The Influence of Transit on Demographic and Housing Change

Arthur C. Nelson
Professor of Planning and Real Estate Development
College of Architecture, Planning and Landscape Architecture
1040 N. Olive Road
University of Arizona
Tucson, AZ 85719
E: acnelson@email.arizona.edu
V: 520.621.4004

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Abstract

Though it is assumed that population, households and housing will be attracted to transit stations, there are no studies demonstrating this conclusively with respect to light rail transit (LRT), streetcar transit (SCT) or bus rapid transit (BRT) systems, or with respect to distance to transit stations. This articles help close these gaps in literature. Using census data between 2000 and 2010, this article compares the percentage change in sets of performance indicators pertaining to population overall and by race/ethnicity, households by household type, householder age and household income, and housing overall and by tenure for discrete distance bands from transit stations with respect to the percentage change in the counties within which these systems operate ("transit counties"). For LRT and SCT systems, the growth rates of nearly all performance indicators in the closest band (1/8 mile) exceeded that of transit counties, but for the other distance bands, percentage changes were usually less than that of transit counties, though overall there was positive growth out to 3/4 mile from LRT stations and 1/2 mile from SCT stations. For BRT systems the situation was nearly reversed, as the poorest performing distance band was that closest to BRT stations while performance was mostly positive though not as great as transit counties from 1/8 mile to 3/4 mile. Interestingly, the best-performing BRT distance was between 3/4 to one mile from BRT stations. Numerous observations, guidance for future research, and a long term challenge are offered.

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Introduction and Research Overview

Transit systems, and especially transit oriented development, offer many promises related to people and housing. However, for the most part there is very little research assessing whether transit and the stations serving them are effective in attracting new residents and influencing housing choices. Some studies address mostly individual station area but not of metropolitan areas as a whole (Cervero and Seskin, 1995; Cervero et al., 2004; Kolko, 2011). In particular, no studies systematically analyze the change in population and housing associated with fixed guideway transit systems, such as light rail transit (LRT), streetcar transit (SCT) and bus rapid transit (BRT) systems in the U.S. The only metropolitan-scale studies addressing the influence of BRT systems on population and housing are from outside the U.S. (Carrigan et al., 2013; Cervero, 2013).

Of interest in this article is the extent to which LRT, SCT and BRT station areas attract population, households and housing consistent with expectations (Belzer et al., 2007; Belzer and Poticha, 2010; Belzer et al, 2011; Carrigan et al., 2013; Cervero et al., 2004; Dawkins and Buehler, 2010; Dawkins and Moeckel 2016). Indeed, only one study addresses population and housing change for all transit systems in the U.S.—the Center for Transit Oriented Development (2014) but it does not differentiate by type of system, distance from transit stations, or provide detail on the race/ethnicity of people, households by age and type and income, and housing based on tenure. This article helps close an important gap in the transit literature, especially related to LRT, SCT and BRT systems.

This article begins with the research question, outlines the analytic framework, reports results for each type of transit system, and concludes with a summary and a challenge.

Research Question

The following research question guides research reported in this article:

> *Relative to the counties within which transit systems operate ("transit counties"), is there an association between LRT, SCT and BRT station distance and change in population, households by householder age and household type and income; and housing by total supply, vacancy rates and tenure?*

The study areas include the entire metropolitan statistical area as defined in 2010 for comparisons to change with one-half mile of census block-group centroids to LRT, SCT and BRT stations. While the largest share of influences likely occur within the first one-half mile, emerging literature indicates the full effect of transit systems is felt up to two miles away (see Nelson et al., 2015). Nonetheless, literature shows that the largest share of change occurs within the first one-half mile of fixed-guideway transit systems (see Center for Transit Oriented Development, 2014).

Analytic Framework

The analysis used in this study calculates the percentage change in LTR, SCT and BRT station area with respect to demographic and housing performance indicators described below between 2000 and 2010 compared to the percentage change for the "transit county" as a whole. The transit county is that within which the transit system operates. The "station area" is actually a series of distance bands from the transit station including:

- Less than or equal to 1/8 mile;
- More than 1/8 to less than or equal to 1/4 mile;
- More than 1/4 mile to less than or equal to 1/2 mile;
- More than 1/2 mile to less than or equal to 3/4 mile; and
- More than 3/4 mile to less than or equal to 1.0 mile.

We use the universe of block groups (BGs) whose centroids fall within any given distance band of transit stations. The analysis is a pre-post difference test using *Z*-scores at $p < 0.01$ to assess whether there are significant differences in demographic and housing percentage changes between 2000 and 2010. Data for the analysis are the decennial census for 2000 and 2010, though 2012 ACS 5-year data are used for median household income for 2010. The analysis is applied to all Light Rail Transit, Streetcar Transit and Bus Rapid Transit systems operating no later than 2005. They include:

- Light rail transit (LRT): Charlotte, Dallas, Denver, Houston, Minneapolis, Phoenix, Portland, Sacramento, Salt Lake, San Diego and Seattle.
- Bus rapid transit (BRT): Bronx (New York City), Cleveland, Eugene-Springfield, Kansas City, Las Vegas, Los Angeles, Phoenix, Pittsburgh, and Salt Lake City.
- Streetcar transit (SCT): Portland, Seattle and Tampa.

Performance of transit station areas is measured in terms of the following population, household and housing indicators.

Population

Three population performance indicators are considered.

Population—In order to meet apparent market demand for transit accessibility, the population of station areas should increase over time at a rate faster than their transit counties.

