Property Values and Transportation Facilities: Finding the Transportation-Land Use Connection

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This article reviews empirical studies of the relationship between transportation facilities—highways, heavy rail, and light rail transit systems—and property values. The main objective is to develop an explanation for inconsistent results presented in this literature over the past several decades. Results from these studies vary based on whether travel time or travel distance is used as a measure of accessibility. When researchers measure access to highways and rail transit in terms of travel time, study results usually indicate the expected inverse relationship between access to transportation facilities and property values. When studies use travel distance as a measure of access to transportation facilities, results tend to show mixed property value effects. The delineation of study areas also appears to influence the direction of results. This article offers a new interpretation of the transportation facility-property value literature that improves our ability to measure this relationship and to anticipate land-market responses to transportation facilities.

There is little doubt, theoretically and practically, that the relationship between transportation and land use is significant. The most common empirical approach used to measure this relationship is to examine how property values vary with distance to a transportation facility. However, this approach is fraught with mixed results. Four decades of inconsistent empirical findings have led to a variety of attempts to explain why the results are so unpredictable and what we can learn from them. This article suggests a new interpretation of the literature in hopes of improving its usefulness for academic and professional pursuits in transportation and land use planning.

Theoretical Expectations

An important underlying assumption of the monocentric model is that travel costs (money and time) increase with distance to the central business district (CBD). The monocentric model assumes that the CBD is important for households as a place of employment and is important to firms as an export node, a source of secondary services, and a place where managers can easily engage in face-to-face communication (Alonso 1964). Travel costs increase when the distances between households and employment locations increase or when distances between firms and the places they need to conduct business increase. This generalization about the correlation between travel distance and travel costs is sensible in a monocentric city. Trip making is simpli-

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fied in the monocentric model—variations in travel costs for households and firms are based only on the distance to one centrally located concentration of activity.

In hypothesizing about how new transportation facilities affect property values, researchers generally assume that nearby firms or households experience reduced travel costs and that travel cost savings allow firms or households to bid up property values. This hypothesis is based on the assumption that new facilities connect households or firms to the destinations they need to reach (for example, households to employment locations and firms to export nodes, services, and information). The hypothesis is also based on the assumption that travel cost savings vary significantly with the distance a household or firm is located from a transportation facility. Yet, a transportation facility is not a final destination; it is an intermediary source of connection between an origin and a destination. Thus, the distance between a property and a transportation facility—the measure of access used in most transportation-property value studies—may not accurately reflect changes in travel costs. These assumptions regarding travel costs and distance are feasible if cities are monocentric and new facilities are built to support the obvious travel patterns associated with monocentricity. However, if cities are polycentric and generate more unpredictable travel patterns, the usefulness of any particular facility to nearby residents or firms is not readily apparent because the facility may or may not connect households and firms to places and services they need. In polycentric cities, there may be no correlation between travel costs for households and firms and distance to a specific transportation facility, especially when there is little certainty about the final destinations of particular households and firms.

The most accurate way to analyze how property values vary in relation to a new transportation facility is to first examine how the facility affects travel costs for households and firms. Measures of actual travel times should reflect travel costs more accurately than the distance of a household or firm to a particular transportation facility. If travel times decrease for nearby households and firms, then there is a strong basis for hypothesizing that these travel cost savings will be used to bid up the price of nearby properties.

In summary, the assumption that the distance to concentrations of activity is positively correlated with travel costs is defensible. (The monocentric model assumes that distance to the CBD, where all activity is located, is positively correlated with travel costs.) The assumption that the distance to a transportation facility is positively correlated with travel costs is not as defensible because a particular facility may or may not serve certain households and firms. If a facility adequately serves some group of households or firms, it is reasonable to expect to see travel cost savings used to bid up property values. Travel cost savings may be small or nonexistent if a facility does not serve nearby households and firms. In this case, there is no basis for expecting property values to increase.

Current Interpretations

Knight and Trygg (1977) offer an early explanation for the inconsistent and perplexingly weak evidence of the transportation-property value relationship. They conclude that factors other than transportation investments, such as land use controls and economic growth, influence land-market responses. These conclusions are widely accepted and cited by researchers who find mixed or unexpected results. Yet, most of the variables identified by Knight and Trygg continue to be left out of property value and transportation facility analyses even though the importance of these variables is widely accepted and intuitively sensible. There is no strong empirical support yet, simply because researchers have not followed through in controlling for these variables.

