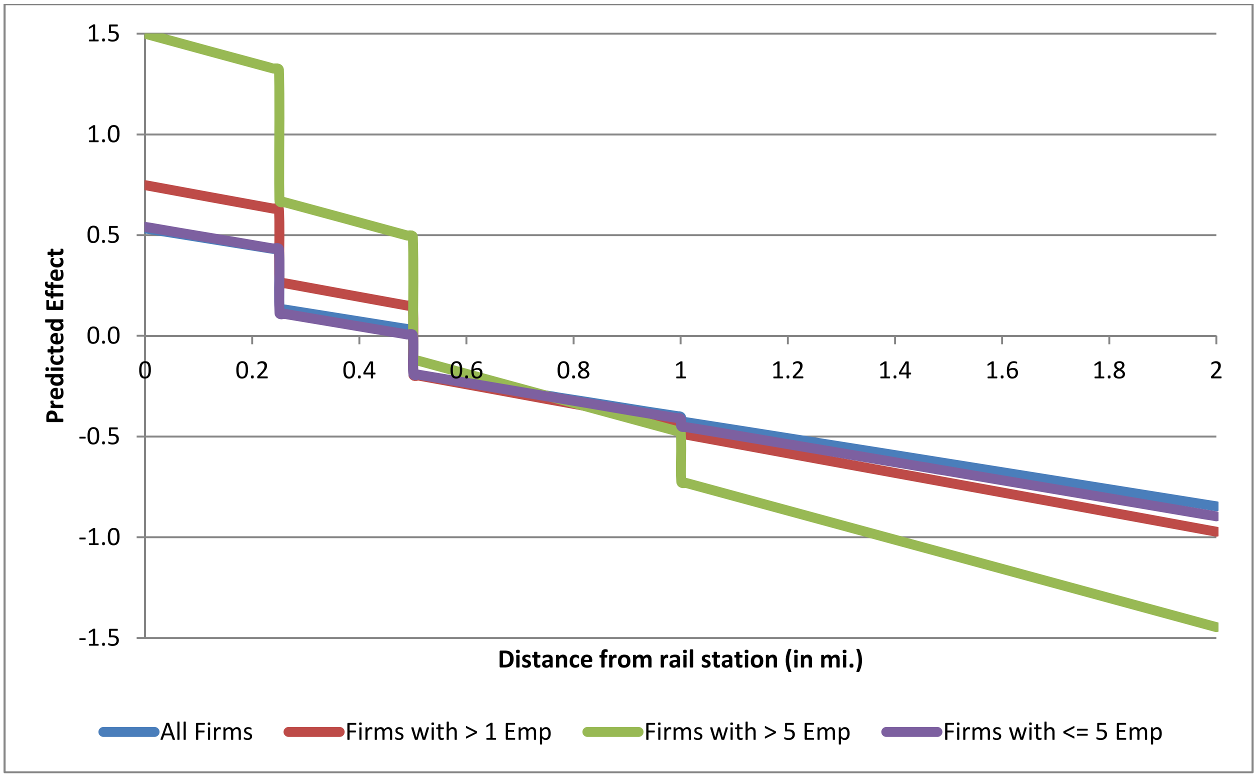
spatial data). Table 8 summarizes the model results.

In the reduced model, the model coefficients for all the distance variables are all larger than the same coefficients in the full model. With the exception of the distance threshold variable indicating that the block is between one-half and one-mile from a rail station, the signs on all the variables are all the same, though the size of the coefficient for this variable is small in both cases. The general pattern across models, in terms of how firm size affects the coefficients is the same; larger sized firms have greater associations with station proximity. Comparing the graphs of the predicted effect of the distance variables (Figure 10) shows how these differences translate into larger predicted effects. (Note that because the range of predicted values is larger in this reduced model than in the full model, the y-axis is different than the other graphs of predicted values). This suggests that in the analysis of Portland firm births, without the spatial and demographic control variables, our reduced model would over-estimate the effect of access to rail stations on the number of firm births.

Table 8. Portland model without spatial or demographic variables

	All Firms		Firms with > 1 Emp		Firms with > 5 Emp		Firms with <= 5 Emp	
Distance to Station								
Distance to station (in mi)	-0.423	***	-0.486	***	-0.723	***	-0.448	***
Station Distance >= 10 mi	-0.056	***	-0.052	***	-0.057	***	-0.061	***
<= 1/4 mi	0.533	***	0.748	***	1.500	***	0.541	***
1/4 to 1/2 mi	0.241	***	0.388	***	0.852	***	0.226	***
1/2 to 1 mi	0.021		0.051	*	0.245	***	0.036	
> 1 mi. (ref. cat.)								
Firm Variables								
Number of firms	0.007	***	0.010	***	0.042	***	0.010	***
Number of firm deaths	-0.007	***	-0.004	***	-0.024	***	-0.010	***
Year variables not shown								
Constant	5.230	***	5.090	***	5.360	***	5.160	***
N	504072		504072		504072		504072	
Log-likelihood	-240000		-180000		-49000		-230000	
Chi2	42911		30484		4493		47057	

Figure 10. Portland predicted effects of station distance variables without spatial or demographic variables



Our analysis of firm births for six specific industries in the Portland region suggests that locations near rail stations are positively associated with firm births for all of our industry categories, though the effect size varies. Table 9 summarizes the results of the final models for each industry classification and Figure 11**Error! Reference source not found.** graphs the predicted effect of the distance variables for each of the industry classifications.

