Household Transportation Cost Variation with Respect to Distance from Light Rail Transit Stations

Arthur C. Nelson (corresponding author)
Professor of Planning and Real Estate Development
College of Architecture, Planning and Landscape Architecture
University of Arizona
520.621.4004
acnelson@arthurcnelson.com

Dejan Eskic
Research Analyst
Metropolitan Research Center
University of Utah

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Abstract

It seems an article of faith that transportation costs as a share of household income increase with respect to distance from downtowns, freeway interchanges, and light rail transit stations. Considerable literature reports price effects of these points on residential property values but none measure explicitly differences in household transportation costs as a share of household budgets. Our study helps close this gap in literature. We use ordinary least squares regression analysis to address this issue. We evaluate census block group data for all 12 metropolitan areas with light rail transit stations operating in 2010. We use the Department of Housing and Urban Development Location Affordability Index database which estimates the share of household budgets consumed by transportation. In addition to control variables, we measure the distance of block group centroids to the center of central business districts, freeway interchanges, and light rail transit stations. We use the quadratic transformation of the distance variable to estimate the extent to which distance affects are found. We find that household transportation costs as a share of budgets increase with respect to distance from downtowns and transit stations to about 20 miles and seven miles respectively. We offer implications for planning and housing, as well as for future research.

Introduction

Conventional theory of location and land-use, especially residential location, in post-World War II, automobile dominant American metropolitan areas has household demand for location as a function of income, household size, and location costs – that is, the transportation costs associated with accessing work, shopping, services, recreation and other purposes from a prospective home. House and lot size increased the farther from centers one went. At some point, a household achieved equilibrium where preference for housing and neighborhood attributes were maximized given location costs. Conventional models of location and land-use decisions (see Alonso-Muth-Mills), however, did not consider lenders' underwriting standards which often capped principal-interest-taxes-insurance payments at 28 percent of the household's income available to service a mortgage.

By failing to consider location costs in the mortgage underwriting decision, lenders induce households to purchase homes farther away from centers than they may have chosen otherwise, resulting in more land-extensive development patterns across America's metropolitan landscapes. Combined with the ability to deduct mortgage interest against taxable income, the practice in most states to under-value owner-occupied homes for property tax assessment purposes, average-cost pricing of utility services resulting in high-cost areas paying less than their costs with low-cost areas paying more, and heavily subsidized highway investments among other actions (Blais 2010) led to inefficient land-use patterns. Some call it sprawl.

In recent years a growing body of literature has argued that housing and transportation costs need to be considered together when considering housing affordability.[1] Ewing and Hamidi (2015) note that HUD's definition of affordability—where no more than 30 percent of a household's income would be spent on housing—along with indexes of others are "structurally flawed in that they only consider costs directly related to housing, ignoring those related to utilities and transportation" (Ewing and Hamidi: 5). The 2013 Consumer Expenditure Survey, for instance, reports that total housing costs consume 33.6 percent of income[2] while transportation costs consume another 17.6 percent for a total H+T of 51.2 percent. If a household's transportation costs could be reduced by half, however, it would not able to acquire a home mortgage for a more expensive home in a more efficient location that capitalizes the savings even though it would not be economically worse off.

Conceptually, transportation cost savings are realized by locating in or near such places as downtowns, mixed-use developments, and transit stations. Studies only estimate these savings in two ways. First, a suite of studies based on work by the Center for Neighborhood Technology uses secondary data to estimate the share of trips by mode and household type at the block group, and then derive vehicle miles traveled through inferences based on other secondary data. The actual distance from block groups to such points as downtowns and transit is not estimated directly.[3] For several household types, CNT's studies estimate housing costs that are constant across large geographies such as counties while transportation costs vary by block group.

Another set of studies use hedonic regression analysis to estimate the variation in real estate values with respect to distance from such points as the downtown center and transit stations. Higgins' and Kanaroglou's (2015) review of 40 years of literature on market responsiveness to transit investment provide a thorough review of the models, methods, and outcomes using this technique. Transportation costs *per se* are not included in any of those studies.

We know of no research that estimates variation in transportation costs spatially.[4] Our study helps close this gap. Our particular interest is in knowing whether and the extent to which proximity to transit stations affects the share of transportation costs incurred by households. If so, the finding may help explain part of the capitalization effect numerous studies find with respect to residential property values and rents. It may also add new information to the discussion on the relationship between housing affordability and transportation costs as a function of transit station proximity. In establishing this relationship, we will also explore similar relationships with respect to distance from downtown and freeway interchanges.