Another organizing view of past research is that studies from the 1950s, 1960s, and 1970s generally show positive property value effects associated with new transportation facilities, but studies from the 1980s and 1990s generally show small property value effects. Giuliano's (1989) explanation of this difference is based on the idea that the marginal increases in accessibility that were associated with the construction of the interstate highway system were large enough to exert shifts in land use patterns. However, the marginal increases in accessibility from recently built infrastructure are not large enough to change property values and land use patterns. This explanation is appealing, but it is contradicted by the existing body of empirical work. For example, there are early studies that find no evidence of a land value response to transportation investments (Golden 1968; Eyerly 1966; Burton and Knapp 1965). There are also more recent studies that find significant transportation-property value relationships (Palmquist 1982; Gamble et al. 1974).

Landis et al. (1995) offer another explanation for why the empirical literature "diverges" so far from theoretical expectations. They suggest that a transportation technology noticeably influences accessibility levels when the technology is new, but the technology's influence declines over time. In the period shortly after the introduction of a new transportation technology, properties located in areas that benefit from increased accessibility are "underpriced". Over time, the values of these properties increase, and a new land-market equilibrium is reached. Landis et al. argue that once the economy of an urban area adjusts to the initial effects of a new transportation technology, additional investment in the technology will not generate equally strong property value effects. Under this interpretation, results from transportation-property value studies vary according to the extent to which land markets have adjusted to the travel cost savings brought about by the introduction of a particular transportation technology.

These three explanations provide little direction on how to empirically capture a transportation system's effect on property values. Knight and Trygg (1977) might argue that controlling for land use policy and economic conditions will improve our understanding of transportation effects. Giuliano's (1989) interpretation seems to suggest that transportation facilities may no longer offer significant improvements in accessibility. The explanation offered by Landis et al. (1995) suggests that research should account for the relative changes in accessibility that result from a particular transportation technology and the degree to which land markets have adjusted to that transportation technology.

One concern that has not been addressed in these interpretations is the accurateness of the variable most commonly used to measure accessibility, namely, the distance of a property to the transportation facility. Using distance as a measure of accessibility overlooks the more important questions of how travel costs are reduced and which travelers experience these reduced costs.

This article examines how results vary based on whether travel time or travel distance is used as a measure of accessibility. Results from the studies that use distance as a measure of accessibility vary. However, the results of the studies that use travel time as a measure of access more consistently reflect the expected theoretical relationship. The goals of this literature review are (1) to clarify the empirical literature in hopes on improving the measurement of the transportation-property value relationship and (2) to provide clearer guidance for practitioners about expected property value responses to transportation investments. The real questions are, "Has this transportation facility improved travel times for travelers," and if so, "which travelers?" If the facility improves travel times, then we should expect those travelers who experience travel time savings to bid up property values. If the facility does not improve travel time, then we should not expect a land-market response.

Approximately twenty-nine studies that examine how transportation facilities affect property values have been conducted over the past four decades. Several reviews of this literature have also been completed (Huang 1996, 1994; Kelly 1994; Parsons, Brinkerhoff, Quade, and Douglass, Inc. 1996; Giuliano 1989; Dyett 1981; Gamble and Davinroy 1978). Two methods predominate these analyses: experiment-control analysis and multivariate regression. Yet, almost no two studies have similar study designs. This complicates attempts to generalize about the overall body of results. The main focus of this article is to determine how results vary based on the independent variables used to measure accessibility. The way results vary based on other study design factors, such as the definition of test and control areas, is also considered.

Eleven highway studies and eighteen rail transit studies are reviewed. The article focuses on only those studies that examine how transportation facilities affect property values; thus, it excludes a large body of literature on how transportation investment affects other aspects of the urban environment such as population, employment, and amounts and types of actual land use change.

Guiliano's (1988) categorization of empirical research into first and second generation studies is maintained here. The first generation highway studies span the 1950s and 1960s and primarily employ experiment-control methods. The second generation highway studies are from the 1970s and 1980s. Second generation studies generally use regression analysis. No analyses of the effects of highway investments on property values were found for the 1990s. The first and second generation categories of rail transit studies roughly correspond to the two waves of rail construction (heavy and light rail construction) in the United States. The first generation rail studies analyze heavy rail systems built in the 1960s and 1970s. The second generation studies examine the more recent light rail systems. Regression analysis is predominately used in both generations of rail studies.