The results suggest that being within a quarter mile from a rail station is positively associated with firm births for all six industry categories and the variable for this distance threshold is significant in all six models. However, the graph shows that this positive relationship between firm births and distance to a rail station declines quickly. Beyond a half-mile from a rail station, none of the six industry categories have a positive relationship. Further, blocks between one-half and one-mile from a rail station are not statistically significant in any of the models.

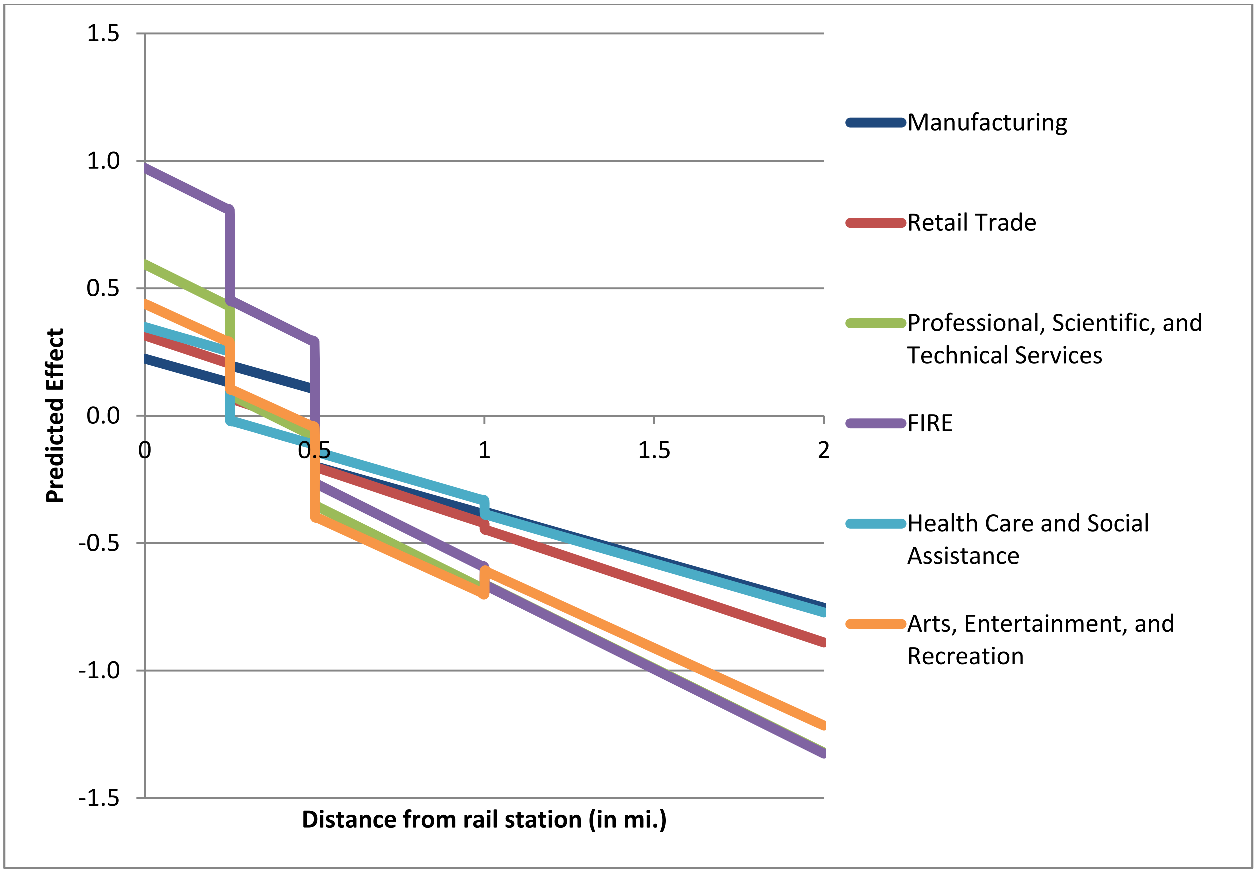
The graphs of the predicted effect of distance also show that the being near a rail station has the largest effect on firm births in FIRE industries (Finance and Insurance, and Real Estate and Rental and Leasing). The predicted effects are smallest for manufacturing and health care and social assistance.

Proximity to the CBD is most important for manufacturing firms and least important for health care and social assistance as well as for arts, entertainment, and recreation sectors. The accessibility ratio is highest for the retail trade sector and the FIRE sector. Highway access is also most important for the retail trade sector.