White (non-Hispanic)—Mostly because of income (see below), White persons may outbid all others for location in station areas thereby growing at a rate faster than their transit counties.

Minority—Though minority and lower income households may seek station areas, they may be outbid or displaced because of income effects (see below).

Households by Householder Age, Type and Income

Several performance measures related to households are evaluated in this analysis.

Households—As population increases in station areas so will total households. But because those households are less likely to have children than the transit county as a whole, household sizes will be smaller, meaning that proportionately more households will be attracted to station areas.

Three very general kinds of households are measured: households with children, single person households, and all others which are noted as 2+ adult households without children.

Households with Children—Literature suggests that households with children are unlikely to be attracted to station areas and instead will be drawn to mostly suburban areas with detached homes.

Single-Person Households—In contrast, single person households are less tied to locations because of their composition. Literature suggests that they may be attracted to station areas, so their population in those areas should increase at a faster pace than transit counties.

2+ Adult households—These households are without children, with a large share being empty nesters who no longer need suburban detached homes in which to raise families. Many others in this group include same-sex couples or young households not yet raising children who may also be attracted to station areas at a faster pace than transit counties as a whole.

Three performance measures relate to households based on householder age.

Households with Householders under 35 Years of Age—These households are mostly early career, single, renter, and entirely Millennial. Though they cannot afford much space they do not need much, and more so than other generations at the same same age,

they tend to eschew automobile ownership. Higher shares of this age group are expected to choose station areas than transit counties as a whole.

Households with Householders Aged 35 to 64—In contrast, these households are the most likely to have children and better incomes, and tend to choose detached homes in the suburbs. Station areas are not expected to match the pace of these householders relative to transit counties as a whole.

Households with Householders Aged 65 and over—These are households that tend to be downsizing and are mostly empty-nesters, and may prefer to relocate to smaller homes on smaller lots, or to attached homes. Growth in these households may be higher in station areas than for transit counties as a whole.

The last household performance indicator is median household income.

Median Household Income—Literature suggests that higher income households may be attracted to station areas, and as such growth in those areas may occur at a faster pace than the metropolitan area as a whole. They may also outbid or displace lower income households in ways noted earlier.

Housing and Tenure

Four performance measures are created relating to housing and tenure.

Total Housing Units—A key expectation of transit stations is their attractiveness to residential development. As such, the rate of change in total housing units in station areas may exceed that of transit counties as a whole.

Occupied Housing Units—If transit makes station areas more attractive to the residential market, not only will more homes be added to the inventory but the number of occupied homes should also increase. One reason is that existing vacancies may be absorbed in addition to more units added. In any case, the rate of change in occupied units in station areas should be higher than for transit counties as a whole.

Owner Occupied Units—If station areas are effective in attracting higher income households (who may outbid and displace lower income ones), the growth rate of owner occupied housing in station areas should be higher than for transit counties.

Renter Occupied Units—From a different perspective, if station areas are effective in attracting younger households or households transitioning from home ownership, such as empty nester households, the growth rate of renter occupied housing in station areas should be higher than for transit counties.

Growth Share Summary

One performance measure is used to gauge overall station area performance in attracting people.

> *Household Share of Change*—Overall, if they are effective in attracting people who wish to live there, station areas should see proportionately more households choosing those locations than choosing to live elsewhere in the transit county. Nonetheless, transit counties outside station areas will likely see much larger numerical changes.

While literature suggests people and housing will gravitate to transit station areas, this is not a foregone conclusion. For the most part, new fixed-guideway transit systems are built where development already exists to maximize ridership and revenues. In transit counties prone to sprawl, new development is more likely to occur away from fixed-guideway transit systems than toward them. Even if the rate of change in population, households and housing near stations exceeds that of the transit county, the numerical change may be actually quite small because the baseline figures for station areas are likely small. Given this perspective, we now present our results.

Results

Results are presented respectively for LRT, SCT and BRT systems. A summary table is reported for each system analysis. It shows the total percentage change for transit counties across all the performance indicators as well as for each of the distance bands from transit stations. In those tables, bold figures means the percentage change within the distance band occurred at a faster pace than for the transit county as a whole and the difference was statistically significant using

the z-score at $p < 0.01$. (Numbers in italics indicate no statistically significant difference.) Two summary figures are also presented. Because we suspect householder age is the most informative indicator of all population and household indicators, the first figure plots the aggregate numerical change in households by householder age category for each distance band. The second figure plots the aggregate numerical change in owner and renter occupied units by distance band from transit stations.[1]

Light Rail Transit Systems

Demographic and housing performance indicators for LRT systems with respect to distance bands from light rail stations are reported in Table 1. Figures 1 and 2 illustrate numerical change by distance band with respect to change in households by householder age and change in home occupancy by tenure, respectively.

Within the first 1/8 mile LRT station performance is impressive, showing apparently substantial percentage changes in demographic and housing performance. Equally interesting is the lack of impressive outcomes for all other distance bands, though most do show positive changes for most performance indicators between 2000 and 2010; but they performed less well than the LRT counties as a whole.

Consistent with expectations, the closest distance band saw an overall increase in population and added White residents at a faster pace than transit counties as a whole, but minority population change lagged. Interestingly, there was negative population growth in the second band (more than 1/8 mile to less than or equal to 1/4 mile) but moderately impressive growth in the third band (more than 1/4 mile but less than 1/2 mile).

[1] Because we are not comparing numerical changes to the transit county and that we report results from the universe of block groups, statistical tests of significance are not needed.