FIRST GENERATION HIGHWAY STUDIES: METHODS AND STUDY DESIGN

The first generation highway studies generally analyze data associated from a test and control site for some designated period before and after freeway construction. This approach entails collecting property value data from two geographic areas. Theoretically, these test and control areas are identical except for the presence of a freeway within the test area. Property value data are compared to determine whether significant differences exist between the test and control areas. Differences in property value data are attributed to the freeway since ideally all other variables are held constant. Each of the first generation highway studies uses test-control methods, but other aspects of their study designs are notably different. The size of test areas, for example, ranges from parcels within five blocks of a freeway corridor (Adkins 1959) to an area within two miles of a freeway interchange (Eyerly 1966). Study periods range from a three-year before-and-after period in Adkins's (1959) study to a twelve-year longitudinal analysis (Bone and Wohl 1959). Table 1 summarizes the characteristics of the first generation highway studies.

All of the first generation highway studies use property values as a measure of land use. This provides some consistency across studies; however, the sources of property value data vary. Property value data were collected from a variety of sources, including real estate sales records and county property assessments. Some researchers attempt to address the difference between land value and the value of improvements to the land, but others do not. For example, Adkins (1959) uses real estate sales data and attempts to remove the effect of improvements by subtracting the appraised tax value of the improvements from real estate sales.

Results

Table 1 provides a summary of the first generation highway study results. Three of the six first generation studies show the expected positive relationship between freeway access and property values (Adkins 1959; Bone and Wohl 1959; Lemly 1959). Bone and Wohl (1959) found that property values in the test area increased 180 percent over the study period compared to control site values that increased only 85 percent. Adkins (1959) found test area property values increased 334 percent more than control area property values in Houston, Texas; 483 percent more in the Dallas, Texas, test area; and 77 percent more in the San Antonio, Texas, test area. Three of six test-control studies show a weak or insignificant relationship between freeway access and property values (Golden 1968; Eyerly 1966; Burton and Knapp 1965).

Some generalizations can be made about the direction of results and characteristics of these first generation studies. In the three that indicate a positive relationship between freeway access and property values, test areas were confined to areas no more than 0.5 miles from the freeway. All studies not finding a relationship used test areas that included properties located from 1.5 to 2.0 miles from the freeway. This trend indirectly supports the idea that study results vary according to how well the access variable is specified. Including properties within a narrowly defined test area, such as within 0.5 miles of a freeway corridor or perhaps up to 1.0 mile of a freeway interchange, increases the likelihood that study results will indicate the expected relationship between property values and freeway access. In the first generation studies, researchers who analyzed property values in test areas where residents were more likely to experience travel time savings generally found expected property value increases.

The results of the first generation highway studies do not show a clear positive relationship between early highway construction and increases in property values. This may raise questions about Giuliano's (1989) interpretation that earlier studies generally find property value effects associated with transportation facilities because of dramatic increases in accessibility. One would expect more than three of the six first generation studies to show a clearly positive relationship between highway access and property values if this interpretation was accurate. One explanation for the inconsistency in these early studies is that the direction of results depends on the specific characteristics of the study design. Most important, results appear to vary based on the size of the test areas.

SECOND GENERATION HIGHWAY STUDIES: METHODS AND STUDY DESIGN

Second generation highway studies generally employ regression analysis. These studies are similar in the choice of property value as the dependent variable. However, other aspects of the studies' designs differ. As with the first generation highway studies, the study areas and the length of study periods vary for second generation highway studies. The explanatory variables used in these regression analyses also vary. Table 2 summarizes the design characteristics of the second generation highway studies.

Palmquist (1982) uses regression analysis and compares regression coefficients from test and control areas. Pendleton (1963), Cribbins et al. (1965), and Gamble et al. (1974) each analyze a single study area, but the size of the study areas ranges from within 2.5 miles of a highway facility in the study conducted by Cribbins et al. to within 1.1 miles in Palmquist's study. Study periods vary, ranging from Pendleton's cross-sectional analysis to a fifteen-year longitudinal study by Cribbins et al.