We begin with a discussion of our analytic approach, model, and data. We then report results and interpretations. We finish our article with implications for planning and housing policy, and future research.

Analytic Approach, Model and Data

As modeling depends on the availability and nature of data, we start with a general discussion of our data with details presented in the context of individual variables below.

Our aim is to measure the variation in household transportation costs with respect to distance from light rail transit (LRT) stations. Fortunately, HUD's Location Affordability Index (LAI) includes a block group-level database of all metropolitan counties in the U.S. It includes estimates of median household transportation costs for the year 2010 (for details, see http://www.locationaffordability.info/lai.aspx?url=user_guide.php). Among the several household types for which estimates are made, we use figures for the "regional typical" household. The methodology is transparent and consistently applied to all block groups. We use other data for 2010 as described below.

Because our main interest is the variability of transportation costs with respect to LRT stations, we apply our analysis to those 12 metropolitan areas having LRT systems in 2010. For each system, we construct a database geocoding all LRT stations and then measuring their distance to the centroids of the nearest block group. Our study area is 40 miles from the central business district (CBD) of each LRT system.

We use the standard-form ordinary least squares regression model adapted for our purposes:

Transportation Cost Share = ***f****(Income, Minority and Household Type, Tenure and Vacancy, Jobs-Housing Ratio, Metropolitan Controls, Location)*

Transportation Cost Share is the dependent variable. It is defined as the percent of median household income consumed by transportation costs for the regional typical household at the block group level in 2010.

Income, Minority Status and Household Type is a vector estimating transportation costs as a share of median household income, minority affiliation, and household type. Income is from the 5-year ACS for block groups. As ***Median HH Income*** increases the share of its income used for transportation falls (Center for Housing Policy 2006). We hypothesize a negative association between median household income and Transportation Costs.

We include percent block group households whose householders are other than White Non-Hispanic, calling them ***Minority Householder Share***. Data are from the 5-year ACS for block groups. We suspect that minority households will spend a higher share of income on transportation. The reason is that minority households are segregated away from key destinations such as work (see Galster and Cutsinger 2007).

In addition to income, transportation costs vary by household type. In assessing motivations to move, household satisfaction, mode journey-to-work and other factors, Emrath and Siniavskaia (2009) allocate households by married couples with and without children, single parents, single persons, and all others. We adapt their scheme to estimate the share of median household income consumed by transportation costs based on the share of block group households reported in the 5-year ACS for block groups that have children, have two or more adults without children, and single persons. Because it has the highest median household income, our model excludes two or more adult households without children (the referent). The operational variables are ***Percent HHs with Children*** and ***Percent Single Person HHs***. Compared to the referent household group, we expect households with children to spend more on transportation while single person households will spend less as a share of household income.

The **Tenure and Vacancy** vector relates to key measures of housing at the block group level. One measure is the ***Homeownership Rate*** and a second is the ***Residential Vacancy Rate***. In most metropolitan areas, the homeownership rate increases with respect to distance from downtowns but it also means transportation costs rise as well; we expect a positive association between the block group home ownership rate and share of median household income applied to transportation costs. Likewise, as vacancy rates for all residential units tend to increase with respect to distance from downtowns we expect a positive association between block group residential vacancy rates and share of median household income at the block group level consumed by transportation. We use block group data from the 5-year ACS for these variables.

In theory, the higher the ***Jobs-Housing Ratio*** the lower the transportation costs as a share of median household income at the block level (Stoker and Ewing 2014). The reasoning is that more plentiful job opportunities closer to home increases the chances of working closer to home. Also, some households will self-select to live closer to work if job and housing opportunities are proximate. We expect a negative association between share of income spent on transportation and the block group's jobs-housing ratio. For jobs, we use data from the Longitudinal Employment Dynamics (LED) database published by the Census Bureau at the block group level for 2010. Total jobs from the LED are the numerator and total occupied housing units from the 5-year ACS are the denominator.

As our analysis includes all 12 metropolitan areas with light rail systems operating in 2010, we need to include **Metropolitan Controls** to capture the unique contributions of each metropolitan area to our regression equation. We use the newest system, Seattle, as our referent. We have no *a priori* expectations of the direction of associations with respect to any given metropolitan area.