Percentage change in households by type was mostly consistent with expectations, albeit with some surprises. The key surprise was the sizeable change in householders aged 35 to 64 in the first band (less than or equal to 1/8 mile) though given that most households in this age group do not have children this may not be as surprising as it may have been a few decades ago. The percentage change in householders aged 65 or more and in households with children performed about as expected. Consistent with expectations, the change in median household income between 2000 and 2010 across all distance bands was higher than the change in overall LRT counties' median household income, with the highest changes occurring in the first three distance bands (to and including 1/2 mile).

The growth rate across all housing indicators in the first distance band exceeded that of transit counties and was reasonably impressive for several other bands.

Figures 1 and 2 illustrate an interesting trend: though the closest band added by far the most households among all the bands, the third and fourth bands also gained large amounts. The second band is interesting for its visual lack of performance (reported statistically in Table 1). We speculate on reasons later.

Overall, about 7.4 percent of LRT counties' household growth occurred within 3/4 mile of LRT stations. Though seemingly small, the total land area of these bands is a small fraction of transit counties. Numerically, nearly 50,000 households were attracted to locations within 3/4 mile of LRT stations.

Table 1
Demographic and Housing Change between 2000 and 2010 within Light Rail Station Distance Bands

Demographic Feature	Transit County	<=1/8 mile	>1/8 mile to <=1/4 mile	>1/4 mile to <=1/2 mile	>1/2 mile to <=3/4 mile	>3/4 mile to <=1 mile
Population						
Total Population	12%	**15%**	-6%	8%	3%	-7%
White	6%	**18%**	-6%	**11%**	4%	*-5%*
Minority	24%	12%	-7%	1%	1%	*-9%*
Households						
Total Households	12%	**22%**	3%	9%	6%	-1%
HH with Children	7%	0%	*-20%*	-2%	-4%	-16%
2+Adult no Children	1%	**26%**	**8%**	*13%*	11%	5%
Single Person HH	13%	**29%**	11%	10%	7%	4%
HH Age <35	1%	**25%**	**7%**	**7%**	10%	*-10%*
HH Age 35-64	15%	**23%**	3%	11%	7%	5%
HH Age 65+	18%	7%	*-10%*	7%	-4%	0%
Median HH Income	25%	**44%**	**43%**	**43%**	**38%**	**33%**
Housing						
Total Housing Units	15%	**27%**	5%	12%	10%	3%
Occupied Units	12%	**22%**	3%	9%	6%	-1%
Owner Occupied	11%	**19%**	3%	*7%*	3%	4%
Renter Occupied	13%	**23%**	2%	10%	8%	*-5%*
Growth Share Summary						
HH Share of Change		4.1%	0.2%	1.7%	1.4%	-0.3%

Note:
Bold means change occurred at a faster pace in station areas than for the transit county as a whole and the difference was statistically significant using the Z-score at $p < 0.01$. Numbers in italics indicate no statistically significant difference.

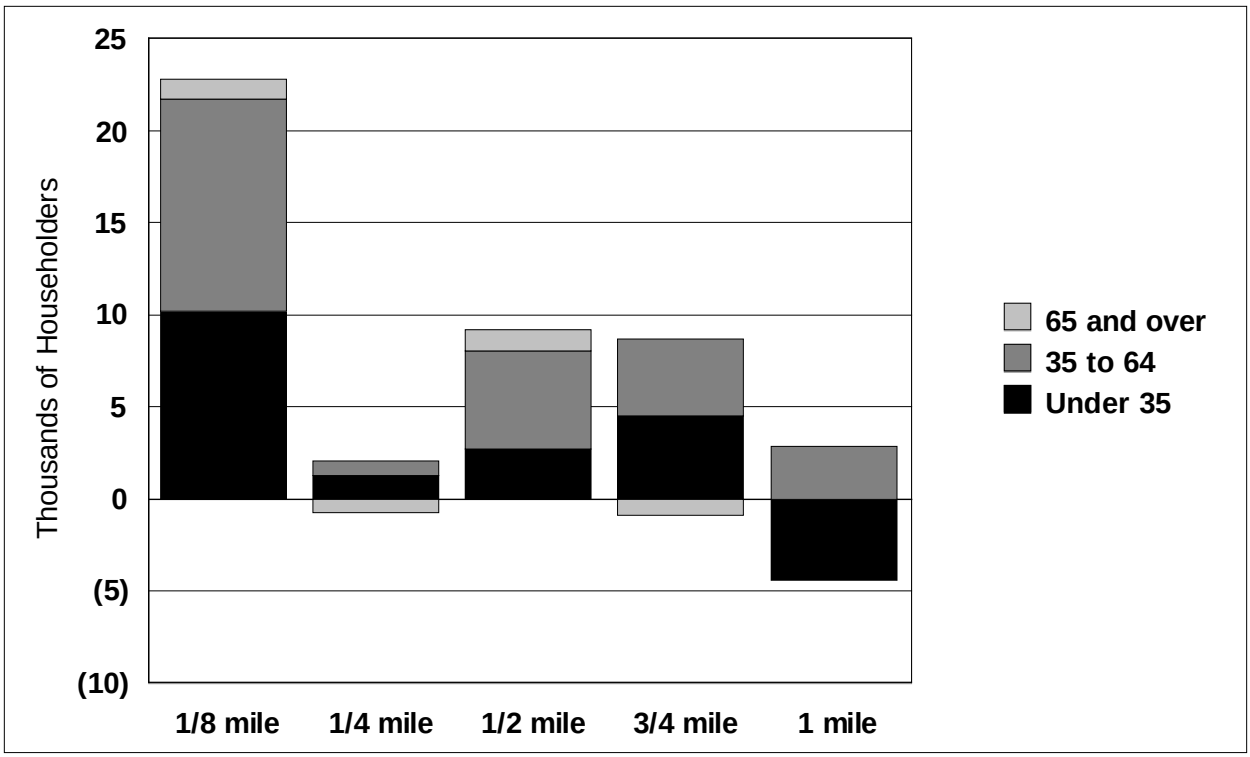

Figure 1
Householder age change within distance bands from **light rail transit** stations. All changes are significantly different from central county change.