Table 9. Portland model results by NAICS category

	Manufacturing		Retail Trade		Professional, Scientific, and Technical Services		FIRE		Health Care and Social Assistance		Arts, Entertainment, and Recreation	
Distance to Station												
Distance to station (in mi)	-0.377	***	-0.445	***	-0.661	***	-0.663	***	-0.386	***	-0.608	***
Station Distance >= 10 mi	-0.018		0.000		-0.006		0.025	***	-0.013		-0.007	
<= 1/4 mi	0.224	*	0.315	***	0.594	***	0.972	***	0.348	***	0.439	***
1/4 to 1/2 mi	0.292	***	0.180	***	0.248	***	0.620	***	0.079		0.258	*
1/2 to 1 mi	-0.010		0.022		-0.020		0.068		0.053		-0.092	
> 1 mi. (ref. cat.)												
Firm Variables												
Number of firms	0.168	***	0.070	***	0.058	***	0.093	***	0.135	***	1.070	***
Number of firm deaths	-0.064	***	-0.028	***	-0.034	***	-0.033	***	-0.018		-0.689	***
Spatial Variables												
PDX CBD dist <= 2 mi	0.728	***	0.345	***	0.591	***	0.322	***	0.200	*	0.200	*
Emp. Density (1,000 per sq. mi.)	0.0006	***	0.0004	***	0.0002	***	0.0003	***	0.0005	***	0.0006	***
Pop. Density (1,000 per sq. mi.)	0.064	***	0.101	***	0.101	***	0.087	***	0.108	***	0.111	***
Accessibility Ratio	0.757	***	1.150	***	0.611	***	0.739	***	1.010	***	0.983	***
Dist. to highway (in mi)	-0.855	***	-0.973	***	-0.787	***	-0.967	***	-0.925	***	-0.718	***
Census Tract Data												
Percent Black	-0.293		-0.381		0.546	**	-0.641	*	0.495		0.956	**
Percent Hispanic	1.330	***	0.608	*	1.450	***	0.240		1.710	***	0.304	
Median HH Income (in 1,000s)	0.000	***	0.000	***	0.000		0.000	**	0.000	***	0.000	***
Median Rent	0.001	***	0.001	***	0.000	***	0.001	***	0.001	***	0.001	***
Percent College Ed	1.870	***	1.430	***	3.180	***	2.660	***	2.430	***	3.330	***
Year variables not shown												
Constant	3.650	***	3.410	***	2.930	***	3.130	***	3.180	***	3.360	***
N	504,072		504,072		504,072		504,072		504,072		504,072	
Log-likelihood	-27,000		-60,000		-64,000		-48,000		-34,000		-16,000	
Chi2	5,326		11,756		13,552		10,154		8,092		6,099	

Figure 11. Portland predicted effects of station distance variables by industry category



DALLAS

Unlike our analysis of firm births in Portland, our models for the Dallas region suggest that firm births are negatively correlated with being near rail stations, with the exception of the model of firms with greater than five employees. In addition, distance from a station has a smaller effect on firm births in Dallas compared with Portland. Table 10 summarizes the model results for the entire Dallas data set and for the data subsets.

Looking at the results for model A for the analysis of all firms, we can see that the coefficient for distance to station is negative, indicating that firm births decrease as the distance from the nearest rail station increases. In model B, when we add distance thresholds to examine the effects near rail stations, we find that the coefficients for the distance thresholds are all negative and significant. This implies that blocks within one-mile of a rail station have fewer firm births than blocks further than one-mile from the rail station. The coefficients for blocks within a quarter-mile from the nearest rail station is -0.124, suggesting that blocks in this ring have 12 percent fewer firm births compared with the reference category, blocks further than one-mile from the nearest rail station.

There a few notable differences between the all firms model those for other firm sizes. Looking at model B for firms larger than one employee, the coefficient for distance to station is slightly stronger (more negative) than the model of the entire dataset (-0.179 compared with -0.131) and all three distance thresholds are significant and negative (-0.05, -0.16 and -0.142) suggesting that blocks within a quarter mile have 5 percent fewer firm births, blocks between one-quarter and one-half mile have 15 percent fewer firms and blocks between one-half and one-mile from a rail station have 13 percent fewer firm births compared with blocks further than one-mile from the nearest rail station.

The model of larger firms, those with greater than five employees, suggests that blocks near rail stations are associated with more firm births rather than fewer, unlike the models of smaller firm births. In model B, the coefficient measuring distance to rail station is much larger than the model for all firms (-0.244 compared with -0.131) and the distance threshold indicating that a block is within one-quarter mile of a station is positive and significant (0.183). This suggests that for these larger firms, blocks within a quarter mile of a rail station have 20.1 percent more firm births than blocks greater than a mile from a rail station. Among the Dallas models, this is the only distance threshold variable that is positive and significant.

Turning to the other variables, we find that the number of firms in the block is positively correlated with firm births (0.004) while the number of firm deaths is negatively correlated (-0.001). These effects are larger for the firms with more than five employees. Blocks that are within two miles of the center of the CBD in Dallas or Fort Worth are both positively associated with more firm births, with those near the Dallas CBD having a greater impact than those near the Fort Worth CBD (we tested these two CBD coefficients and they are not significantly different from each other). This coefficient also increases in value for the models with larger firms. Additionally, population and employment densities and the accessibility ratio are all positively associated with more firm births; the employment density parameter value is quite small, suggesting this is not substantively important, similar to the Portland results.

The accessibility ratio shows that the importance of transit is greater for larger firms. Overall, however, the parameter value is less than in our Portland models, so transit access relative to highway access is less critical in Dallas. Interestingly, the highway distance parameter, while significant, has a lower negative value than in the Portland models. This may be because the arterial road system in Dallas is likely more extensive than in Portland, so access to major highways may be less important.

For our Census variables, the percent of the tract population that identify as Black has a positive coefficient except for the model with firms greater than five employees. Percent Hispanic has a lower level of statistical significance, is general negative, but is not statistically significant in the model with larger firms. Median household income and median rent, while statistically significant, have very small parameter values and are thus not substantively important. Percent of the tract population with college educations is positively associated with firm births and has more of an effect for larger firms; this is similar to the Portland result, but in these models the coefficient value is substantially smaller than in the Portland results, suggesting human capital matters less for new firms in Dallas relative to Portland.