The second generation studies employ two different types of variables to measure freeway accessibility. Pendleton (1963) and Palmquist (1982) use travel times and travel distances to the CBD to measure the changes in accessibility brought about by a highway improvement. Gamble et al. (1974) use a regional accessibility index calculated by the Metropolitan Washington Council of Governments. The index incorporates travel times and distances between residential and employment areas. Cribbins et al. (1965) use the distance of a property from the nearest freeway right-of-way or interchange as a measure of access. The other independent variables, including property and neighborhood characteristics, are generally consistent for the second generation studies.

TABLE 1. First Generation Highway Studies

Author	Study Area / Transportation System	Size of Study Area	Study Period / System Opening	Dependent Variable	Access Variable	Access Variable Significant?
Adkins 1959	1. Houston, TX Gulf Freeway 2. Dallas, TX Central Expressway 3. San Antonio, TX San Antonio Expressway	Test area: within 5 blocks of freeway Control area: sites "out of sphere of influence of freeway"	1. Before: 1939-41 After: 1954-56 Opening: 1945 2. Before: 1941-45 After: 1951-55 Opening: 1953 3. Before: 1941-45 After: 1952-56 Opening: 1954	Percentage change in land value between study and control areas	a. Band of properties adjacent to freeway b. Band of properties 1 to 3 street blocks from the freeway c. Band of properties 3 to 5 street blocks from the freeway d. Band of properties abutting the freeway and up to 3 blocks from freeway	1a. 334% (difference between study and control area land values) 1b. –9% 2a. 483% 2b. 0% 2c. 58% 3d. 77%
Lemly 1959	Atlanta, GA 7.5-mile portion of North Expressway	Not indicated	Before: 1941-46 After: 1952-56 Opening: 1951	Change in land values	a. Band A adjacent to expressway b. Band B adjacent to band A c. Band C adjacent to band B (band widths not provided)	Difference between average percentage change in land values in band A and band B is 196% Difference between average percentage change in land values in band B and band C is –118%
Bone and Wohl 1959	Lexington, MA Route 128	Test area: within 0.5 miles of freeway (3,922 acres) Control area: remainder of Lexington (6,625 acres)	1945-57 / 1951	Assessed values of single-family residential properties	Dichotomous distance variable (properties within 0.5 miles of freeway compared to those outside)	Test area assessed values increased 180% over the study period Control area assessed values increased 85%
Burton and Knapp 1965	Fairfax County, VA 22 miles of Capital Beltway	Three study areas (ranging from adjacent parcels up to 1.5 miles from freeway) are compared	Before: 1951-58 After: 1958-62 Opening: 1958	Residential and vacant land values	a. 0.5- to 1.5-mile band on "inside" of beltway b. 1.0-mile band centered on beltway c. 0.5 to 1.5-mile band on "outside" of beltway	a. Values increased 104% more in after period as compared with before period b. Values increased 39% more in after period as compared with before period c. Values increased 30% more in after period as compared with before period
Eyerly 1966	York, PA Four interchanges on I-83	Test area: 2-mile radius around interchanges Control area: remainder of townships	1961-65 / not indicated	Change in appraised property values	Properties within 2 miles of freeway interchange	Test area showed an average increase of 3.8% in property values Control area showed average increase of 4.4% in property values
Golden 1968	Chicago, IL Eleven test-control areas along five expressways in the Chicago area	Test areas: within 1 mile of expressways Control areas: outside 1 mile of expressways and similar to test areas in terms of socio-economic characteristics and size	1939-63 / 1951-61	Residential, commercial, and industrial property values	*t*-test used to evaluate the significance of difference in mean property values between test and control areas	Of the thirty-three test-control comparisons (three land use types in eleven study areas), only eight showed higher *t*-scores in the test area after period