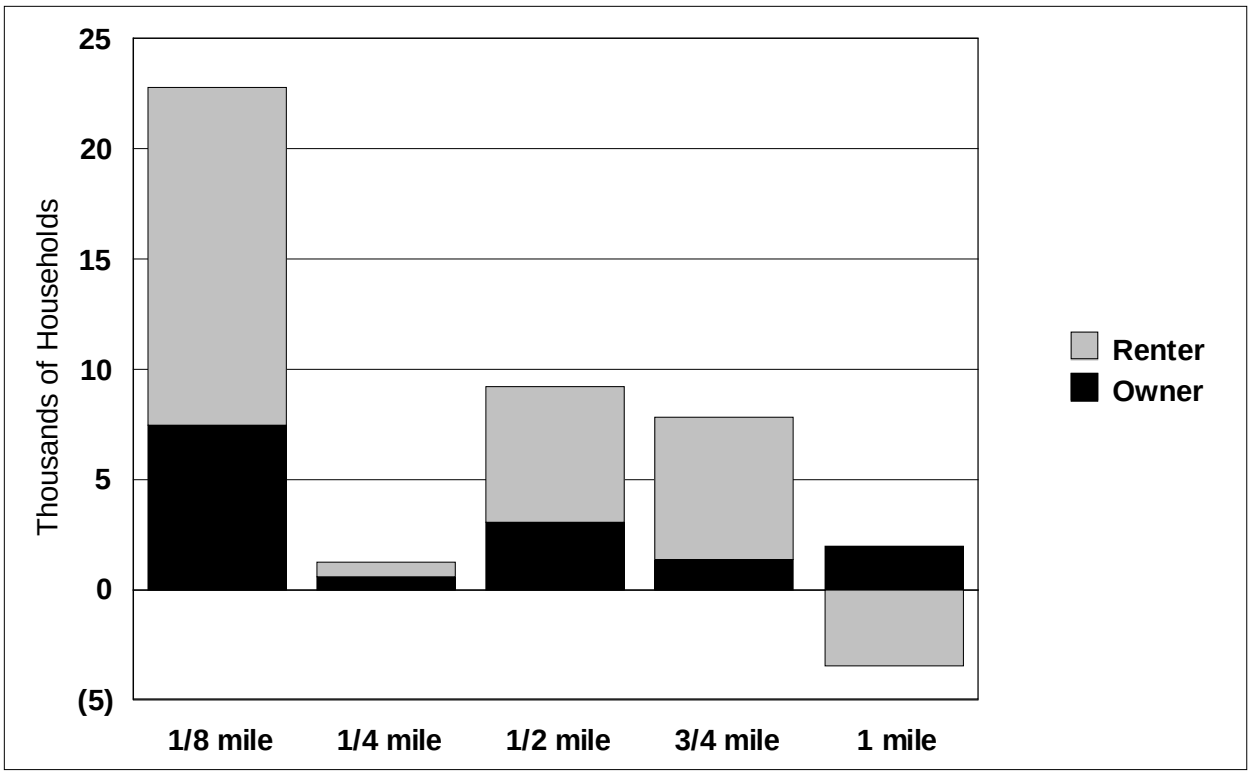

Figure 2
Tenure change within distance bands from **light rail transit** stations. All changes are significantly different from central county change.

Streetcar Transit Systems

Table 2 reports demographic and housing performance indicators for SCT systems across distance bands from streetcar stations while Figures 3 and 4 show numerical changes with respect to households by householder age and home occupancy by tenure, respectively.

Similar to LRT systems, Table 1 shows that SCT performance is most prevalent in the closest distance band, less than or equal to 1/8 mile. Nearly all performance indicators show greater percentage change in the first distance band compared to SCT counties. Even the exception, percentage change in minority population, is nearly equal to transit county change (35 percent compared to 36 percent change, respectively).

Though there are some impressive percentage changes in several other distance bands relative to SCT counties, the actual numerical changes are small, as shown in Figures 3 and 4. In effect, only the first distance band has meaningful results. Those figures clearly show how dominant the closest distance band is in attracting households and occupied housing units. This pattern raises implications for transit planning that will be offered later.

Notably, Table 2 shows that 6.9 percent of all household growth in SCT counties occurred in the closest SCT band, with a total of 8.6 percent share through the first half mile. Given the small spatial area of these bands, SCT performance in attracting households is impressive. Numerically, about 10,000 households were attracted to SCT stations up to 3/4 mile away, mostly in the downtowns of Portland, Seattle and Tampa.