Finally, we analyzed a model of smaller firms, those with five or fewer employees. Just as we found in Portland, the coefficients for the model of smaller firms and the model of the full data set are fairly similar. In model B, the coefficients for the distance thresholds are all negative and significant suggesting blocks near rail stations have fewer small firm births compared with blocks further from rail stations. Holding all else equal, blocks within a quarter-mile from the nearest rail station have 12 percent fewer small firm births, blocks between one quarter and one-half mile have 15 percent fewer small firm births and blocks between one-half and one-mile have 12 percent fewer firm births compared with the reference category, blocks further than one-mile from the nearest rail station. The remaining variables are all similar to the model of the full dataset.

As we did with the Portland analysis, we also conducted an analysis of firms with 20 or fewer employees. Because these results are very similar to those for the full data set, we do not show these results.

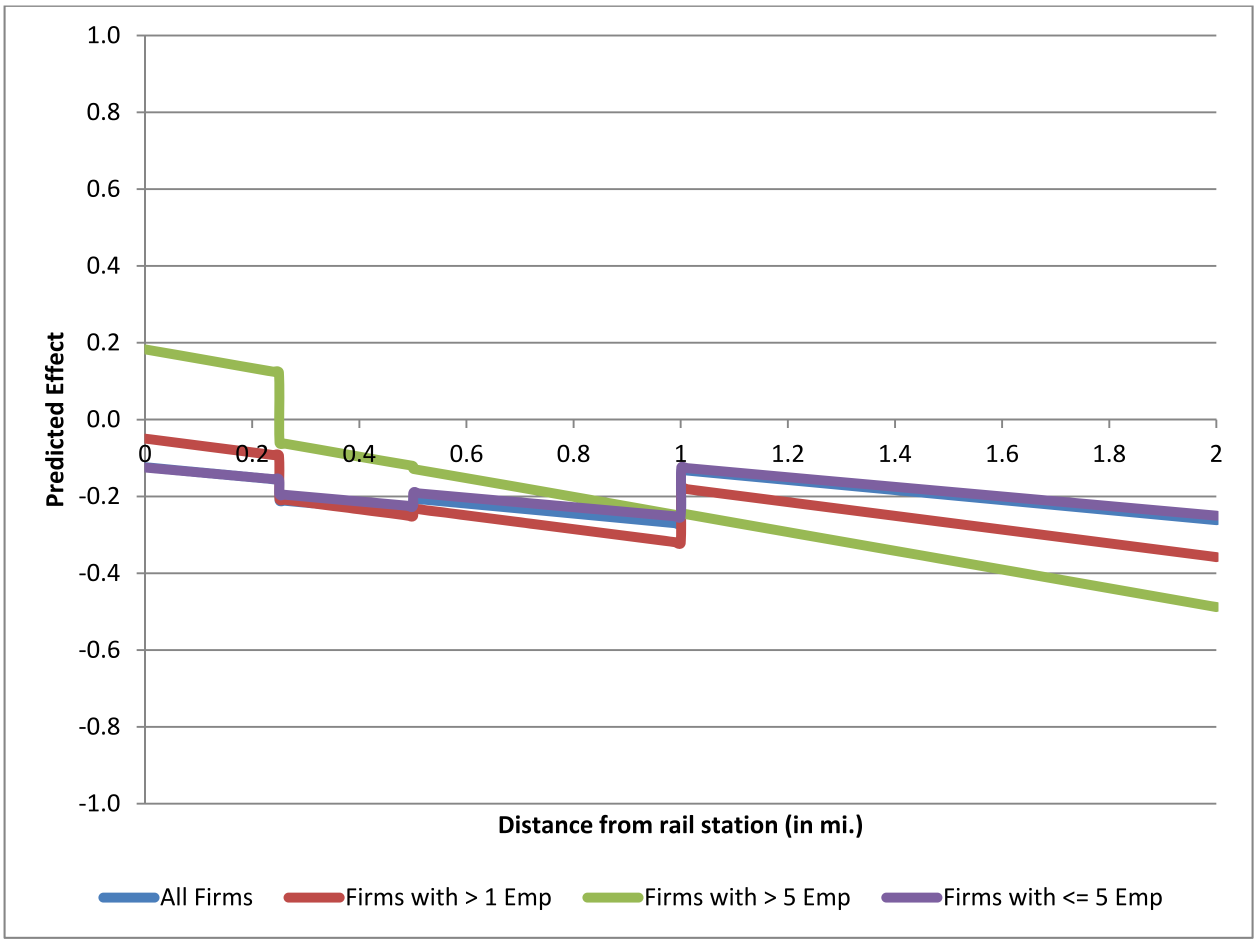
Table 10. Dallas negative binomial model coefficients

