MINETA NATIONAL TRANSIT RESEARCH CONSORTIUM

Transit Access and the Agglomeration of New Firms: A Case Study of Portland and Dallas

MNTRC Report 12-15

MNTRC
MINETA NATIONAL TRANSIT RESEARCH CONSORTIUM

RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

MINETA TRANSPORTATION INSTITUTE
LEAD UNIVERSITY OF MNTRC

The Norman Y. Mineta International Institute for Surface Transportation Policy Studies was established by Congress in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The Institute's Board of Trustees revised the name to Mineta Transportation Institute (MTI) in 1996. Reauthorized in 1998, MTI was selected by the U.S. Department of Transportation through a competitive process in 2002 as a national "Center of Excellence." The Institute is funded by Congress through the United States Department of Transportation's Research and Innovative Technology Administration, the California Legislature through the Department of Transportation (Caltrans), and by private grants and donations.

The Institute receives oversight from an internationally respected Board of Trustees whose members represent all major surface transportation modes. MTI's focus on policy and management resulted from a Board assessment of the industry's unmet needs and led directly to the choice of the San José State University College of Business as the Institute's home. The Board provides policy direction, assists with needs assessment, and connects the Institute and its programs with the international transportation community.

MTI's transportation policy work is centered on three primary responsibilities:

Research

MTI works to provide policy-oriented research for all levels of government and the private sector to foster the development of optimum surface transportation systems. Research areas include: transportation security; planning and policy development; interrelationships among transportation, land use, and the environment; transportation finance; and collaborative labor-management relations. Certified Research Associates conduct the research. Certification requires an advanced degree, generally a Ph.D., a record of academic publications, and professional references. Research projects culminate in a peer-reviewed publication, available both in hardcopy and on TransWeb, the MTI website (http://transweb.sjsu.edu).

Education

The educational goal of the Institute is to provide graduate-level education to students seeking a career in the development and operation of surface transportation programs. MTI, through San José State University, offers an AACSB-accredited Master of Science in Transportation Management and a graduate Certificate in Transportation Management that serve to prepare the nation's transportation managers for the 21st century. The master's degree is the highest conferred by the California State University system. With the active assistance of the California Department of Transportation, MTI delivers its classes over a state-of-the-art videoconference network throughout the state of California and via webcasting beyond, allowing working transportation professionals to pursue an advanced degree regardless of their location. To meet the needs of employers seeking a diverse workforce, MTI's education program promotes enrollment to under-represented groups.

Information and Technology Transfer

MTI promotes the availability of completed research to professional organizations and journals and works to integrate the research findings into the graduate education program. In addition to publishing the studies, the Institute also sponsors symposia to disseminate research results to transportation professionals and encourages Research Associates to present their findings at conferences. The World in Motion, MTI's quarterly newsletter, covers innovation in the Institute's research and education programs. MTI's extensive collection of transportation-related publications is integrated into San José State University's world-class Martin Luther King, Jr. Library.

REPORT 12-15

TRANSIT ACCESS AND THE AGGLOMERATION OF NEW FIRMS: A CASE STUDY OF PORTLAND AND DALLAS

Robert B. Noland, Ph.D.
Daniel G. Chatman, Ph.D.
Nicholas J. Klein, Ph.D.

June 2014

A publication of

Mineta National Transit Research Consortium

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. CA-MNTRC-14-1145	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Transit Access and the Agglomeration of New Firms: A Case Study of Portland and Dallas		**5. Report Date** June 2014
		6. Performing Organization Code
7. Authors Robert B. Noland, Ph.D., Daniel G. Chatman, Ph.D., and Nicholas J. Klein, Ph.D.		**8. Performing Organization Report** MNTRC Report 12-15
9. Performing Organization Name and Address Mineta National Transit Research Consortium College of Business San José State University San José, CA 95192-0219		**10. Work Unit No.**
		11. Contract or Grant No. DTRT12-G-UTC21
12. Sponsoring Agency Name and Address U.S. Department of Transportation Research & Innovative Technology Administration 1200 New Jersey Avenue, SE Washington, DC 20590	Edward J. Bloustein School of Planning and Public Policy Rutgers, The State University of New Jersey 33 Livingston Avenue New Brunswick, NJ 08901	**13. Type of Report and Period Covered** Final Report
		14. Sponsoring Agency Code
15. Supplemental Notes		

16. 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 geocoded, 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 between 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.

17. Key Words Firm formation; Agglomeration; Transit; Accessibility; Urban economics	**18. Distribution Statement** No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 50	**22. Price** $15.00

Form DOT F 1700.7 (8-72)

Library of Congress Catalog Card Number:
2014941473

To order this publication, please contact:

Mineta National Transit Research Consortium
College of Business
San José State University
San José, CA 95192-0219

Tel: (408) 924-7560
Fax: (408) 924-7565
Email: mineta-institute@sjsu.edu

http://transweb.sjsu.edu/mntrc/

061314

ACKNOWLEDGMENTS

The genesis of this research began with work we conducted for the Transit Cooperative Research Program (TCRP) and we would like to thank the support of the TCRP H39 panel and Larry Goldstein who managed the project. The data used in this research was originally purchased for the TCRP H39 project. Bryan Grady conducted some of the first analysis of the data. Arash Mirzaei, Hua Yang, and Zhen Ding at the North Central Texas Council of Governments provided data and information on the transit network in Dallas. Aaron Breakstone at Metro provided data and information for the Portland transit network. Nicholas Tulach provided GIS support in the early stages of this work. Additional funding was also provided by the region 2 University Transportation Center and we acknowledge the support of the Bloustein School at Rutgers University in providing matching funding.

The authors also thank MTI staff, including Deputy Executive Director and Research Director Karen Philbrick, Ph.D.; Director of Communications and Technology Transfer Donna Maurillo; Research Support Manager Joseph Mercado; and Webmaster Frances Cherman who also provided additional editorial and publication support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

A major impetus for metropolitan areas developing new transit systems or expanding existing ones is to spur economic development within the region. Economic growth can be stimulated through a variety of mechanisms. Rail transit, in particular, is held to be a source of economic growth and development. An important question is whether—and, if so, how—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 the density of firms and employment within station areas.

This study analyzes whether new firms are more likely to form near rail transit stations. Two relatively new light-rail systems—in Portland, Oregon, and Dallas, Texas—were selected for examination. A large, time-series database of firm births for the period 1991–2008 provided the data. Specific industry sectors and a variety of firm sizes were targeted with two objectives: 1) to determine what association, if any, exists between the opening of new light-rail stations and the births of new firms in the area, and 2) to identify contextual differences between the two cities that may account for any differences in the results.

The National Establishment Time-Series (NETS) dataset, derived from Dun & Bradstreet records, was used as a data source. The database includes information on firm size, industrial category, dates of firm birth and death, and location. The NETS data were used to develop a geographically specific dataset that includes firm location relative to rail transit stations. The availability of 18 years of time-series data made it possible to evaluate how firm births within those regions have changed over time and how births of firms may be influenced by proximity to new rail stations. The analysis examines firms of various sizes—including those with only one employee (i.e., a sole proprietor), those with five or fewer employees, and larger firms—and across a variety of specific industry sectors. A random effects, negative-binomial regression model was used to examine associations between proximity to rail stations, transit and auto accessibility, and local (block-level) measures of agglomeration 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.

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 proximity to the rail station. The difference between the two regions holds for different firm sizes and across sectors. Agglomeration benefits are apparent in both regions, as births of larger firms have stronger associations with transit proximity. The stronger effect on births of firms with five or more employees 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 the sharing of knowledge. However, 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. It is important for urban and transportation planners to understand the source of these differences since new firms may be an important driver of regional growth, and clustering of these firms can lead to external agglomeration benefits.

Portland has adopted more stringent policies than Dallas-Ft. Worth in focusing development near rail stations and within the CBD. These include 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 both in the CBD and elsewhere, some of which naturally occurs near rail stations,. By contrast, Dallas has no comprehensive planning around transit, and there is ample parking in the CBD. Portland's transit system also provides relatively better access than does the Dallas system, with a much higher mode share for all transit ridership and a higher mode share of rail. Both factors likely increase the attractiveness of rail station areas to firm startups.

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 farther 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 potentially necessary condition for economic growth and 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, firms of various sizes, and firms in a variety of sectors. The analysis aims to show the variations that occur but also to highlight the substantial differences found in the two metropolitan case studies.

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 the individual has acquired 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 the churn and turbulence 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 individuals’ intent 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 an increase in 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 the size of existing firms; theoretically this is based on the assumption that existing firms are “seedbeds for future entrepreneurs,” that is, places where employees acquire the skills to start their own firms (Kangasharju 2000, 355-373). Another study examined the birth of manufacturing firms in Texas (Sutaria and Hicks 2004, 241-262). They found that the presence of more large firms leads to more firm births; but rather than argue that these larger firms spin off entrepreneurs, they argue that the new firms 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 firms 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; 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 (Anas, Arnott, and Small 1998, 1426-1464). 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; 2004, 693-712; 2004, 649-668) modeled firm births in both Spain and Portugal 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 to 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 than relocated firms on local market conditions, 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.

This 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 both are included in the 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, the Green line in 2009, and the Orange line 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 covers 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: Portland streetcar, MAX light rail, and Westside Express Service (WES) Commuter Rail line. This analysis includes only the MAX light-rail network, as the WES Commuter Rail opened in 2009. The first MAX light-rail line, the Blue Line, opened initially in 1986 and was expanded in 1998. The Red (airport) Line opened in 2001, the Yellow Line in 2004, and the Green Line in 2009 (TriMet). In total, the MAX system serves 85 stations along 52 route-miles. In FY2011, MAX averaged 126,800 weekday boardings (compared with an average of 190,300 weekday trips on TriMet buses and 1,450 trips on WES) (TriMet).