Table 2
Demographic and Housing Change between 2000 and 2010 within Streetcar Station Distance Bands

Demographic Feature	Transit County	<=1/8 mile	>1/8 mile to <=1/4 mile	>1/4 mile to <=1/2 mile	>1/2 mile to <=3/4 mile	>3/4 mile to <=1 mile
Population						
Total Population	18%	**44%**	**27%**	11%	-8%	-3%
White	13%	**47%**	**31%**	**16%**	1%	*12%*
Minority	36%	35%	13%	2%	-23%	*-19%*
Households						
Total Households	17%	**42%**	8%	14%	-3%	-1%
HH with Children	12%	**31%**	***19%***	0%	-22%	-14%
2+Adult no Children	22%	**64%**	19%	*21%*	4%	11%
Single Person HH	18%	**34%**	-0%	12%	12%	-4%
HH Age <35	9%	**42%**	-0%	**21%**	-4%	*11%*
HH Age 35-64	21%	**46%**	13%	14%	-5%	-4%
HH Age 65+	17%	**32%**	*11%*	-1%	7%	-10%
Median HH Income	23%	**68%**	**26%**	**34%**	21%	**48%**
Housing						
Total Housing Units	20%	**55%**	14%	17%	-1%	-4%
Occupied Units	17%	**42%**	8%	14%	-3%	-1%
Owner Occupied	12%	**114%**	**32%**	*10%*	-17%	-1%
Renter Occupied	26%	**28%**	-3%	16%	15%	*-1%*
Growth Share Summary						
HH Share of Change		6.9%	0.4%	1.3%	-0.2%	-0.1%

Note:
Bold means change occurred at a faster pace in station areas than for the transit county as a whole and the difference was statistically significant using the Z-score at $p < 0.01$. Numbers in italics indicate no statistically significant difference.

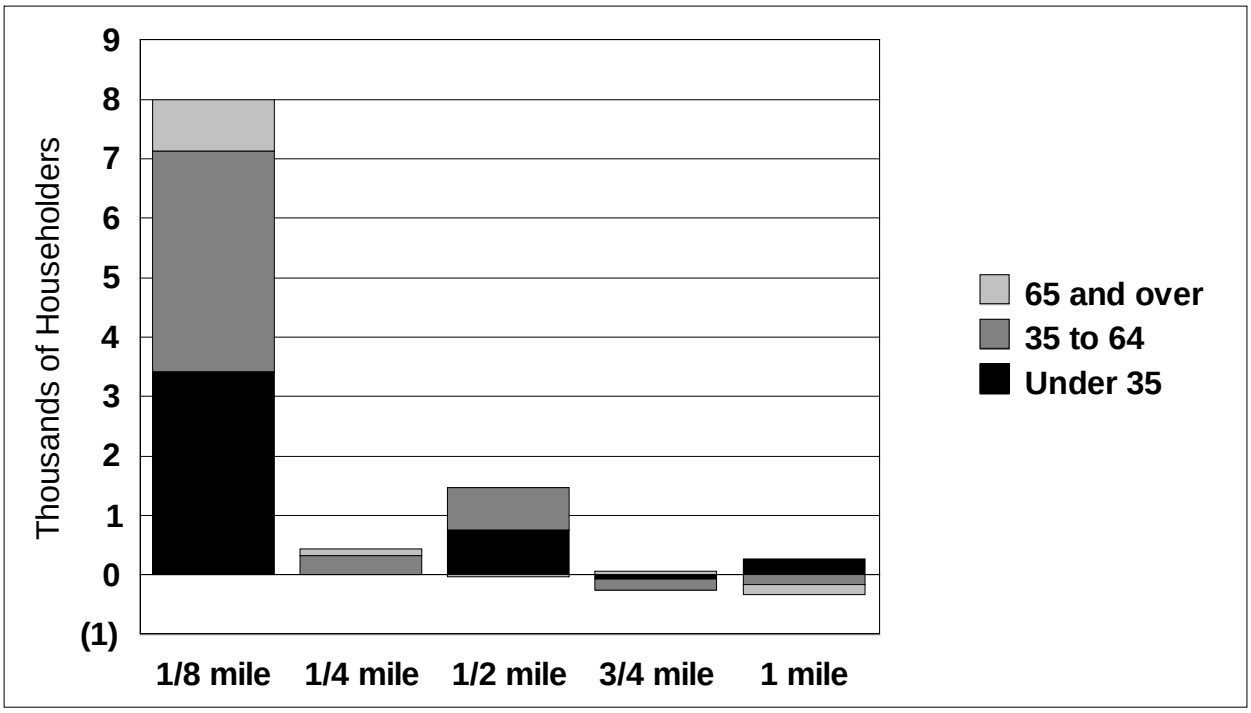

Figure 3
Householder age change within distance bands from **streetcar transit** stations. All changes are significantly different from central county change.