	All Firms				Firms with > 1 Emp				Firms with > 5 Emp				Firms with <= 5 Emp			
	Model A		Model B		Model A		Model B		Model A		Model B		Model A		Model B	
Distance to Station																
Distance to station (in mi)	-0.159	***	-0.131	***	-0.206	***	-0.179	***	-0.237	***	-0.244	***	-0.150	***	-0.125	***
Station Distance >= 10 mi	0.040	***	0.032	***	0.043	***	0.036	***	0.043	***	0.045	***	0.037	***	0.030	***
<= 1/4 mi			-0.124	***			-0.050				0.183	***			-0.125	***
1/4 to 1/2 mi			-0.177	***			-0.162	***			0.001				-0.163	***
1/2 to 1 mi			-0.140	***			-0.142	***			-0.006				-0.128	***
> 1 mi. (ref. cat.)																
Firm Variables																
Number of firms	0.004	***	0.004	***	0.004	***	0.004		0.023	***	0.023	***	0.005	***	0.005	***
Number of firm deaths	-0.001	***	-0.001	***	0.000		0.000		-0.012	***	-0.012	***	-0.002	***	-0.002	***
Spatial Variables																
DAL CBD dist <= 2 mi	1.050	***	1.090	***	1.260	***	1.290	***	1.530	***	1.530	***	0.967	***	0.999	***
FTW CBD dist <= 2 mi	0.766	***	0.804	***	0.873	***	0.899	***	1.110	***	1.080	***	0.725	***	0.761	***
Emp. Density (1,000 per sq. mi.)	0.0002	***	0.0002	***	0.0003	***	0.0003	***	0.0002	***	0.0002	***	0.0003	***	0.0003	***
Pop. Density (1,000 per sq. mi.)	0.107	***	0.108	***	0.102	***	0.103	***	0.046	***	0.047	***	0.112	***	0.112	***
Accessibility Ratio	0.356	***	0.400	***	0.473	***	0.508	***	0.841	***	0.837	***	0.283	***	0.325	***
Dist. to highway (in mi)	-0.296	***	-0.296	***	-0.386	***	-0.386	***	-0.665	***	-0.664	***	-0.272	***	-0.272	***
Census Tract Data																
Percent Black	0.232	***	0.211	***	0.164	***	0.149	***	-0.319	***	-0.297	***	0.210	***	0.192	***
Percent Hispanic	-0.043		-0.074	*	-0.093	*	-0.118	**	-0.129		-0.108		-0.055		-0.084	*
Median HH Income (in 1,000s)	0.004	***	0.004	***	0.005	***	0.005	***	-0.005	***	-0.004	***	0.004	***	0.004	***
Median Rent	0.000	***	0.000	***	0.000	***	0.000	***	0.001	***	0.001	***	0.000	***	0.000	***
Percent College Ed	0.556	***	0.517	***	0.501	***	0.466	***	1.090	***	1.080	***	0.707	***	0.670	***
Year variables not shown																
Constant	1.320	***	1.330	***	1.000	***	1.010	***	-0.498	***	-0.502	***	1.450	***	1.460	***
N	1,090,458		1,090,458		1,090,458		1,090,458		1,090,458		1,090,458		1,090,458		1,090,458	
Log-likelihood	-640,000		-640,000		-500,000		-500,000		-140,000		-140,000		-600,000		-600,000	
Chi2	110,000		110,000		70,440		70,487		15,416		15,439		120,000		120,000	

Figure 12 graphs the cumulative effect of straight-line distance and distance thresholds coefficients as a function of distance from rail stations for each of the panel models for Dallas. Comparing this graph with the same graph for Portland (Figure 9), we can clearly see that in both cases, the relationship between station distance and firm births is strongest for the largest firms (those with greater than five employees).

In addition, compared with Portland, the slope for the lines in the Dallas graph are smaller, indicating that distance from a rail station has a smaller effect in the Dallas region compared with Portland. More importantly, the lines are mainly below zero suggesting that firm births are more likely away from the transit station, except for larger firms. The overall predicted effect of the distance coefficients in Dallas range from 0.2 to -0.4 compared with 0.6 to -0.85 in Portland.