Over the 20 years of the time series, the economies of the Portland and Dallas region have shown a significant divergence. Median income levels in Portland have increased while those in Dallas have decreased. While both regions have seen a decrease in median income since the Great Recession, the decrease in Dallas has led to a median income level below that of 1990 (Table 1).

Table 1. Median Income Changes in the Portland and Dallas Regions (Adjusted to 2008 Dollars)

	Portland	Dallas
1990	$53,800	$56,800
2000	$60,700	$60,900
2008	$59,300	$54,500

Both regions have grown in population. Portland grew from 1.2 million in 1990 to 1.6 million in 2008, while Dallas saw faster population growth of about 50% from 3.3 to 4.9 million.

Table 2 shows employment fractions in the four largest industrial sectors for each region and how these have changed over time. For both regions, the manufacturing sectors have seen the largest reduction in employment, and Portland has marginally more employment in manufacturing than does Dallas. The manufacturing industry provides the largest share of employment in Portland, but it is exceeded in Dallas by the combined sectors for real estate, professional, management and administration, information, and FIRE (Finance, Insurance, Real Estate, Rental, and Leasing). In both regions these combined sectors have stayed relatively stable in terms of their share of total employment. The wholesale/retail trade and transportation/warehousing sector has grown in both regions, more so in Portland as a fraction of total employment. The education, health care, and social assistance sector has grown substantially in the Dallas region, less so in Portland.

These changes are relatively minor, except the reduction in manufacturing employment. The fundamental sources of employment in both regions appear similar with only minor differences. These differences are unlikely to affect the results of the analysis presented below.

Table 2. Share of Employment in the Major Industrial sectors in the Portland and Dallas Regions

	Portland		Dallas	
	1990	2008	1990	2008
Manufacturing (31-33)	31.51%	24.91%	28.68%	21.84%
Information, FIRE, Real Estate, Professional, Management, Administrative (51-56)	27.34%	28.04%	26.33%	26.69%
Wholesale and Retail Trade, Transportation and Warehousing (42, 44-45, 48-49)	16.63%	19.34%	18.07%	19.11%
Education, Health Care and Social Assistance	10.00%	11.97%	10.79%	14.84%

Note: NAICS are in parentheses.

A case study of planning in the Dallas region found no significant planning to encourage station area development (Chatman et al. 2012). This may be 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 parking. Yet, according to case study research, many developers perceive parking as undersupplied (Chatman et al. 2012).

By 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 (TriMet), 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 studied Portland counties is much smaller—only 1.6 million persons and 645,000 housing units. The majority of Dallas residents fall into one or more minority groups, while almost three-quarters of Portland's population identify as Non-Hispanic White (45.3% versus 74.7%). A greater share of Dallas residents are Non-Hispanic Black (16.1% versus 3.2%), and almost three times as many residents identify as Hispanic in the Dallas study area (29.9% versus 11.5%). The share of Non-Hispanic Asian residents is similar (5.8% in Dallas and 6.5% 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 auto at much higher rates (96.2 versus 84.2%) and use transit and non-motorized modes much less than Portland residents. Some 5.6% of Portland residents take transit to work, compared with only 0.7% in Dallas, and 4.1% of Portland residents use bicycles or walk to work compared with 1.1% of those in Dallas.

IV. DATA

The relationship between firm births and proximity to transit stations was derived from data on firm locations, births, deaths, moves, sales, number of employees, and industry classifications obtained from the longitudinal National Establishment Time-Series (NETS) database for the years 1990 to 2009. The data (purchased from Walls & Associates) covers three counties surrounding Portland, OR (Clackamas, Multnomah and Washington counties) and three counties surrounding Dallas, TX (Dallas, Tarrant, and Collin counties). The NETS database does not include reliable information on firm births for the initial year or firm deaths for the final year; therefore, this analysis was limited 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 that could not be geocoded, the resulting dataset for Portland contained information on 57,000 to 130,000 firms per year and included approximately 172,000 firm births and 103,000 firm deaths across all years. For Dallas, the dataset contained information on 180,000 to 390,000 firms per year and included approximately 570,000 firm births and 365,000 firm deaths across all years. The data was aggregated to Census block level—i.e., firm births and deaths were counted for each Census block. There were 28,004 blocks in the Portland region. Multiplied by 18 years, the data yielded 504,072 records. In the Dallas region, 18 years of data for 60,586 blocks yielded 1,090,458 records.

Data subsets were created to study whether the effects varied for firms of different sizes. Two of the subsets excluded small firms—one included only firms with more than one employee and the other only firms with more than five employees. A third subset included *only* smaller firms—those with five or fewer employees. Table 3 summarizes the total number of firms for each of the datasets for Portland and Dallas. In the Portland database, 29.4% of the firms have a single employee (i.e., a sole proprietor), and 75.9% have five or fewer. For Dallas, 25.1% of all firms have one employee, and 75.1% have five or fewer. On average, firm size is lower in 2008 than in 1990, but most firms in the study did not change in size over time.

Table 3. Number of Firms by Year

	Portland				Dallas-Ft.Worth			
	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, firms with more than five employees increased by 38% between 1991 and 2008, while firms with fewer than five employees increased by 164%. For Dallas, the growth rates are 41% and 150%, respectively.

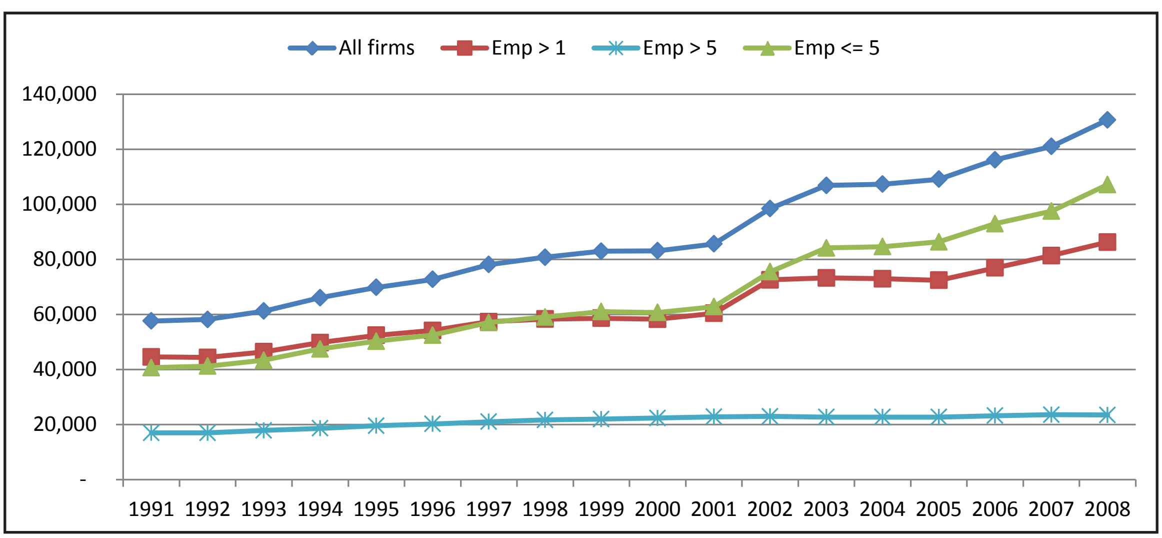

Figure 1. Portland Firms by Year

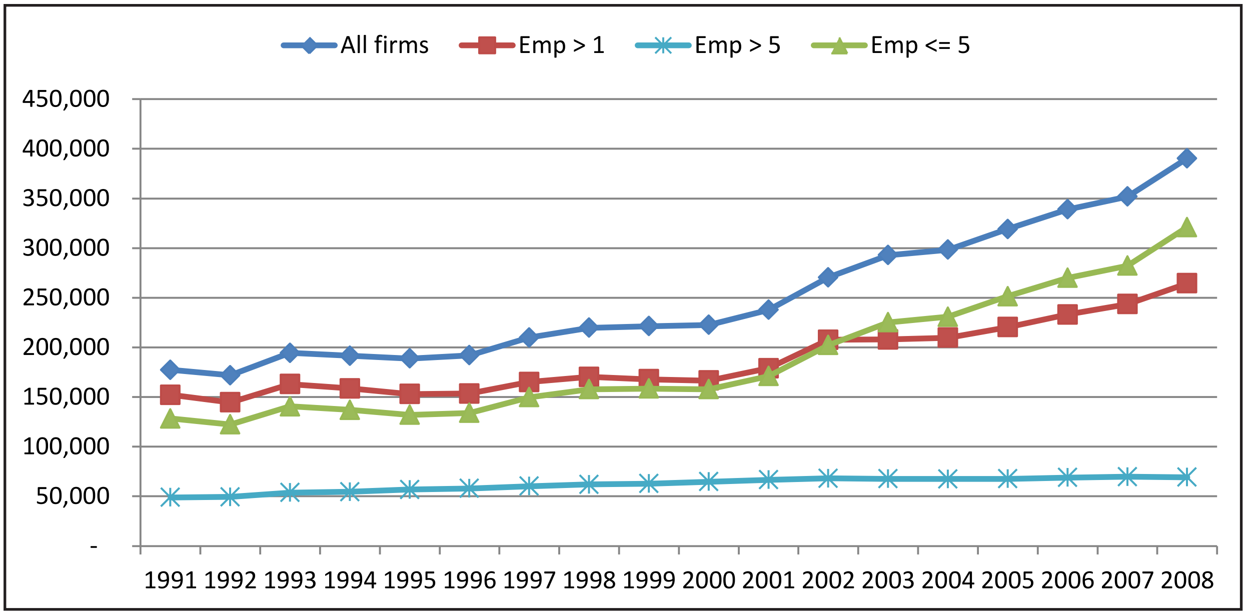

Figure 2. Dallas Firms by Year

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, there is a decrease in firm births for larger firms in the 2000s. Much of the growth in firms over the time period of this 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 employ 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, this analysis examines associations between transit proximity and the birth of different sized firms.