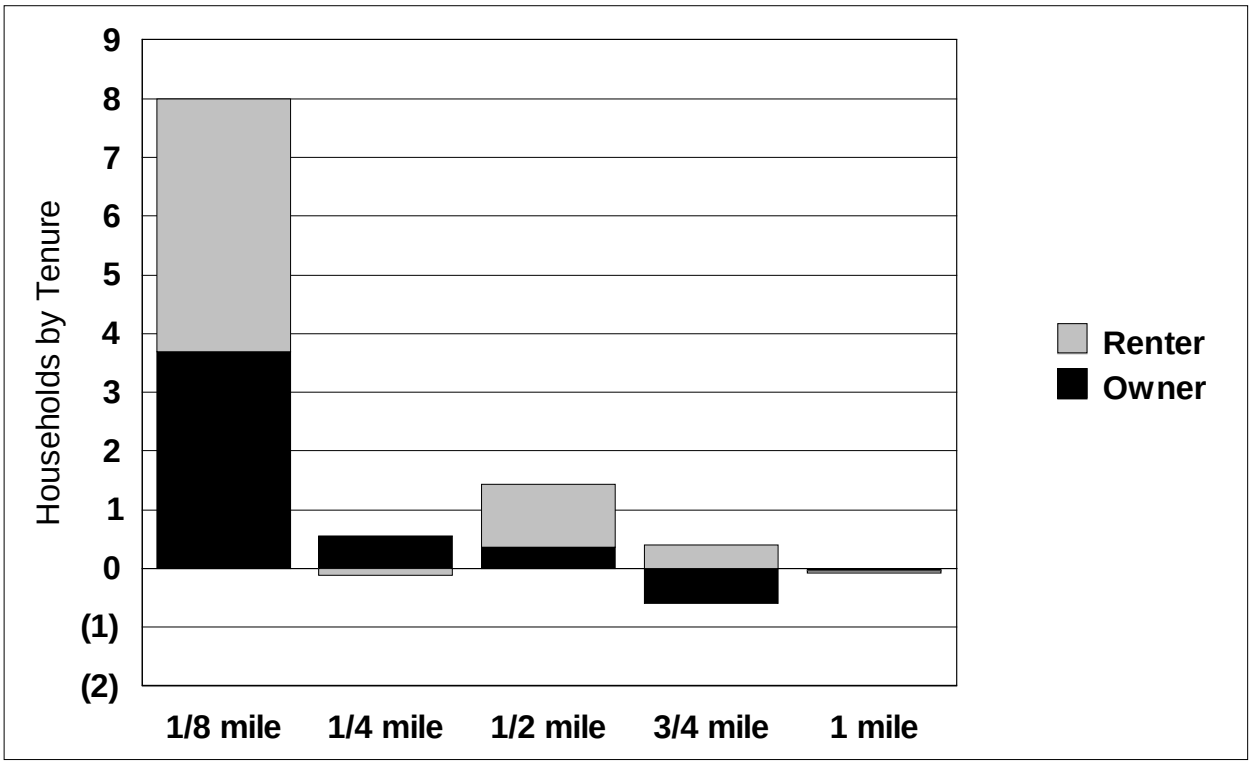

Figure 4
Tenure change within distance bands from **streetcar transit** stations. All changes are significantly different from central county change.

Bus Rapid Transit Systems

BRT system performance is in stark contrast to that LRT and SCT systems. Performance among nearly all the indicators in the first distance band is less than that for BRT counties. Indeed, the only indicator where it performs better is among households with householders under 35 years of age. On the whole, the nearest distance band accounted for only two tenths of one percent of BRT county household growth. The next three distance bands, to 3/4 mile, showed only two indicators across all bands that performed better than BRT counties as a whole: increase in minority population and renters. On the other hand, those three bands accounted for nearly nine percent of the share of household growth in the BRT counties.

Also in stark contrast to LRT and SCT systems is that it is the band farthest away from BRT stations, more than 3/4 mile to less than or equal to one mile, that performs nearly as well as the closest distance band for those systems. Indeed, it also accounted for 9.5 percent of BRT county household growth. Moreover, across all distance bands, the first mile around BRT stations accounted for 18.6 percent of the change in households in BRT counties. Figure 5, for the numerical change in households by householder age and Figure 6, for the numerical change in households by tenure illustrate trends reported in Table 3.

We speculate that BTR proximity has important effects on residential choice but perhaps not in the closest distance band. We observe that BRT lines are along major collector and arterial street corridors and stations are often at or near busy intersections. Indeed, previous work by Nelson et al. (2013) of the Eugene-Springfield BRT systems that the first one-eighth mile saw considerable growth in jobs. It could be that BRT stations attract jobs but dissuade or even displace people. That performance indicators perform best at the farthest band from BRT stations is nonetheless perplexing. It implies that if BRT systems attract population and housing growth,

it does so at a distance people are willing to walk to BRT stations that is not otherwise supported strongly in the literature—three quarters to one mile away.

On the other hand, we note that, except for Pittsburgh where two of its three BRT lines have been operating since the early 1980s and all lines were operating during the study period, all BRT systems in the US have been operating since the middle 2000s or later. So, those systems have been operating over half or less of the study period (2000 to 2010) and the last three years were impacted by the Great Recession. Moreover, most BRT systems operate in slow to stagnating regional economies where new development is not as robust as seen in the metropolitan areas with LRT and SCT systems. BRT population, household and housing performance may become more like that of LRT and SCT systems over the next decade.

Table 3
Demographic and Housing Change between 2000 and 2010 within Bus Rapid Transit Station Distance Bands

Demographic Feature	Transit County	<=1/8 mile	>1/8 mile to <=1/4 mile	>1/4 mile to <=1/2 mile	>1/2 mile to <=3/4 mile	>3/4 mile to <=1 mile
Population						
Total Population	7%	3%	**8%**	4%	6%	**10%**
White	6%	2%	5%	1%	2%	**7%**
Minority	7%	6%	**16%**	**12%**	**16%**	**19%**
Households						
Total Households	7%	3%	*7%*	5%	6%	**10%**
HH with Children	-2%	-4%	**-0%**	-4%	-3%	**1%**
2+Adult no Children	16%	7%	14%	9%	11%	*16%*
Single Person HH	7%	2%	6%	***8%***	**8%**	**11%**
HH Age <35	-11%	**-7%**	**-2%**	**-5%**	**-6%**	**1%**
HH Age 35-64	12%	*11%*	*12%*	9%	8%	**14%**
HH Age 65+	15%	-4%	8%	8%	**18%**	11%
Median HH Income	31%	27%	**32%**	26%	26%	28%
Housing						
Total Housing Units	10%	6%	**11%**	9%	**13%**	**14%**
Occupied Units	7%	-4%	0%	-1%	-1%	3%
Owner Occupied	6%	-0%	5%	-0%	0%	**7%**
Renter Occupied	8%	5%	**10%**	**10%**	**12%**	***14%***
Growth Share Summary						
HH Share of Change		0.2%	3.0%	2.8%	3.1%	9.5%

Note:
Bold means change occurred at a faster pace in station areas than for the transit county as a whole and the difference was statistically significant using the Z-score at $p < 0.01$. Numbers in italics indicate no statistically significant difference. (In the case of HH Age < 35, the loss of households for the distance bands was either less than the loss rate for the transit county as a whole or positive.