Figure 12. Dallas predicted effects of station distance variables

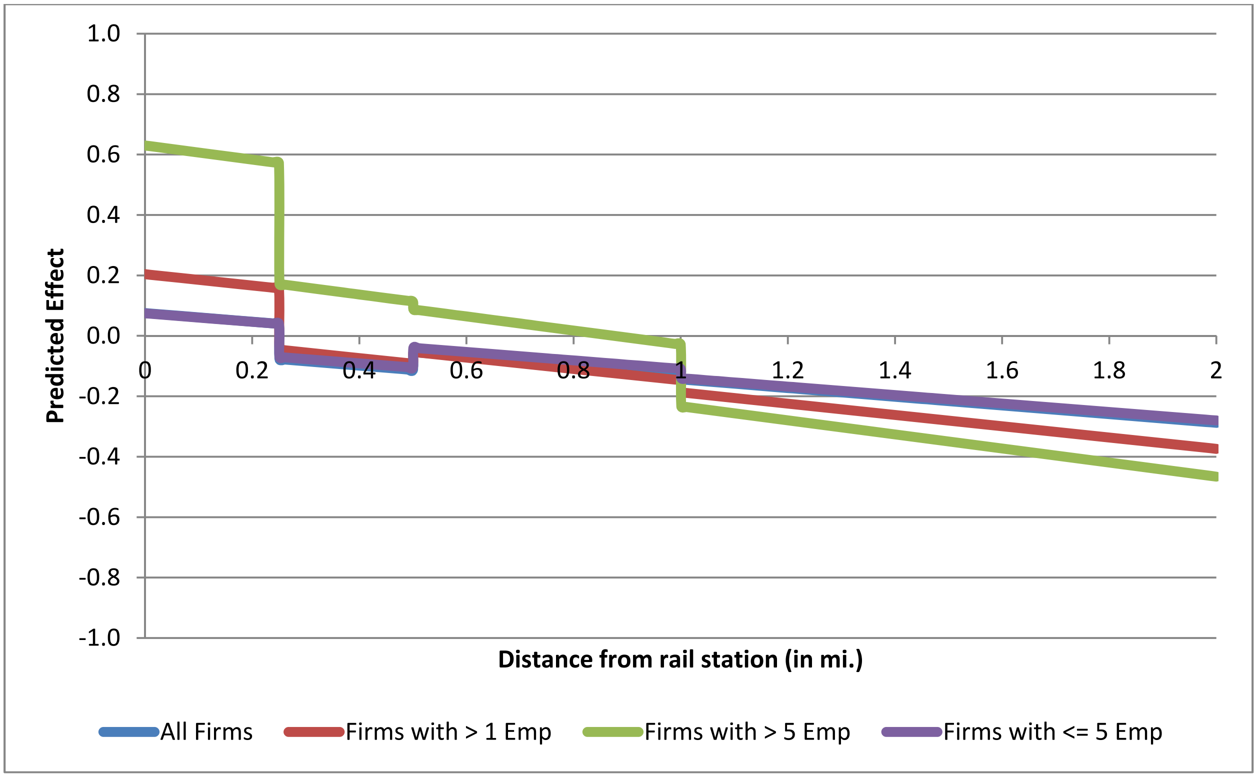


Once again, we also compared the full model to a reduced model that omitted spatial and demographic variables. Table 11 and Figure 13 summarize the results of the reduced model. The reduced model results show a larger effect of locating near rail stations, compared with the full model. Further, blocks located within a quarter mile of a rail station are significant and positively associated with firm births in all of the reduced models whereas this was only true in the case of larger firms when we ran the full model. Comparing the graphs of the predicted effects of station distance on firm births for the full and reduced models, Figure 12 and Figure 13, suggest that without the additional demographic and spatial control variables, our models would overestimate the effect of rail station proximity on firm births and assume a positive rather than a negative effect for all but larger firms.

Table 11. Dallas model without spatial or demographic variables

	All Firms		Firms with > 1 Emp		Firms with > 5 Emp		Firms with <= 5 Emp	
Distance to Station								
Distance to station (in mi)	-0.144	***	-0.187	***	-0.233	***	-0.140	***
Station Distance >= 10 mi	0.025	***	0.027	***	0.025	***	0.022	***
<= 1/4 mi	0.076	**	0.204	***	0.630	***	0.074	**
1/4 to 1/2 mi	-0.041		0.001		0.230	***	-0.035	
1/2 to 1 mi	0.018		0.040	**	0.204	***	0.031	*
> 1 mi. (ref. cat.)								
Firm Variables								
Number of firms	0.004	***	0.004	***	0.024	***	0.006	***
Number of firm deaths	-0.001	***	-0.001	***	-0.013	***	-0.003	***
Year variables not shown								
Constant	4.020	***	4.050	***	4.440	***	3.950	***
N	1,090,548		1,090,548		1,090,548		1,090,548	
Log-likelihood	-650,000		-510,000		-140,000		-610,000	
Chi2	100,000		59,680		10,890		110,000	

Figure 13. Dallas predicted effects of station distance variables without spatial or demographic variables



Our analysis of firm births by industry category in Dallas suggests a mixed relationship between firm births and distance from rail stations. For a few industries, being near a rail station is positively associated with firm births. With the exception of the arts, entertainment and recreation industry, the distance coefficients are smaller in Dallas model compared with Portland.

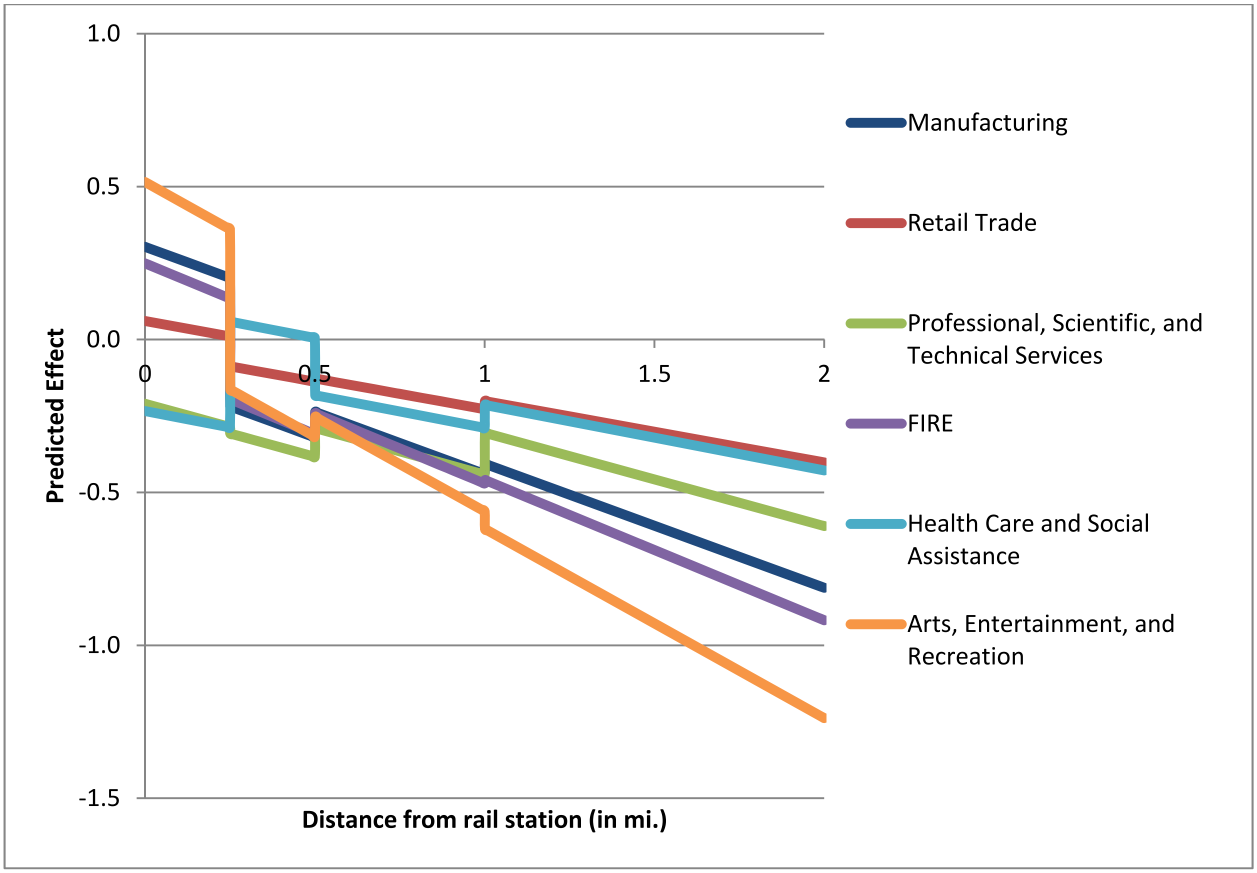
Figure 14 graphs the predicted effect of the distance variables for the six industry classifications for Dallas. In the Dallas region, being near a rail station has the largest effect on firm births for arts, entertainment and recreation firms followed by FIRE and manufacturing firms. The smallest effect is for health care and social assistance firms.