TABLE 2. Second Generation Highway Studies

Author	Study Area / Transportation System	Size of Study Area	Study Period / System Opening	Dependent Variable	Access Variable	Access Variable Significant?
Pendleton 1963	Washington D.C. Metropolitan Area Washington D.C. Area highway system		1961 / not indicated	Residential sales price	Job accessibility index Log of distance to the White House 1959 driving time to the CBD	1. A hundred points of job accessibility index are valued at $2.33 2. One minute less driving time to the White House adds $63.68 to house price 3. One unit of log distance is valued at $3,552
Cribbins et al. 1965	The state of North Carolina 57 miles of interstate freeway (I-95, I-85, I-40)	Within 2½ miles of freeway (not a test-control study)	1947-61 / 1958-60	Residential sales price	a. Distance of property to freeway right-of-way b. Distance of property to freeway ramp	One of eleven regressions shows that distance to freeway right-of-way is significant and greater in the after period than in the before period (residential properties along I-85)
Gamble et al. 1974	North Springfield, VA I-495	Within 4,000 feet of freeway (not a test-control study)	1969-71 / 1961	Residential sales price	Washington Council of Government accessibility index	$2,950 increase in property value associated with increased accessibility Negative effects of freeway concentrated within 400 feet of facility
Palmquist 1982	King County, Seattle, WA 1. I-405 2. I-5	1. Test area: between 100 feet and 5,900 feet from freeway Control area: general area east of Lake Washington 2. Test area: between 100 feet and 5,900 feet from freeway Control area: general area in northern part of King County	1. 1962-76 / 1970 2. 1958-76 / 1965	Residential property sales price indices	Accessibility index incorporating travel times between property and major activity centers	12% appreciation rate in test area residential price index (author states this is greater than control area but does not provide rate of appreciation in control area) 15% appreciation in test area (author states this is greater than control area but does not provide rate of appreciation in control area)

Results

Table 2 summarizes the second generation highway study results. Three of the four second generation highway studies show the expected positive correlation between freeway access and property values (Palmquist 1982; Gamble et al. 1974; Pendleton 1963). Palmquist (1982) and Gamble et al. (1974) show that properties that abut a freeway are adversely affected in comparison to properties that are located farther away. They conclude, however, that the net effect of freeway access on property values is positive. The results of the Cribbins et al. (1965) study indicate no consistent freeway effect.

What explains the pattern of findings for the second generation studies? A majority of the second generation findings indicate that there is a positive relationship between access to highways and property values. As suggested in the discussion of first generation highway studies, the size of a study area may influence the direction of results. The only second generation study that did not find a consistently positive relationship between highways and property values (Cribbins et al. 1965) included property data from up to 2.5 miles from the right-of-way, farther away from the freeway than each of the other studies. The accessibility benefits of freeways may not extend 2.5 miles beyond a freeway. The effects accruing to properties closer to the freeway may be overshadowed when an analyst includes properties that are too far away to benefit from increased freeway access.

The second generation studies appear to support the idea that effects on property values are only found when an analyst focuses on properties relatively closer to a transportation facility. This is sensible given that individuals who reside in properties closer to the highway facility are more likely to gain travel time savings. Residents or employers located farther from the facility may not gain accessibility improvements in terms of travel-time savings. Increases in property values at these more distant locations should not be expected. Although the Pendleton (1963) and Gamble et al. (1974) studies include properties in relatively larger study areas, they find expected inverse relationships between access and property values. However, it is important to note that these studies use travel time, rather than travel distance, to measure accessibility. Pendleton uses travel time to the CBD. Gamble et al. use an accessibility index derived from travel times. These measures of travel time are direct indications of changes in the accessibility levels that are associated with particular properties. A property's distance from a freeway may not always directly relate to a level of accessibility.

Final results are reported in a variety of ways in the second generation highway studies. Pendleton (1963) reports that a one-minute decrease in driving time to the CBD adds $63.68 to the price of a house, and a price increase of $444 can be attributed to a house located three miles from the CBD rather than four miles. Gamble et al. (1974) show that improved accessibility accounts for an increase of $2,950 per property in the entire North Springfield, Virginia, area. Palmquist's (1982) results indicate that, over the same time period, properties within approximately one mile of a freeway right-of-way appreciated 12 to 15 percent more than comparable properties that are located beyond a mile from the freeway.

EFFECTS OF RAIL TRANSIT ON LAND VALUES

Two periods of rail construction have occurred in the United States in recent decades. Several cities began constructing heavy rail systems in the 1960s and 1970s, including San Francisco, California, Atlanta, Georgia, and Washington, D.C. Empirical studies of property value effects were conducted following the opening of these rail systems. In the late 1970s and 1980s, approximately twelve cities, including San Diego, California; Portland, Oregon; and Buffalo, New York, initiated construction of light rail systems (Cervero 1984). Both heavy and light rail construction of new and expanding systems continues in the 1990s in more than twenty U.S. cities (Parsons, Brinkerhoff, Quade, and Douglass, Inc. 1996). This presents transportation researchers with continuous opportunities to study how both heavy and light rail transit systems affect property values.