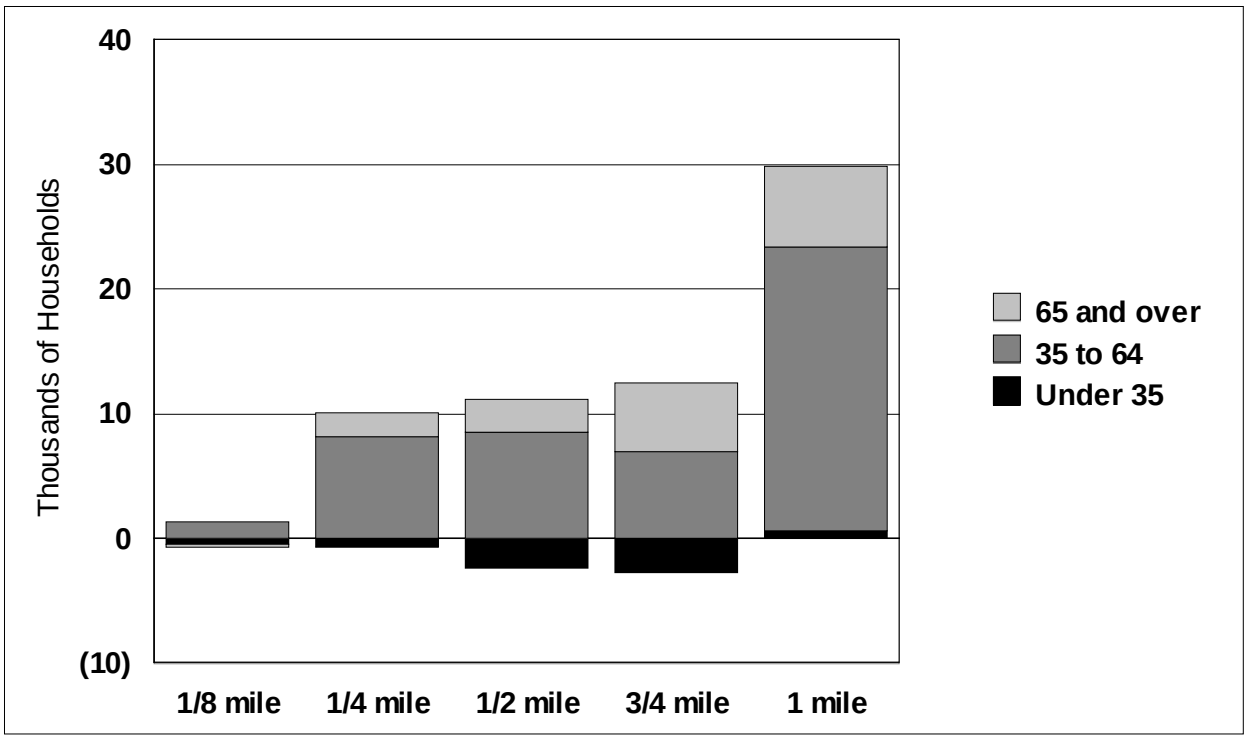

Figure 5
Householder age change within distance bands from **bus rapid transit** stations. All changes are significantly different from central county change.