The graphs suggest that locating within a quarter mile from a rail station is positively associated with firm births in all the industries except two: professional, scientific and technical services and health care and social assistance. Beyond a quarter-mile, firm births are negatively associated with distance from a rail station with the exception of health care and social assistance (though this distance threshold is not statistically significant). These results differ from those for Portland where all sectors had more firm births in proximity to stations and the manufacturing sector had the smallest association with station proximity.

Table 12. Dallas model results by NAICS category

	Manufacturing		Retail Trade		Prof., Scientific,		FIRE		Health Care and		Arts,	
Distance to Station												
Distance to station (in mi)	-0.406	***	-0.201	***	-0.305	***	-0.459	***	-0.214	***	-0.619	***
Station Distance >= 10 mi	0.021	***	0.018	***	0.028	***	0.020	***	0.012	**	0.008	
<= 1/4 mi	0.303	***	0.060		-0.210	***	0.249	***	-0.234	**	0.515	***
1/4 to 1/2 mi	-0.117		-0.037		-0.231	***	-0.080		0.112		-0.008	
1/2 to 1 mi	-0.034		-0.027		-0.137	***	-0.012		-0.075		0.057	
> 1 mi. (ref. cat.)												
Firm Variables												
Number of firms	0.122	***	0.016	***	0.035	***	0.034	***	0.081	***	0.472	***
Number of firm deaths	-0.104	***	-0.013	***	-0.019	***	-0.025	***	0.028	***	-0.299	***
Spatial Variables												
DAL CBD dist <= 2 mi	0.935	***	0.462	***	1.400	***	1.250	***	1.590	***	1.050	***
FTW CBD dist <= 2 mi	0.763	***	0.439	***	1.100	***	0.794	***	0.706	***	0.880	***
Emp. Density (1,000 per sq. mi.)	0.001	***	0.001	***	0.000	***	0.000	***	0.001	***	0.001	***
Pop. Density (1,000 per sq. mi.)	0.051	***	0.097	***	0.101	***	0.106	***	0.143	***	0.108	***
Accessibility Ratio	0.437	***	0.258	***	0.415	***	0.326	***	0.077		0.159	**
Dist. to highway (in mi)	-0.366	***	-0.393	***	-0.317	***	-0.501	***	-0.469	***	-0.410	***
Census Tract Data												
Percent Black	0.012		0.282	***	0.079		0.040		0.945	***	0.338	***
Percent Hispanic	0.313	***	0.500	***	0.299	***	0.351	***	0.537	***	0.326	**
Median HH Income (in 1,000s)	0.000	*	0.000		0.000	***	0.000	***	0.000	***	0.000	***
Median Rent	0.001	***	0.001	***	0.001	***	0.001	***	0.001	***	0.001	***
Percent College Ed	1.010	***	0.742	***	2.400	***	2.470	***	1.820	***	1.980	***
Year variables not shown												
Constant	3.710	***	3.160	***	2.610	***	3.070	***	2.490	***	3.160	
N	1,090,458		1,090,458		1,090,458		1,090,458		1,090,458		1,090,458	
Log-likelihood	-79,000		-210,000		-170,000		-140,000		-90,000		-46,000	
Chi2	7,927		22,237		20,178		18,038		12,168		8,861	

Figure 14. Dallas predicted effects of station distance variables by industry category



VII. DISCUSSION AND CONCLUSIONS

The analysis presented here highlights that there can be major differences in the association between new firm births and proximity to new and growing transit systems. Both Portland and Dallas have relatively new and extensive light rail systems as well as commuter rail, yet our results show that new firms tend to cluster around stations in the Portland region but not in the Dallas-Ft. Worth region. Why there is a difference between these two cities is important for urban and transportation planners to understand, as our working assumption is that new firms generate regional growth and that clustering of these firms can lead to external agglomeration benefits.

The simple answer is that Portland has been more pro-active in focusing development both around their transit stations and within the CBD. Policies complementary to this include maximum parking caps in the CBD and an urban growth boundary to control and focus development in the core. Dallas is almost the opposite, with no comprehensive planning around transit and ample parking in the CBD. This suggests that fully maximizing the benefits of a transit network, in terms of promoting new firm growth and clustering of those firms, requires coordinated planning effort and supportive policies.