FIRST GENERATION (HEAVY RAIL) TRANSIT STUDIES: METHODS AND STUDY DESIGN

Regression analysis is used in all but one of the heavy rail transit studies. As with the highway studies, there is considerable variation in other aspects of heavy rail studies, including the size of the study areas, the length of the study periods, and the independent variables used to estimate property values. An important characteristic of the first generation rail studies is that two distinct measures of access are used as independent variables. Four of thirteen heavy rail studies use measures of access that are based on travel times (Armstrong 1994; Voith 1991; Bajic 1983; Dewees 1976). In the remaining studies, access is measured as a parcel's distance from a rail corridor or station (e.g., Landis et al. 1995; Cervero and Landis 1993; Gatzlaff and Smith 1993; Nelson and McClesky 1990; Dyett et al. 1979; Falcke 1978). Table 3 summarizes some of the first generation rail studies' characteristics, including the approaches used to measure transportation access. Although travel time and travel distance are both intended to measure accessibility levels, they are quite different measures. Travel time variations should be

TABLE 3. First-Generation Rail Transit Studies (heavy rail)

Author	Study Area / Transportation System	Size of Study Area	Study Period / System Opening	Dependent Variable	Access Variable	Access Variable Significant?
Boyce et al. 1972	Camden County, NJ Lindenwold Rail	Test area: Lindenwold corridor Control area: Woodbury corridor	1965-71 / 1969	Residential sales price	Travel cost savings (difference between auto and rail travel costs to the CBD)	Travel cost savings significant in estimating residential sales price ($149 increase in sales price for each dollar travel cost savings) Travel savings not significantly related to residential sales price in the control area
Lerman et al. 1978	Washington, D.C. Washington Metrorail	Within 2 miles of Metrorail station	1969-76 / not indicated	1. Single-family residential sales price 2. Multifamily residential sales price 3. Retail property sales price	a. Reciprocal form of straight-line distance to nearest station b. Straight-line distance to nearest transit station c. Transit distance to CBD	1a. 1,077 2b. –6,464 3b. –0.678 1c. –5,767 2c. 4,556
Dewees 1976	Toronto Bloor-Danforth subway line	Within 1 mile of Bloor subway corridor	1. 1961 2. 1971 / opening 1968	Single-family residential sales prices	a. Walking distance to Bloor Street b. Distance along Bloor to CBD c. Time cost to Bloor Street d. Time cost to Bloor and then CBD e. Monetary cost of travel to Bloor f. Monetary cost of travel to Bloor and then CBD g. One-third mile walking distance (dummy variable) h. One-third mile walking distance (dummy variable) i. One-third mile time cost (dummy variable)	1a. –0.17 2a. *ns* 1b. *ns* 2b. –5.94 1c. –16.4 2c. –23.7 1d. *ns* 2d. –29.5 1e. *ns* 2e. na 1f. *ns* 2f. na 1g. –0.52 2g. *ns* 1h. *ns* 2h. –43.8 1i. *ns* 2i. –55.8
Dyett et al. 1979	San Francisco BART	1. Six residential areas within 5,000 feet of a BART station 2. Three commercial areas within 5,000 feet of a BART station	1973-76 / 1972-74	1. Residential property prices 2. Office rents	Distance to BART station in feet	Four of six station areas had greater residential price increases compared to other residential areas Office rents only increased slightly after station openings compared with other office areas
Bajic 1983	Toronto Spadina Subway Line	1. Test area: within 4 kilometers of subway line 2. Control area: Metropolitan Toronto	a. Before: 1971 b. After: 1978 Opening: 1978	Single-family residential sales prices	a. Transit commute time from property to subway line b. Auto commute time from property to freeway interchange	1ai. –0.1279 2ai. –0.1256 1aii. –0.0947 2aii. –0.0285 1bi. –0.2284 2bi. –0.1602 1bii. –0.0844 2bii. –0.0190

(continued)