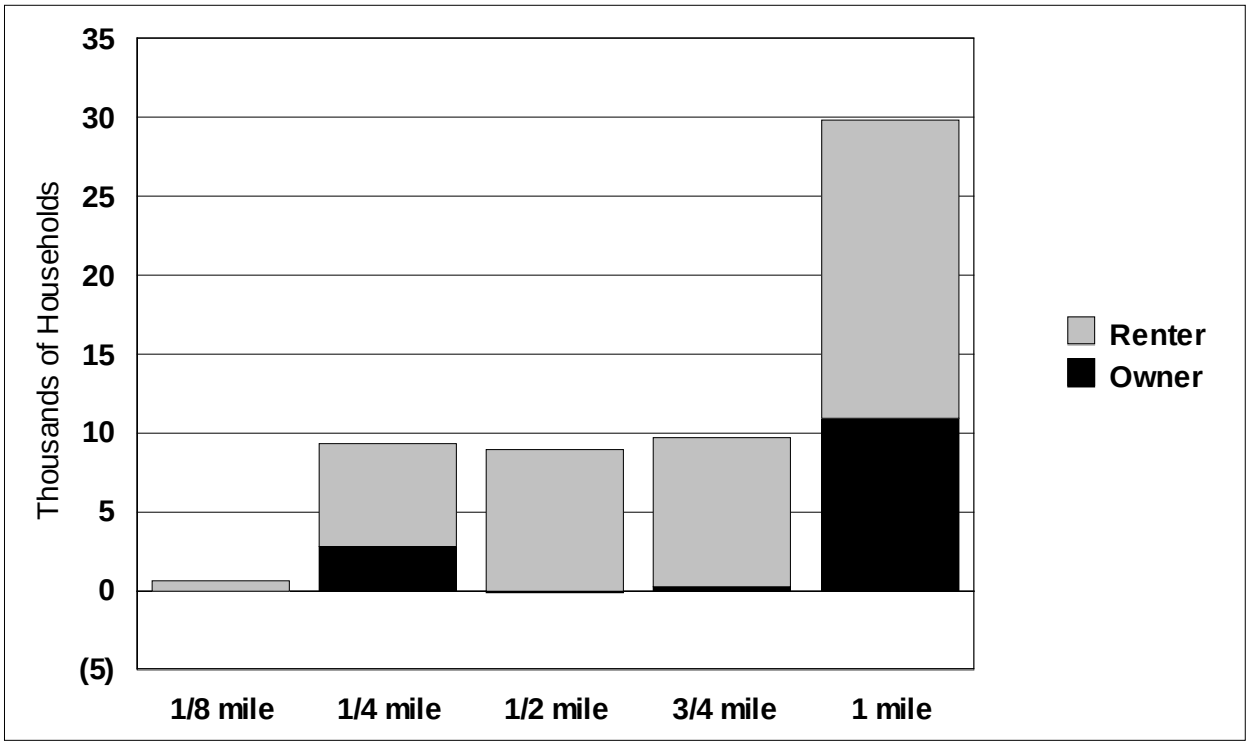

Figure 6
Tenure change within distance bands from **bus rapid transit** stations. All changes are significantly different from central county change.

Summary and Challenge

This may be the first study to assess changes over time in population, household and housing indicators for multiple fixed guideway transit systems with respect to distance bands from transit stations. Key findings are summarized here.

Light Rail Transit

Within the first distance band (less than or equal to one-eighth mile), LRT stations are associated with greater increases in total population though not minorities, all household types and ages excluding households with children and householders age 65 and over, and all housing performance than LRT counties as a whole. Yet, this is nearly the opposite case in the second distance band (more than 1/8 mile but less than or equal to 1/4 mile), as most performance indicators are negative or otherwise smaller than percentage changes in LRT counties. Perhaps the presence of LRT stations shifts residential markets favoring the closest band, as new residential development occurred at nearly twice the LRT county rate. Much of this development would seem to occur on infill and redevelopment sites, which can be costly in terms of time and resources. However, despite its proximity to LRT stations, the second band may also require infill and redevelopment activities that are too time-consuming and costly in the near term—our study covers only 10 years, three of them being impacted substantially by the Great Recession.

Given residential development pressures in the first distance band, we wonder whether and the extent to which firms are being outbid or displaced. If so, do they locate in the second or more distant bands? Ongoing research may help address this question.

The third and fourth distance bands (together more than 1/4 mile to less than 3/4 mile) are associated with moderately positive growth, though for the most part at a slower pace than LRT counties as a whole.

LRT stations may influence residential activities to about ¾ mile from transit stations. Within this distance, LRT station areas accounted for 7.4 percent of their respective LRT counties' growth during the 2000s.

Streetcar Transit

Indicators for SCT show clearly that the closest distance band performs best across all distance bands. Like LRT systems, minority population growth lagged in the SCT counties but all other indicators exceeded SCT county growth rates. And although other distance bands had occasional indicators exceeding SCT county growth rates, the numerical figures showed very little association between SCT proximity and change in population, households and housing. Indeed, only the closest distance band was associated with any meaningful share of SCT county household growth, at 6.9 percent. Moreover, the total distance over which there was positive household growth is just 1/2 mile, within which about 8.6 percent of SCT county growth occurred. Considering the counties are large—King County, WA, Multnomah County, OR, and Hillsborough County, FL—this is not a trivial outcome.

As with LRT systems, we wonder whether the attractiveness of the closest band for residential development is outbidding or even displacing jobs to the next distance bands. Ongoing research will address this. Moreover, over time we may say the second or more distant bands become attractive to residential as the closest band becomes saturated. There is some evidence of this in our database for the Portland SCT system which has been operating since the late 1990s, though the other two systems have been operating only since the early to middle 2000s.

Bus Rapid Transit

BRT system performance with respect to population, households and housing appears to be mirror image of that seen for LRT and SCT systems, and yet aggregate performance to one mile from BRT stations is actually superior. Based on prior research by Nelson et al. (2013), it may be that firms and jobs dominate the closest distance band, and that the highway corridors and BRT stations do not lend themselves to being especially attractive to residential development. Together, the middle three distance bands (more than 1/8 mile to less than or equal to 3/4 mile) accounted for 8.9 percent of BRT county growth or more than all growth in the first mile of LRT and SCT systems. Over the entire study area distance, BRT systems accounted for 18.6 percent of BRT county growth, or about 65,000 households. This is impressive performance especially considering that most BRT systems and all those operating in growing metropolitan areas initiated operations in 2004 or later, including the three years of the study period affected by the Great Recession. It seems possible that over time BRT systems will demonstrate their effectiveness in attracting residential development, though perhaps mostly beyond 1/8 mile from BRT stations.

The Challenge

As impressive as these outcomes are for all transit systems studied, demand may nonetheless exceed supply. Nelson (2013) observes that about a quarter of American households would choose to live near transit, even in attached rental units, if the supply existed. Considering that America will add 40 million households between 2015 and 2050, and that 10 million may want to live near transit, there is much to be done to accommodate apparent market demand.

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