The difference between the two regions holds for different firm sizes, and different industrial sectors. In all cases, there is a much stronger association with transit proximity and new firm birth in the Portland region compared to the Dallas-Ft. Worth region. In both regions, births of larger firms tend to be associated with greater proximity to transit stations, perhaps reflecting the greater agglomeration benefits that they receive.

REFERENCES

Anas, Alex, Richard Arnott, and Kenneth A. Small. 1998. "Urban Spatial Structure." *Journal of Economic Literature* 36 (3): 1426-1464.

Chatman, Daniel G. and Robert B. Noland. 2013. "Transit Improvements, Physical Agglomeration, and Productivity in US Metropolitan Areas." *Urban Studies*.

Chatman, Daniel G., Robert B. Noland, Nicholas K. Tulach, Bryan P. Grady, Kaan Ozbay, Lars Rognlien, Andrew Desautels, et al. 2012. *Methodology for Determining the Economic Development Impacts of Transit Projects*. Washington, DC: Transportation Research Board.

Coyne, Christopher J., Russell S. Sobel, and John A. Dove. 2010. "The Non-Productive Entrepreneurial Process." *The Review of Austrian Economics* 23 (4): 333-346.

Dallas Area Rapid Transit. "DART Facts.", accessed July 24, 2013, http://www.dart.org/about/dartfacts.asp.

———. "DART History.", accessed July 24, 2013, http://www.dart.org/about/history.asp.

Duranton, Gilles and Diego Puga. 2001. "Nursery Cities: Urban Diversity, Process Innovation, and the Life Cycle of Products." *American Economic Review*: 1454-1477.

Guimarães, Paulo, Octávio Figueirdo, and Douglas Woodward. 2003. "A Tractable Approach to the Firm Location Decision Problem." *Review of Economics and Statistics* 85 (1): 201-204.

Hausman, Jerry A., Bronwyn H. Hall, and Zvi Griliches. 1984. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship." *Econometrica* 52: 909-938.

Holl, Adelheid. 2004. "Manufacturing Location and Impacts of Road Transport Infrastructure: Empirical Evidence from Spain." *Regional Science and Urban Economics* 34 (3): 341-363.

———. 2004. "Start-ups and Relocations: Manufacturing Plant Location in Portugal." *Papers in Regional Science* 83 (4): 649-668.

———. 2004. "Transport Infrastructure, Agglomeration Economies, and Firm Birth: Empirical Evidence from Portugal." *Journal of Regional Science* 44 (4): 693-712.

Jacobs, Jane. 1969. *The Economy of Cities*. New York: Random House.

Jun, Myung-Jin. 2008. "Are Portland's Smart Growth Policies Related to Reduced Automobile Dependence?" *Journal of Planning Education and Research* 28 (1): 100-107.

Kangasharju, Aki. 2000. "Regional Variations in Firm Formation: Panel and cross-section Data Evidence from Finland." *Papers in Regional Science* 79 (4): 355-373.

Kim, Hyungtai, Paul Waddell, Venkataraman N. Shankar, and Gudmundur F. Ulfarsson. 2008. "Modeling Micro-Spatial Employment Location Patterns: A Comparison of Count and Choice Approaches." *Geographical Analysis* 40 (2): 123-151.

Melo, Patricia C., Daniel J. Graham, and Robert B. Noland. 2010. "Impact of Transport Infrastructure on Firm Formation." *Transportation Research Record: Journal of the Transportation Research Board* 2163 (1): 133-143.

Mukhija, Vinit and Donald Shoup. 2006. "Quantity Versus Quality in Off-Street Parking Requirements." *Journal of the American Planning Association* 72 (3): 296-308.

Reynolds, Paul. 1994. "Autonomous Firm Dynamics and Economic Growth in the United States, 1986–1990." *Regional Studies* 28 (4): 429-442.

Reynolds, Paul, David J. Storey, and Paul Westhead. 1994. "Cross-National Comparisons of the Variation in New Firm Formation Rates." *Regional Studies* 28 (4): 443-456.

Santarelli, Enrico and Marco Vivarelli. 2007. "Entrepreneurship and the Process of Firms' Entry, Survival and Growth." *Industrial and Corporate Change* 16 (3): 455-488.

Shukla, Vibhooti and Paul Waddell. 1991. "Firm Location and Land use in Discrete Urban Space: A Study of the Spatial Structure of Dallas-Fort Worth." *Regional Science and Urban Economics* 21 (2): 225-253.

Sutaria, Vinod and Donald A. Hicks. 2004. "New Firm Formation: Dynamics and Determinants." *The Annals of Regional Science* 38 (2): 241-262.

TriMet. "Facts about TriMet.", accessed July 24, 2013, http://trimet.org/pdfs/publications/factsheet.pdf.

———. "The TriMet Story.", accessed July 24, 2013, http://trimet.org/about/history/trimet_story.htm.

van Oort, Frank G. and Niels S. Bosma. 2013. "Agglomeration Economies, Inventors and Entrepreneurs as Engines of European Regional Economic Development."

The Annals of Regional Science 51: 213-244.

Waddell, Paul, Gudmundur F. Ulfarsson, Joel P. Franklin, and John Lobb. 2007. "Incorporating Land use in Metropolitan Transportation Planning." *Transportation Research Part A: Policy and Practice* 41 (5): 382-410.

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