TABLE 3. Continued

Author	Study Area / Transportation System	Size of Study Area	Study Period / System Opening	Dependent Variable	Access Variable	Access Variable Significant?
Nelson and McClesky 1990	Atlanta, GA East Line of MARTA	Within 1.25 miles of rail right-of-way	1986 / 1971	Single-family residential sales prices	1. Straight-line distance to nearest station 2. Distance to nearest station squared	1. –0.007 2. 0.000115
Voith 1991	Buck, Chester, Delaware, and Montgomery Counties, PA, and Camden County, NJ with commuter rail to a CBD	Not indicated	1980 / not indicated	Aggregate median home value of census tracts	1. Availability of commuter rail service in census tract 2. Travel time from census tract to CBD by auto 3. Number of peak hour trains serving each census tract 4. Difference in commute time between auto and commuter rail 5. Average length of commute in minutes from each tract regardless of destination	1. 7,358.6 2. 157.1 3. *ns* 4. *ns* 5. *ns*
Nelson 1992	Atlanta, GA East Line of MARTA	Within 1.25 miles of rail right-of-way	1986 / 1971	1. Single-family residential sales price from properties on north side of Atlanta 2. Single-family residential sales prices from properties on south side of Atlanta	a. Straight-line distance to nearest station b. Straight-line distance to nearest station squared	1a. 965.72 2a. –1045.6 1b. –23.16 2b. 15.559
Cervero and Landis 1993	1. Atlanta, GA MARTA 2. Washington, D.C. Washington Metrorail	Not indicated	1978-89 / 1. 1972-75 2. Not indicated	Office asking rents	Proximity to rail station compared with proximity to highway interchange	1. 1 of 2 comparisons showed rent premium for office located near rail station 2. 3 of 3 comparisons showed no significant rent difference for office space located near rail or highway
Gatzlaff and Smith 1993	Miami, FL Eight Miami Metrorail station areas	Within 1 square mile of a station	1971-90 / 1984	Single-family residential sales prices	Distance to nearest rail station	Distance to station significant for 3 of 8 stations on 21 mile heavy rail line. Two stations were an amenity for residential properties; one station was a disamenity
Armstrong 1994	Boston, MA Fitchburg-Gardner commuter rail line	Within 10 miles of commuter rail right-of-way	1990 / not indicated	Single-family residential sales prices	1. Estimated auto travel time to nearest highway interchange 2. Actual auto travel time from preferred highway interchange to CBD 3. Estimated travel time to nearest rail station	1. *ns* 2. –0.04550 3. *ns* 4. –0.10929 5. *ns*

					4. Actual travel time from preferred rail station to CBD 5. Estimated walking time to nearest rail station			
Landis et al. 1995	1. Alameda County, CA BART 2. Contra Costa County, CA BART 3. San Mateo County, CA CalTrain	1. Mean distance of properties to stations is 6.4 k., and 2.0 k. to freeway interchange 2. Mean distance of properties to station is 11.5 k., and 3.3 k. to freeway interchange 3. Mean distance of properties to station is 5.3 k., and 2.5 k. to freeway interchange	1990 / 1. 1972-75 2. 1972-75 3. 1980	Single-family residential sales prices	a. Roadway distance to nearest rail station b. Roadway distance to nearest highway interchange c. Adjacency to rail right-of-way d. Adjacency to highway right-of-way	1a. –2.29 1b. 2.80 1c. *ns* 1d. *ns*	2a. –1.96 2b. 3.41 2c. *ns* 2d. *ns*	3a. *ns* 3b. *ns* 3c. *ns* 3d. *ns*
Landis et al. 1995 (same study different dependent variable)	1. Alameda County, CA BART 2. Contra County, CA BART	Within one-half mile of a station	1988-94 / 1972-75	Commercial sales prices (office, retail, industrial, auto, parking, vacant)	a. Within one-quarter mile of station b. Within one-half mile of station	1a. Not significant for any commercial uses 1b. 0.40 (vacant land) 2a. Not significant for any commercial uses 2b. Not significant for any commercial uses		
Landis and Loutzenheiser 1995	1. San Francisco County, CA BART 2. Oakland County, CA BART 3. Walnut County, CA BART 4. Three county area	Within one-half mile of station	1993 / 1972-75	Full-service office asking rents	a. Within one-eighth mile of BART station b. Within one-quarter mile of BART station c. Within three eighths mile of BART station d. Within one-half mile of BART station	1a. *ns* 1b. –0.18 1c. *ns* 1d. 0.23	2a. *ns* 2b. *ns* 2c. *ns* 2d. *ns*	3a. *ns* 3b. *ns* 3c. *ns* 3d. *ns*

NOTE: CBD = central business district; *ns* = not significant; na = not applicable.

more accurate measures of accessibility than distances to transportation facilities. Straight-line distances between properties and a rail facility may not always be correlated with the travel times between those properties and the facility. Aside from the accessibility measures, the remaining independent variables—measures of property and neighborhood characteristics—are similar in the first generation rail studies.