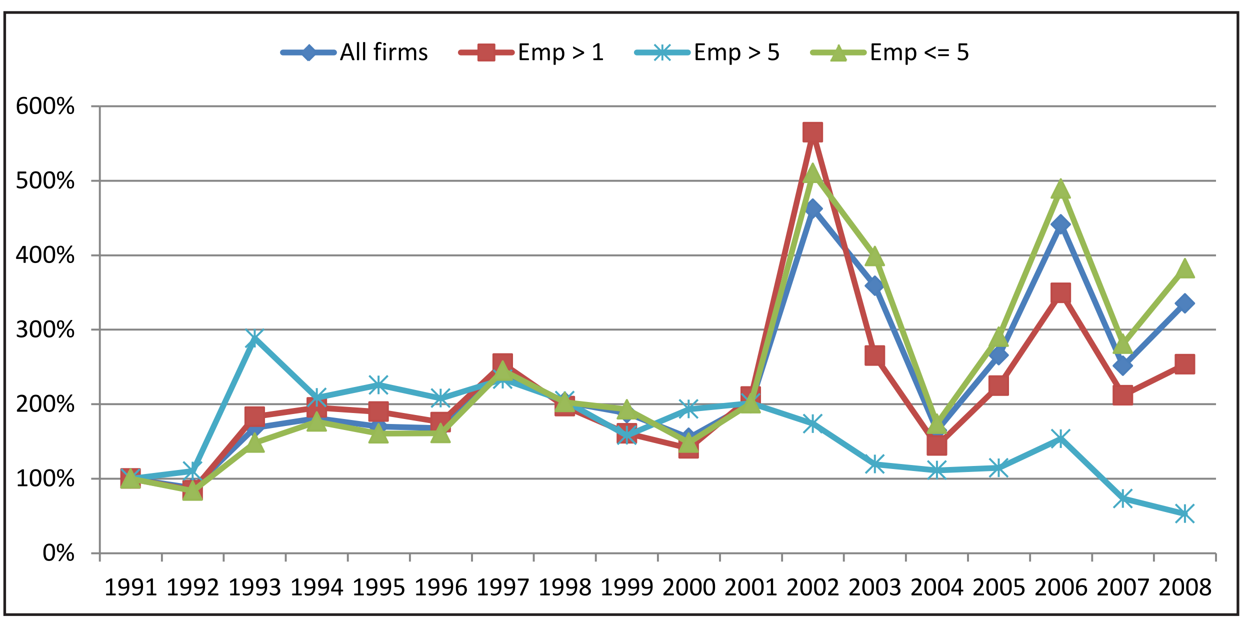

Figure 3. Portland Firm Births Compared with Births in Year 1990

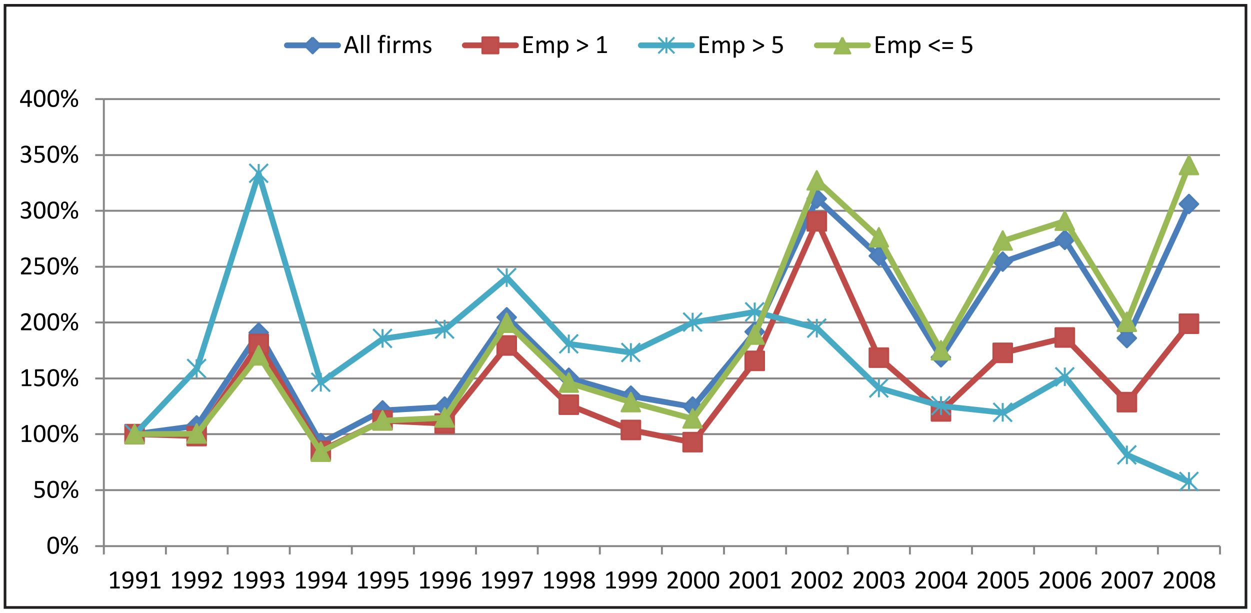

Figure 4. Dallas Firm Births Compared with Births in Year 1990

The firms were also identified by industry classification to learn whether the impact of transit proximity on firm births varied by industry. Six NAICS categories were chosen:

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 4 and Table 5 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. By contrast, this study tested the hypothesis that manufacturing may be less sensitive to transit proximity than other sectors, mainly because large-scale manufacturing may require more space than other industrial sectors, and the land needed for manufacturing firms often is not available near transit stations. 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 4. 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 5. 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 were linked to Census blocks, permitting calculation of counts of firm births, the key dependent variable in this 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.

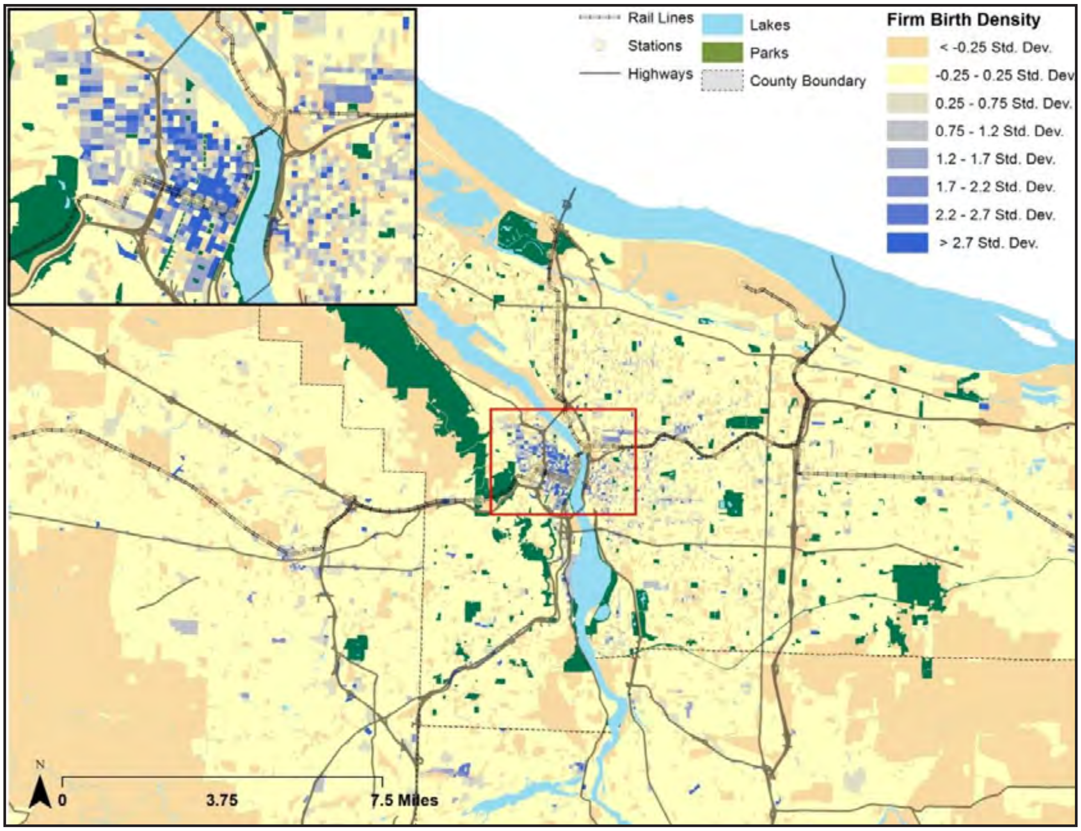

Figure 5. Portland Density of Firm Births Per Square Mile (1991-2008)