The experimental vector estimates the association between block group **Location** and share of median household income consumed by transportation based on three location measures. We measure the centroids of each block group to the center of the central business district (CBD), nearest freeway interchange, and nearest light rail transit station. In all cases, we expect a positive association between distance from these locations and share of median household income spent on transportation. That is, the farther away a block group is from these locations the higher the transportation costs as a share of income.

For the ***Distance from CBD*** and ***Distance from LRT Station*** variables, we include quadratic transformations of the distance measure. This allows us to estimate the distance from those points where transportation costs as a share of household income peak. Only the linear version of the ***Distance from Freeway*** variable provided a significant direction of association consistent with expectations.

Results and Interpretations

Table 1 reports our regression results. The model performs reasonably well as it explains 64 percent of the variation in transportation costs as a share of median household income among nearly 5,400 block groups across 12 metropolitan areas with LRT systems. Indeed, the coefficients for all variables are significant and in the correct directions. Except for the metropolitan controls, we interpret the performance of variables within each of the other control vectors briefly. We then discuss outcomes of the experimental—Location—variables in some detail.

Our analysis indicates that the higher the median household income the lower the share of transportation costs incurred by the household. This is consistent with literature (for a recent review combined with analysis, see Fan and Huang 2012). We also find that even controlling for income and household composition (discussed in detail below), households with minority householders incur higher transportation costs as a share of income than non-minority households. This is consistent with our interpretation of Galster and Cutsinger (2007).

Compared to the block group share of households with two or more adults without children, single-person households spent a smaller share of their incomes on transportation while households with children spend more. This is consistent with other research. Emrath and Siniavskaia, for instance, find that married couples with children as well as single-parent households had longer commutes in terms of distance and time, and owned more cars than single-person households. Married couples without children had comparable commutes and cars as married couples with children but from the consumer expenditure survey we also know they earn higher incomes so their transportation cost shares would be lower. (See also Haas et al. 2008).

Our analysis confirms that home owners spend more on transportation as a share of their income than renters (see Reichenberger 2012). One reason may be America's conventional home mortgage underwriting standards limit mortgages to about 28 percent of a household's expenditures for the home but do not consider transportation costs. Economic savings attributable to location thus cannot be capitalized into higher home mortgages. The result is that households often "drive to qualify" (Gallagher 2014). But there is a downside to this: as total housing plus transportation costs are higher farther away from centers, the overall market for more distant housing weakens with the consequence that vacancy rates for all residential property tend to rise with respect to distance from centers.[5]

In addition to providing an updated literature review generally on the concept of jobs-housing balance, Stoker and Ewing (2014) use ACS journey-to-work data to determine that "more people live and work in the same commute shed if there is job–worker balance and income matching" (p. 485). While we did not control for income-matching, our analysis confirms their central findings. In this case, more jobs with respect to housing units in a block group is associated with lower shares of household income devoted to transportation costs presumably because more people can live near where they work. Indeed, Nelson et al. (2013) find that among households living within a mile of work, a third walked or biked to work in 2009 compared to a fifth in 1995.

Our analysis includes estimates of the association between three different metropolitan locations and the share of household income consumed by transportation. Those controls were distance from the CBD, distance from the nearest freeway interchange, and distance from the nearest light rail transit station.

It should not be necessary to assert that the farther one lives from a downtown the higher their transportation costs. This is the foundation of pioneering urban spatial economic theories (Alonso 1964; Mills 1967; Muth 1969). Redding and Turner (2014) update the key literature of this genre offering several insights based on empirical work such as "… highways cause the decentralization of economic activity … (and) … cause a dramatic increase in driving …" (p. 35). While we find what should be expected—that household transportation costs increase as a share of income the farther they live from downtowns, we also find something that is not often reported in literature: The distance-decay function extends about 20 miles based on the mean from our sample of 12 metropolitan areas. This is the utility of the quadratic transformation of the distance variable.

Similarly, we find that transportation costs as a share of income increases with respect to distance from freeway interchanges, though we could not find a significant association using the quadratic specification.

Of central interest to us is whether and the extent to which transportation costs as a share of income increases with respect to distance from LRT stations. Over the years there have been numerous studies reporting that residential property values increase the closer they are to LRT stations, which is an implicit measure of transportation costs as savings that are presumably capitalized (see Higgins and Kanaroglou 2015). Based on the regression equation, we find that household transportation costs as a share of income increases with respect to distance from light rail transit stations to about seven miles away.