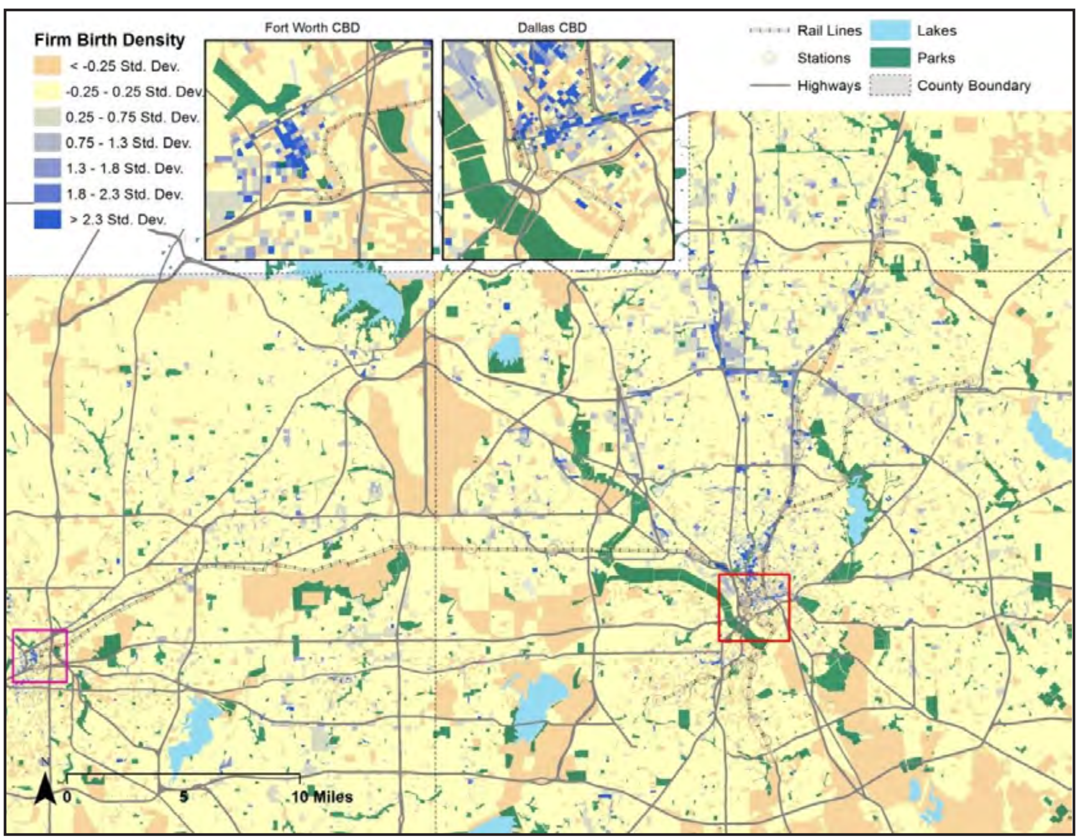

Figure 6. Dallas Density of Firm Births Per Square Mile (1991-2008)

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.

The straight-line distance to rail transit stations based on station opening dates was calculated for each year in the data set using Geographic Information System (GIS) software. 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 both are included in this analysis. Extensions to these systems opened in 1997, 2000, 2001, and 2002. Stations that opened in 2009 or later are excluded.

To study the agglomeration effects near rail stations, Census block centroids within a quarter mile, a half mile, and one mile of rail stations were identified. Table 6 and Table 7 summarize the distribution of firm births by distance to station and firm size for both Portland and Dallas (for Dallas, the table summarizes data only after 1996, when the rail systems opened). In both regions, larger firms are more likely than smaller 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 6. 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
Average, all firms	38.0	24.6	3.7	34.3

Table 7. 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
Average, all firms	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.

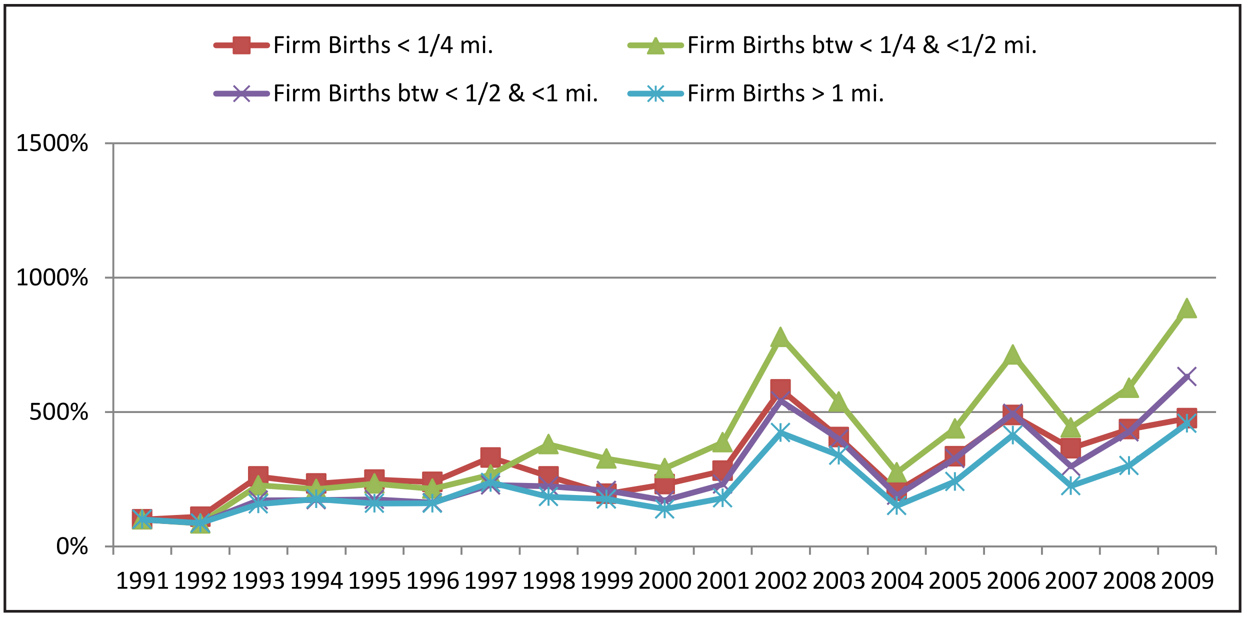

Figure 7. Portland - Change in Firm Births by Distance from Station (all firms)

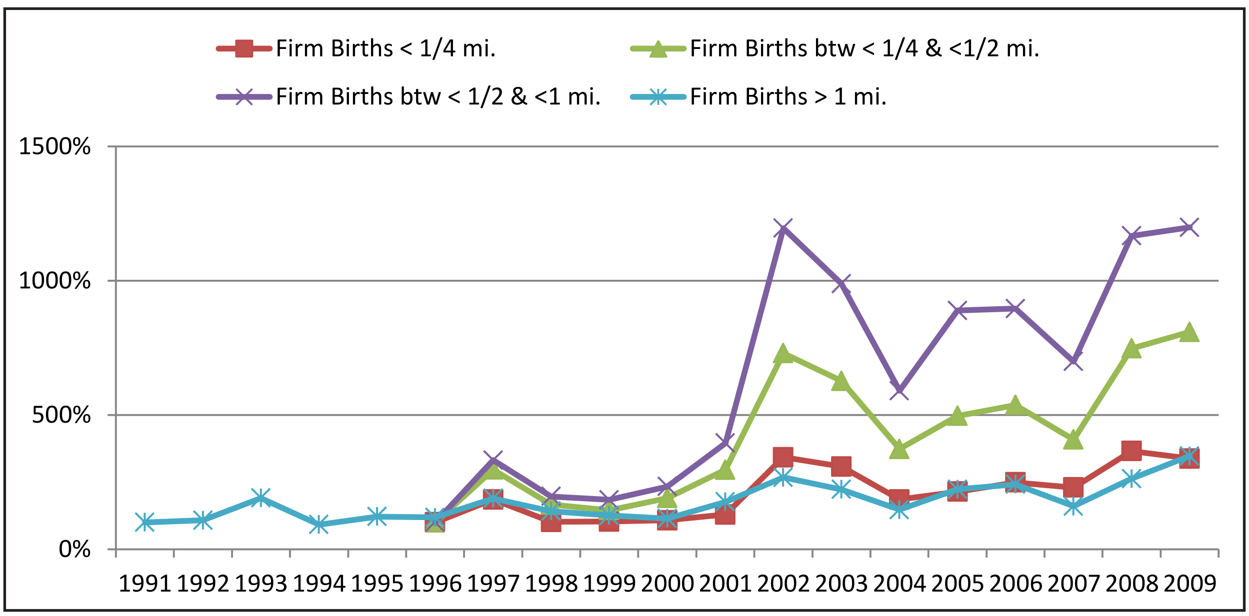

Figure 8. Dallas - Change in Firm Births by Distance from Station (all firms)

Also included are 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, the distance to both the Dallas and Ft. Worth CBDs was calculated. Accessibility was measured by the access of firms to workers' residences.[1] Using data provided by the Dallas and Portland metropolitan planning organizations (North Central Texas Council of Governments and Metro, respectively), both transit and auto access from workers' residences were calculated based on peak-period transit and auto travel

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

times and on worker residential locations for all Transportation Analysis Zones (TAZ). The models use a ratio of transit access to auto access for the TAZ in which the Census block's centroid is located.

The Longitudinal Tract Data Base provides estimates for Censuses from 1970 through 2010. Census Tract boundaries for the year 2010 were used to incorporate basic demographic data from the Censuses of 1990, 2000, and 2010. Each block in the database was then associated with the Census Tract in which the Census block's centroid was located. For the years between decennial Censuses, a straight-line interpolation of the Census data was calculated.

V. METHODS AND ESTIMATION STRATEGY

The key objective of this study is to analyze the association of firm births with proximity to transit stations. The working hypothesis is that firms are more likely to be born and to locate in areas with good transit access. This represents an agglomeration of employment that was hypothesized to occur near transit. This modeling approach does not allow causal inferences; however, the panel dataset permitted the modeling of changes over time and across space.

Firm births within a Census block are discrete events—that is, the number of firms is counted and represented as an integer value greater than or equal to zero. This suggests that count models are an appropriate method, in particular because during the study period there were a large number of blocks with no firm births (zero counts). This ranged from 31% to 83% of all blocks in Portland and 24% to 78% of all blocks in Dallas, depending on the firm size modeled. The final models were estimated as random effects, negative-binomial models (Hausman, Hall, and Griliches 1984, 909-938). The negative binomial distribution was chosen 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.

A random effects formulation was chosen, as some of the data was time-invariant, precluding the use of fixed-effects models. That is, many of the independent variables did not change from year to year. More practically, fixed effects models would not converge when tested, mainly because of the large number of spatial units (Census blocks) modeled. To determine whether random effects models were preferred, models aggregated to the Census tract level were tested, allowing both fixed-effects and random effects models to be estimated. The Hausman test, commonly used to evaluate whether a panel dataset should be modeled as fixed effects or random effects suggested that the random effects model was preferable.

The dependent variable, therefore, was the number of firm births in Census block *i* in year *t*. The independent variables included 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.* The area of each block (in square miles) was used as an offset variable for the model. This meant that the parameter for area was constrained to be equal to one, or, equivalently, firm births per unit area were estimated (essentially normalizing the dependent variable).

The key variable of interest was various measures of distance to rail stations. First, a model with a straight-line distance measure to the nearest rail station (capped at 10 miles on the assumption there would be no effect at such a large distance) was evaluated, along with a dummy variable equal to one if the distance to the nearest station was greater than ten miles or if there were no stations open in the region (which was the case for Dallas prior to 1996). Second, a model was evaluated that adds distance thresholds to test the effects of distance near the station, which may be non-linear. Thresholds were constructed indicating the distance from the Census block to the station using the following breakpoints: up to a quarter mile, a quarter to a half mile, a half mile to one mile, and further than one mile from the station.

To control for other firm activity in each block, the total number of firms and firm deaths in block *i* in year *t* were included. A number of variables measuring the spatial attributes of the block were also included. A dummy variable indicated whether block *i* is within two miles of the center of the CBD (straight-line distance). Also measured were CBDs for both Dallas and Fort Worth; employment density (employees per block per square mile); population per square mile (Census tract population per square mile); an accessibility ratio (transit accessibility to auto accessibility); and distance to the nearest highway (measured as a straight-line distance in miles). Several measures of demographics were included from the Decennial Census. For each year calculations were performed to determine the percentage of the Census tract population who identify as Black or Hispanic, the median household income and rent, and the percent of the tract population with a college education. Finally, dummy variables were included for the years 1991 through 2008. The first year, 1991, was omitted and used as the reference category. Table 8 summarizes the variables in the model for the full Portland and Dallas data sets.

Table 8. Summary Statistics for Model Variables

	Portland				Dallas			
	Mean or percent for dummy variables	Std. Dev.	Min	Max	Mean or percent for dummy variables	Std. Dev.	Min	Max
Firm Births (count within a census block}	0.34	2.14	0	141	0.52	3.28	0	425
Distance to Station								
Station Distance ≥ 10 mi.	26%	0.44	-	-	49%	0.50	-	-
Distance to Station (in mi.)	4.98	3.74	0	10	7.13	3.46	0	10
≤ 1/4 mi.	3%	0.17	-	-	1%	0.09	-	-
1/4 to 1/2 mi.	5%	0.22	-		2%	0.13	-	-
1/2 to 1 mi.	10%	0.30	-	-	4%	0.19	-	-
> 1 mi. (ref. cat.)								
Firm Variables								
Number of Firms	0.20	2.36	0	223	0.33	4.05	0	460
Number of Firm Deaths	3.15	16.96	0	1,064	4.12	23.16	0	2,204
Spatial Variables								
PDX CBD dist. ≤ 2 mi.	8%	0.27	-	-				
DAL CBD dist. ≤ 2 mi.					2%	16%	-	-
FTW CBD dist. ≤ 2 mi.					3%	17%	-	-
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 (/100)	0.04	0.08	0	1	0.16	0.22	0	1
Percent Hispanic (/100)	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 Educated (/100)	0.21	0.12	0	1	0.18	0.14	0	1
Year variables not shown								

VI. RESULTS

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

Of note in all models is that parameter estimates are almost all statistically significant at a high level of confidence. This is primarily because of the size of the dataset. This makes inference difficult but also makes parameter estimation more precise, given the small standard errors on the estimates. Thus, in interpreting the results, parameter values are important and, in particular, the size of the parameter estimates; those 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

Table 9 presents the model for Portland (In the interest of space, the dummy variables for each year are omitted from the table of results). These models suggest that firm births are positively correlated with proximity to rail stations for all firm sizes, as shown by the station distance variables.

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 in model B. Likewise, in model B, firm births in blocks located a quarter to a half mile from the nearest rail station are significant and positive (0.12); beyond a 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 a quarter to a half mile of the station have 12.7% ($1.127 = e^{0.12}$)more firm births than blocks that are more than a mile from the nearest rail station.

The proximity results for the models of other firm sizes suggest that firm size is a factor in whether or not 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 from the station are both significant and positive (0.267 and 0.164) and are larger than in the model for all firms. The percent of firms born in each buffer can be calculated by exponentiating the respective coefficient values ($e^{0.267}$= 1.306 and $e^{0.164}$= 1.178). Therefore, holding all else equal, blocks that are less than a quarter mile from a station witness the birth of 30.6% more firms with ≥2 employees than do blocks farther than one mile from the nearest rail station. Blocks a quarter to a half mile from the station bear 17.8% more firms with ≥2 employees than do blocks that are farther than a half mile from the nearest rail station. This result is more pronounced in the model with firms of more than five employees. In model B, the distance threshold variables indicating that the block is within a quarter mile or between a quarter mile and a half mile are both significant (0.794 and 0.517) and much larger than the other models. For firms with more than five employees, blocks less than a quarter mile from a station have 112% more firm births than blocks that are farther than one mile from the nearest rail station, and blocks within a quarter to a half mile have 68% more firm births than blocks that are farther than a 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 (fewer than 5 employees) is similar to the model for all firms; this is mainly because the data is similar, as 76% of firms have five or fewer employees.

The coefficients for the firm variables, number of firm deaths and total number of firms, conform to 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 of more than 5 employees, the number of firms in the block has a larger effect on firm births (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 of the models used.

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 if by driving. But transit access seems more important. As a 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 of the 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 of the models. There was no prior expectation as to the effect of these two control variables.

Median household income and median rent are near zero, and thus, while statistically significant, have a small association with actual 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 more than 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 9. 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

Note: *p<.05, **p<.01, ***p<.001.

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 that the effect of being near a rail station on firm births is greatest for larger firms, particularly those with more 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).

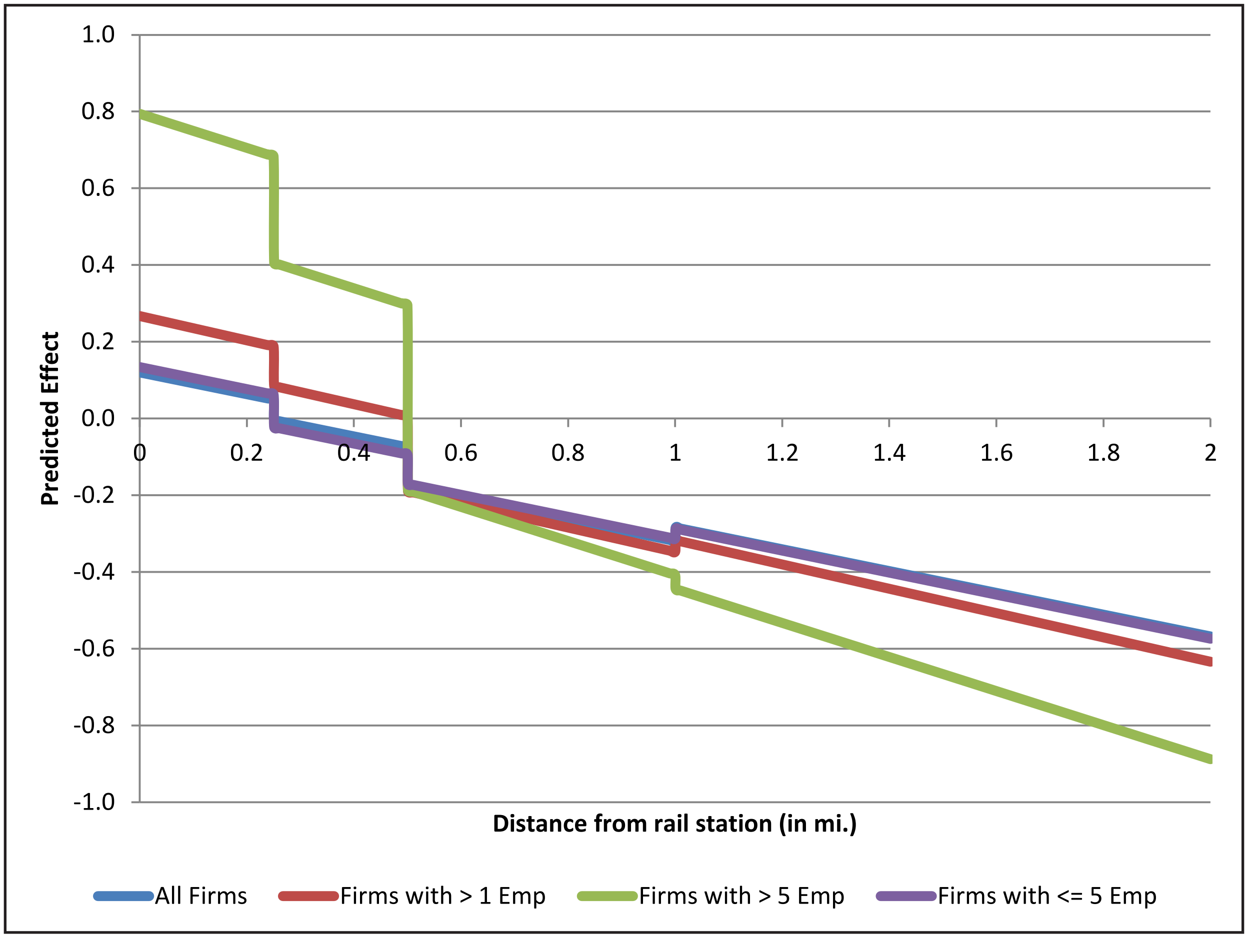

Figure 9. Portland Predicted Effects of Station Distance Variables

Note: The y-axis shows the predicted effect as calculated from the coefficient values. The lines plotted in the graph are calculated as Y = β_i + (distance from station * α) where β_i is the coefficient for the dummy variable of the respective distance band and α is the coefficient for distance from the station. For example, for firms with more than 5 employees, the maximum predicted effect when distance from the station is zero is 0.794 + (0 miles * -0.444) = 0.794.