Implications for Planning and Housing Policy, and Future Research

That households' share of income devoted to transportation increases with respect to LRT stations to about seven miles elicits two important policy implications from us.

First, our findings may be used to relax early efforts to calibrate location-efficient mortgages (LEM). For the most part, the LEM calculations were weighted substantially toward the central business district. Considering just this limitation, research by Blackman and Krupnick (2001) conclude that LEMs do not raise mortgage default rates and should be weighed against anti-sprawl benefits they may offer. We suspect default rates will be lower the closer properties are to LRT stations. Further research may explore the relationship between proximity to LRT stations if not all fixed guideway transit stations and foreclosure rates.[6]

Second, assumptions about planning land uses around LRT stations if not all fixed guideway transit stations may need to be relaxed. The so-called half mile circle planning area has already been challenged through a case study of the Salt Lake County LRT system, which finds that LRT stations confer a market value on apartments to more than one mile (Petheram et al. 2013). Some of us have also found that office rents capitalize proximity to LRT stations in metropolitan Dallas to nearly two miles (Nelson et al. 2015). Our empirical analysis suggests that LRT station planning protocols may need to extend many miles from stations. Not that station planning areas need to extend up to seven miles but station accessibility strategies might be reconsidered given the evidence suggesting that households realize important transportation cost savings within that distance.

The nation will add about 100 million people between now and mid-century. One of us (Nelson 2013) has estimated that about a quarter of American households want to live near fixed guideway transit opportunities though less than 10 percent have those options now. Perhaps one reason is that Americans understand the cost savings associated with living near transit stations. Yet, even if all new homes built between now and mid-century were located near existing or planned fixed-guideway transit stations the demand for living near those stations would still not be met.

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Table 1
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Variable	Beta	t-score
Constant	11.971	39.753 *
Income, Minority and Household Type		
Median HH Income	-0.005	-6.119 *
Minority Householder Share	0.004	3.402 *
Percent HHs with Children	0.004	1.500 *
Percent Single-Person HHs	-0.030	-10.222 *
Tenure and Vacancy		
Home Ownership Rate	0.026	23.123 *
Residential Vacancy Rate	0.019	5.212 *
Jobs-Housing Ratio		
Jobs-Housing Ratio	-0.004	-11.288 *
Metropolitan Controls		
Charlotte	3.674	16.656
Dallas	1.319	6.652
Denver	0.923	4.356
Houston	1.673	7.788
Minneapolis	-0.613	-2.869
Phoenix	2.014	9.517
Portland	1.483	6.711
Sacramento	1.873	8.654
Salt Lake City	2.649	11.047
San Diego	1.255	5.910
Location		
Distance from CBD	0.278	20.973 *
Distance from CBD squared	-0.007	-11.885 *
Distance from Freeway	0.100	3.839 *
Distance from LRT Station	0.356	7.770 *
Distance from LRT Station squared	-0.026	-2.832 *
Regression and Results Summary	**Figure**	
Dependent: Transportation Costs as Share of HH Income		
Analytic unit: Census block groups, 2010		
Number of observations	5,388	
Adjusted R^2	0.642	
F-ratio	440.826	
F-significance	0.000	
* $p < 0.05$, one-tail		
Miles from CBD maxima	19.857	
Miles from LRT Station maxima	6.846	

Endnotes

[1] We refer readers to HUD's Location Affordability Portal for literature and other materials on the concept of housing plus transportation ("H+T") costs (see http://www.locationaffordability.info/).

[2] These costs include "shelter" components such as rent and mortgage, utilities, insurance, maintenance and repairs, and several other expenditures. See http://www.bls.gov/cex/2013/combined/income.pdf.

[3] CNT has produced two significant generations of these studies. The first is reported in http://htaindex.cnt.org/map/ and the second in http://www.locationaffordability.info/default.aspx.

[4] Specifically, we do not know of any study that estimates the slope of change in the share of HH income consumed by transportation with respect to downtown or transit stations.

[5] Our data are used to confirm this through a bivariate regression where Vacancy Rate (VR) is a function of CBD distance: VR = 10.695 + CBD-Distance*-0.258, $p < 0.001$.

[6] We conducted an indirect test of this is using our data through a bivariate regression where Vacancy Rate (VR) as a proxy for foreclosure potential is a function of LRT station distance: VR = 10.344 + LRT-Station-Distance*-0.626, $p < 0.001$.