Also tested was a reduced model with only the full set of distance-to-rail station variables, firm variables and dummy variables for each year (excluding Census variables and other spatial data). Table 10 summarizes the model results.

[2] In each graph, all distance variables are included, not just the significant variables. Separate graphs also were generated that included only the significant distance variables, and the general pattern remained the same.

In the reduced model, the model coefficients for all the distance variables are larger than the same coefficients in the full model. With the exception of the distance threshold variable indicating that the block is between a half mile and one mile from a rail station, the signs on all the variables are 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 had higher 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 from those in the other graphs of predicted values.) This suggests that in the analysis of Portland firm births, without the spatial and demographic control variables the reduced model would overestimate the effect of access to rail stations on the number of firm births.

Table 10. 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

Note: *p<.05, **p<.01, ***p<.001.

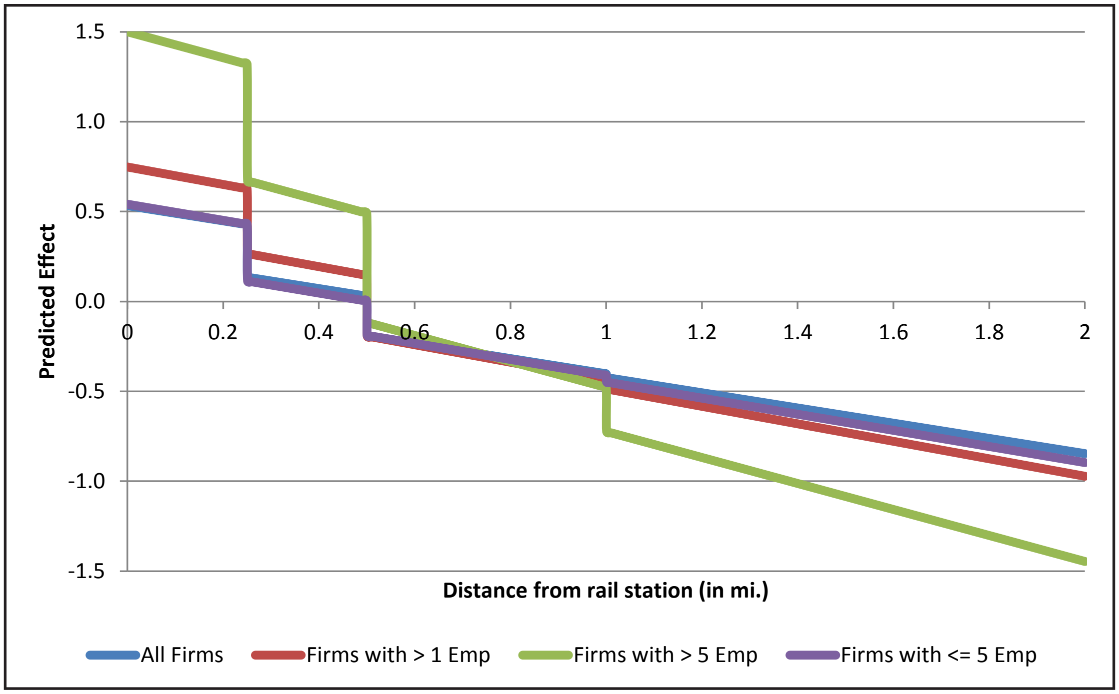

Figure 10. Portland Predicted Effects of Station Distance Variables without Spatial or Demographic Variables

Note: The y-axis shows the predicted effect as calculated from the coefficient values. The lines plotted in the graph are calculated as Y = β_i + (distance from station * α) where β_i is the coefficient for the dummy variable of the respective distance band and α is the coefficient for distance from the station. For example, for firms with greater than 5 employees, the maximum predicted effect when distance from the station is zero, is 1.50 + (0 miles * -0.723) = 1.50.

The 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 the industry categories, though the effect size varies. Table 11 summarizes the results of the final models for each industry classification, and Figure 11 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 a half-mile and a 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 being near a rail station has the largest effect on firm births in FIRE industries. The predicted effects are smallest for manufacturing, health care, and social assistance.

Proximity to the CBD is most important for manufacturing firms and least important for health care and social assistance, and the 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 11. 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

Note: *p<.05, **p<.01, ***p<.001.

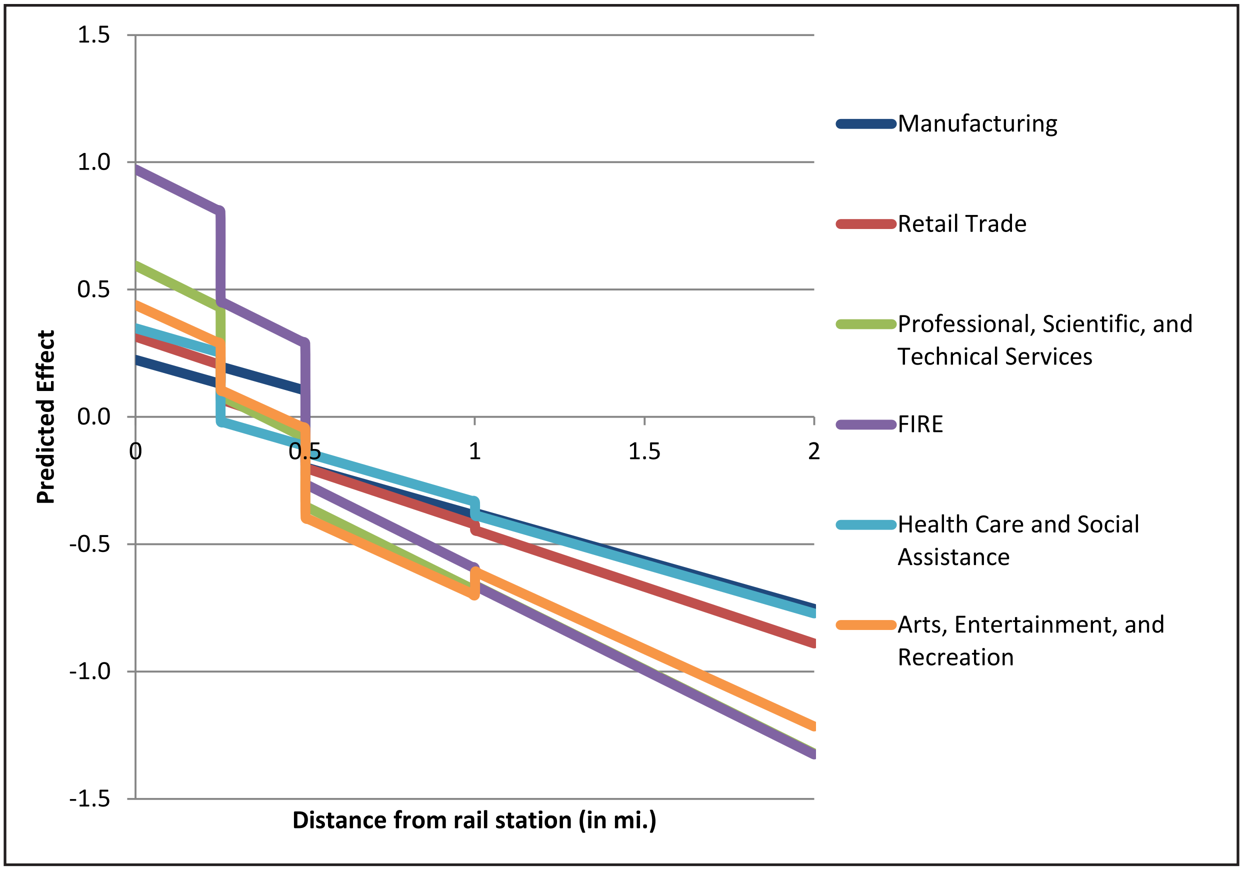

Figure 11. Portland Predicted Effects of Station Distance Variables by Industry Category

Note: The y-axis shows the predicted effect as calculated from the coefficient values. The lines plotted in the graph are calculated as Y = β_i + (distance from station * α) where β_i is the coefficient for the dummy variable of the respective distance band and α is the coefficient for distance from the station. For example, for the FIRE sector, the maximum predicted effect when distance from the station is zero, is 0.97 + (0 miles * -0.66) = 0.97.

DALLAS

Unlike the analysis of firm births in Portland, 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 more than five employees. In addition, distance from a station has a smaller effect on firm births in Dallas than in Portland. Table 12 summarizes the model results for the entire Dallas data set and for the data subsets.

The results for model A for the analysis of all firms indicate 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 distance thresholds were added to examine the effects near rail stations, 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 a 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% fewer firm births compared with the reference category, blocks further than one mile from the nearest rail station.

There are a few notable differences between the all-firms model and 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% fewer firm births, blocks between one quarter and one-half mile have 15% fewer firms and blocks between one-half and one mile from a rail station have 13% fewer firm births compared with blocks farther than one mile from the nearest rail station.

The model of larger firms, those with more 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 a 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% 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, 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 (these two CBD coefficients were tested, and they are not significantly different from one another). 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 the 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 the 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 and is generally 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, a model of smaller firms, those with five or fewer employees, was analyzed. Just as with the findings for 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 of the nearest rail station have 12% fewer small firm births, blocks a quarter to a half mile away have 15% fewer small firm births, and blocks between a half mile and a mile have 12% fewer firm births than the reference category: blocks farther than one mile from the nearest rail station. The remaining variables are all similar to the model of the full dataset.

As with the Portland analysis, an analysis of firms with 20 or fewer employees was conducted for Dallas. Because these results are very similar to those for the full data set, they are not shown.

Table 12. 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

Note: *p<.05, **p<.01, ***p<.001.

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), it is clear that in both cases the relationship between station distance and firm births is strongest for the largest firms (those with more than five employees).

In addition, the lines slope less in the Dallas graph than in the Portland graph, indicating that distance from a rail station has a smaller effect in the Dallas region than in Portland. More important, the lines are mostly below zero, suggesting that firm births are more likely to occur farther away from the transit station, larger firms excepted. 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.

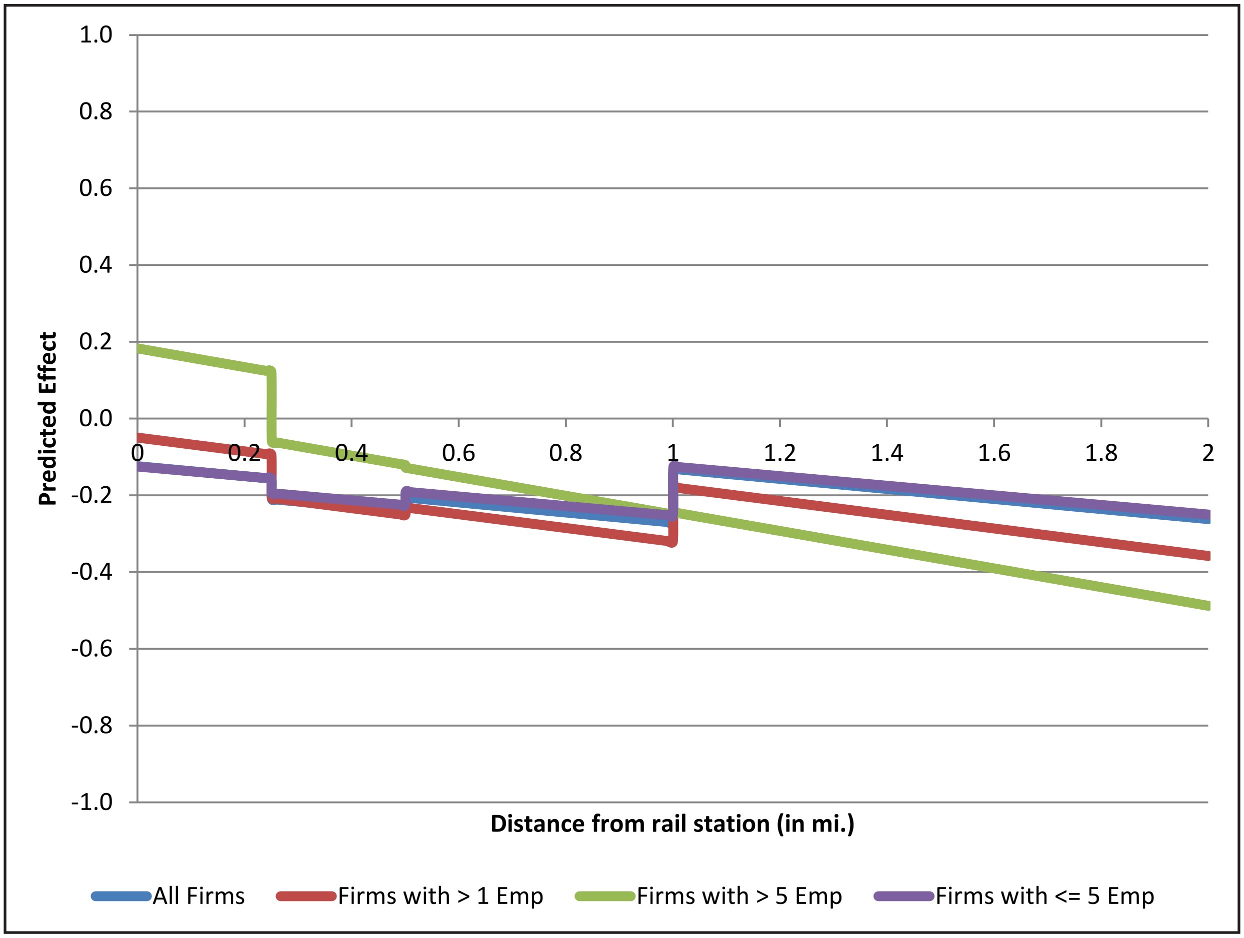

Figure 12. Dallas Predicted Effects of Station Distance Variables

Note: The y-axis shows the predicted effect as calculated from the coefficient values. The lines plotted in the graph are calculated as Y = β_i + (distance from station * α) where β_i is the coefficient for the dummy variable of the respective distance band and α is the coefficient for distance from the station. For example, for firms with greater than 5 employees, the maximum predicted effect when distance from the station is zero, is 0.183 + (0 miles * -0.244) = 0.183.

Once again, the full model was compared to a reduced model that omitted spatial and demographic variables. The results are summarized in Table 13 and Figure 13, which show a larger effect from locating near rail stations compared with the full model. Additionally, 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 true only in the case of larger firms with 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, the 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 13. 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

Note: *p<.05, **p<.01, ***p<.001.

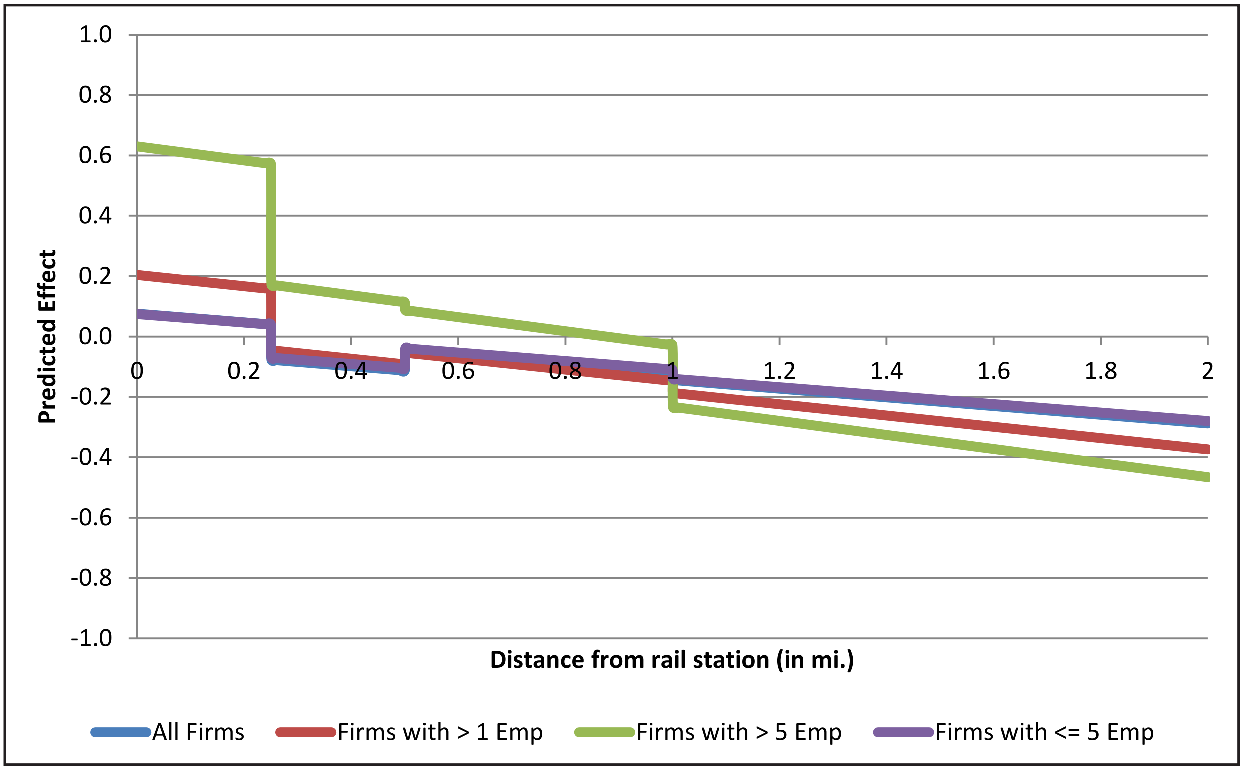

Figure 13. Dallas Predicted Effects of Station Distance Variables Without Spatial or Demographic Variables

Note: The y-axis shows the predicted effect as calculated from the coefficient values. The lines plotted in the graph are calculated as Y = β_i + (distance from station * α) where β_i is the coefficient for the dummy variable of the respective distance band and α is the coefficient for distance from the station. For example, for firms with greater than 5 employees, the maximum predicted effect when distance from the station is zero, is 0.630 + (0 miles * -0.233) = 0.630.

The analysis of firm births by industry 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 the Dallas model compared with Portland.

Figure 14 graphs the predicted effect of the distance variables for the six industry classifications for Dallas. 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 of 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 14. Dallas Model Results by NAICS Category

	Manufacturing	Retail Trade	Prof., Scientific, and Technical Services	FIRE	Health Care and Social Assistance	Arts, Entertainment, and Recreation
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

Note: *p<.05, **p<.01, ***p<.001.

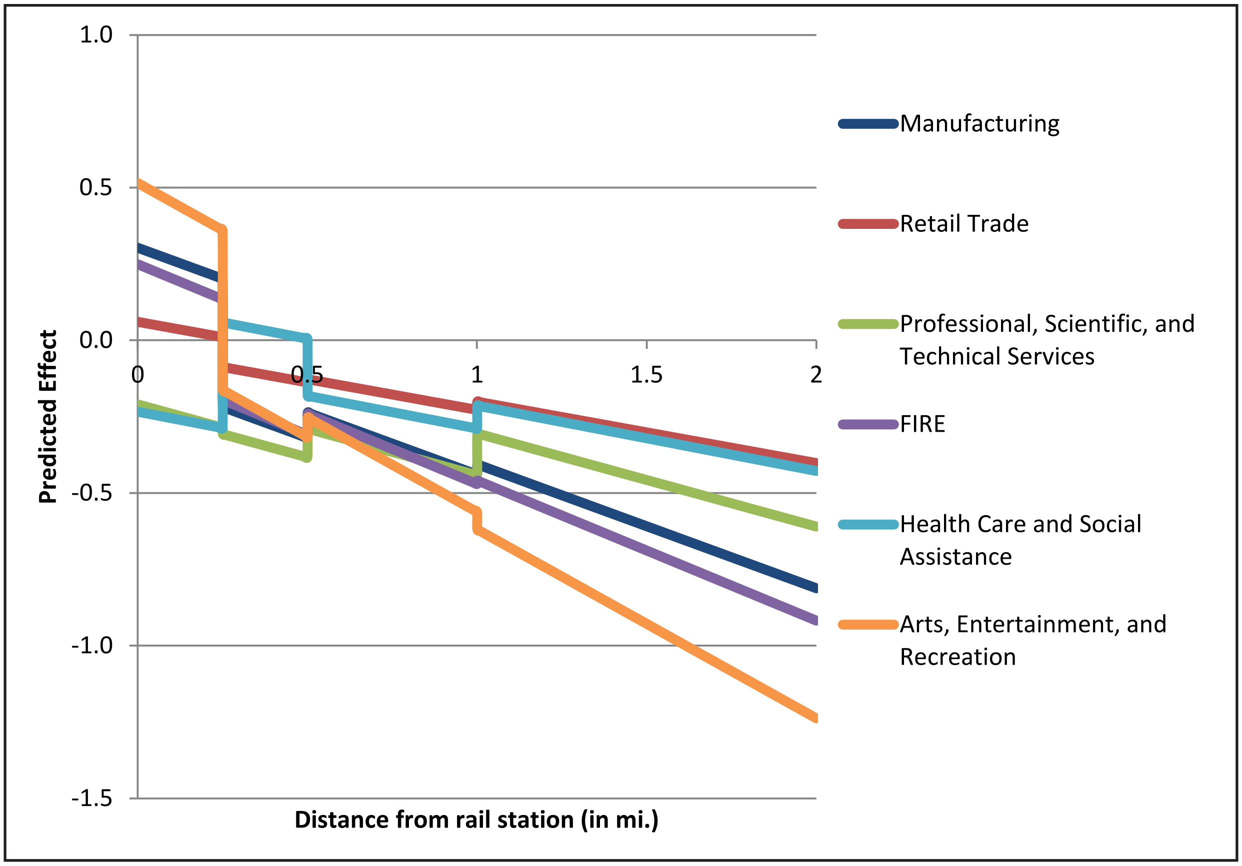

Figure 14. Dallas Predicted Effects of Station Distance Variables by Industry Category

Note: The y-axis shows the predicted effect as calculated from the coefficient values. The lines plotted in the graph are calculated as $Y = \beta_i + (\text{distance from station} * \alpha)$ where β_i is the coefficient for the dummy variable of the respective distance band and α is the coefficient for distance from the station. For example, for the Arts, Entertainment, and Recreation sector, the maximum predicted effect when distance from the station is zero, is 0.515 + (0 miles * -0.619) = 0.515.

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, likely due to local policies. Both Portland and Dallas have relatively new and extensive light-rail systems as well as commuter rail, yet the results show that new firms tend to cluster around stations in the Portland region but not in the Dallas-Ft. Worth region. It is important for urban and transportation planners to understand why these two cities have experienced different results, since it is generally assumed that new firms generate regional growth and that clustering of these new firms can lead to external agglomeration benefits.

In Portland, the rate of firm births declines farther from rail stations. Firm size also matters. Larger new firms tend to locate closer to stations than smaller firms. Highway access also appears to be an important determinant of firm births, although it is less important than transit access. Various differences in industry sectors were also found, with distance to a rail station being most associated with firm births in FIRE industries (finance, insurance, real estate, and rental/leasing), and less so for manufacturing and health care and social assistance, although still positive for these industries.

The Dallas results are substantially different. Except for firms with more than five employees, there is a negative correlation of firm births and rail station proximity. Highway access is less important than in the Portland model, which may simply be due to the presence of an extensive arterial road system providing similar access throughout the region. The analysis of firm births in different industrial sectors also revealed different patterns. In Dallas, being near a rail station is most strongly associated with firm births in arts, entertainment and recreation firms. Firm births are also more common near rail in FIRE and manufacturing, but less so than in Portland. The smallest effect is for health care and social assistance firms, similar to the Portland result.

Why do rail station areas in Portland appear to provide an environment for the birth of new firms, while in Dallas there is less evidence of this? One possible explanation is that Portland has been more proactive in focusing development, both around their transit stations and within the CBD, by adopting 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. It is also possible that the Portland transit network provides much better access than the Dallas network, given the much higher transit mode share in Portland and the more extensive transit network.

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 larger firms receive, particularly in terms of access to the labor force. This result is especially noteworthy since policy makers are interested in seeing new firms with more employment, and rail stations seem to be attractive locations for these firms. To some extent this is a surprising result, as office and retail space might be more constrained in the vicinity of rail stations. On the other hand, in Dallas, firms in the arts, entertainment, and recreation sector are starting up near transit and may require less space than manufacturing firms. But these are speculative interpretations. Without further data and analysis the specific effects that might drive new firms to locate near rail stations cannot be isolated, other than to acknowledge that access is important and that coordinated planning to encourage such development may be necessary.

Future research is needed to fully understand these effects, including analysis in other cities with different transit networks. A deeper understanding of entrepreneurial location choice, using qualitative methods such as structured interviews or focus groups, would also provide further evidence of the role that transit access plays in entrepreneurial decision making.

BIBLIOGRAPHY

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," http://www.dart.org/about/dartfacts.asp (accessed July 24, 2013).

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

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.,” http://trimet.org/pdfs/publications/factsheet.pdf (accessed July 24, 2013).

———. “The TriMet Story,” http://trimet.org/about/history/trimet_story.htm (accessed July 24, 2013).

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.

ABOUT THE AUTHORS

ROBERT B. NOLAND

Robert B. Noland is a Professor at the Edward J. Bloustein School of Planning and Public Policy at Rutgers University and serves as the Director of the Alan M. Voorhees Transportation Center. He received his Ph.D. at the University of Pennsylvania in Energy Management and Environmental Policy. Prior to joining Rutgers University he was Reader in Transport and Environmental Policy at Imperial College London, a Policy Analyst at the US Environmental Protection Agency, and also conducted postdoctoral research in the Economics Department at the University of California at Irvine. The focus of Dr. Noland's research is the impacts of transport planning and policy on both economic and environmental outcomes. His work on economic effects has included examining behavioral reactions to changes in reliability, associations with the built environment, and trip-chaining behavior. Environmental work includes impacts on safety, climate, health, and other factors associated with overall quality of life. Active research areas include developing methods to evaluate the lifecycle greenhouse gas emissions associated with building transport projects; evaluating the economic impacts of transit-oriented development; analysis of walking behavior and links to other travel behavior and the built environment; analysis of traffic and pedestrian safety using spatial analysis techniques; and assessment of the economic effects of transport investments, in particular those associated with agglomeration externalities. Dr. Noland's research has been cited globally in debates over transport infrastructure planning and environmental assessment of new infrastructure. Dr. Noland is currently Associate Editor of *Transportation Research-D (Transport and Environment)* and the *International Journal of Sustainable Transportation*. He also serves as Chair of the Transportation Research Board Special Task Force on Climate Change and Energy.

DANIEL G. CHATMAN

Dan Chatman is an assistant professor of city and regional planning at the University of California, Berkeley. He conducts research on travel behavior and the built environment; residential and workplace location choice; "smart growth" and municipal fiscal decision making; and the connections between public transportation, immigration and the economic growth of cities. Ongoing and recently completed research projects include studies addressing which U.S. transit systems succeed, and why; the implications of immigration trends for sustainable development and economic growth; the effects of dynamic pricing on occupancy and use of onstreet parking in San Francisco; and the relationships between residential location, travel, social interactions, and well-being.

NICHOLAS J. KLEIN

Nicholas J. Klein received his Ph.D. in Planning and Public Policy at the Edward J. Bloustein School of Planning and Public Policy at Rutgers University. He also has a master's degree in urban spatial analytics from the University of Pennsylvania, where he focused on the use of Geographic Information Systems (GIS) and spatial statistics in studying transportation equity. He conducts research on travel behavior and public transit services in diverse communities. His dissertation examined the rapidly growing curbside intercity bus industry, including the so-called “Chinatown Buses.” In addition, he conducts research examining the travel behavior of marginalized populations, such as immigrants to the U.S., and gays and lesbians. At Rutgers, he has worked on several state and federally funded research projects examining public transit issues, particularly the intercity bus industry, the travel behavior of immigrants in New Jersey, and the impact of immigration on the transportation system and participation in public transit planning. Previously, he worked for PB Consult, helping metropolitan planning organizations develop and implement travel demand models.

PEER REVIEW

San José State University, of the California State University system, and the MTI Board of Trustees have agreed upon a peer review process required for all research published by MNTRC. The purpose of the review process is to ensure that the results presented are based upon a professionally acceptable research protocol.

Research projects begin with the approval of a scope of work by the sponsoring entities, with in-process reviews by the MTI Research Director and the Research Associated Policy Oversight Committee (RAPOC). Review of the draft research product is conducted by the Research Committee of the Board of Trustees and may include invited critiques from other professionals in the subject field. The review is based on the professional propriety of the research methodology.

SAN JOSÉ STATE
UNIVERSITY

Funded by U.S. Department of Transportation