The size of first generation study areas range from a five-county metropolitan area (Voith 1991) to properties that are located within 0.33 miles of a transit corridor (Dewees 1976). There is also considerable variation in terms of the study period. Eight of the first generation rail studies are cross-sectional analyses. The remaining five studies use longitudinal data that span from seven to nineteen years.

Results

Table 3 summarizes the research results of the heavy rail studies. Seven of the thirteen heavy rail studies show the expected inverse relationship between property values and heavy rail access. Expected relationships between property values and heavy rail facilities are found in the early studies (e.g., Lerman et al. 1978; Boyce et al. 1972) and in more recent studies by Voith (1991) and Nelson (1992).

There appear to be study design features that distinguish the rail studies that find positive and negative relationships between access and property values. The studies that use measures of access that actually capture changes in travel times are more likely to find a significant relationship between property values and rail access. Four of the seven studies finding the expected inverse relationship between property values and access to heavy rail facilities measure accessibility in terms of the travel time savings that are associated with specific locations rather than a parcel's distance from a transit station or corridor. The remaining three studies, which also find significant relationships between property values and rail facilities, use distance measures of access but in study areas that are narrowly focused on a rail corridor or station. This is similar to the trend found in the first and second generation highway studies: when study areas are more focused around a facility, the results tend to show the expected negative correlation between property values and distance to the transportation facility. This indicates again that it is more likely that the expected relationship between access and property values will be observed when an analyst's measure of access captures variation in actual travel time savings.

The key to predicting the increases in property values that are associated with a transportation facility may be to first determine whether the facility has resulted in travel-time savings for residents and employers. This question is especially critical in studies of rail facilities. In many cases, rail transit may not provide travel-time savings for nearby populations. Thus, rail facilities should not be expected to induce changes in property values. Even when changes in accessibility are accurately measured by a researcher, increased accessibility may be relatively insignificant.

Dewees (1976) found that residents within a one-third mile distance of a subway line experience travel time savings after transportation facility improvements and that these travel-time savings are capitalized in residential property values. Residential property values decreased by $2,370 for every additional hour of travel to the subway line. Bajic (1983) found that residential property values increased by $2,237 after a new subway line opened and that travel-time savings were significant in estimating this change in property values. Voith (1991) found that residential properties in census tracts served by a commuter rail system had a 4 to 10 percent premium over homes in census tracts that were not served by a commuter rail system. He also found that travel time to the CBD was significant in estimating property values. Nelson (1992) did not use a measure of travel-time savings to estimate property value changes. He found that properties in low-income neighborhoods gained value, but properties in high-income neighborhoods did not. This finding indirectly supports the idea that property values change in cases in which travel-time savings occur. Low-income households are more likely to use transit and experience travel time savings from improved service. Higher income households are less likely to use transit and therefore less likely to experience travel time savings from improved transit service.

SECOND GENERATION (LIGHT RAIL) TRANSIT STUDIES: METHODS AND STUDY DESIGN

Light rail transit should have less effect on property values than heavy rail transit because light rail systems have lower average speeds and capacities. Thus, light rail transit should result in less time savings than heavy rail transit. Four of the five second generation rail studies use regression analysis (Ryan 1997; Workman and Brod 1997; Al-Mosaind et al. 1993; Landis and Loutzenheiser 1995; Landis et al. 1995). One of the studies employs a test-control technique (VNI Rainbow Appraisal Service 1992). Table 4 summarizes the design characteristics of the second generation studies.

All five studies use distance from a light rail line or station as a measure of access. Al-Mosaind et al. (1993) developed two models. The first model incorporates distance as a dummy variable and compares residents in and out of a 500-meter walking distance. The second model measures distance as a continuous variable and includes only those properties within a 500-meter walking distance of a light rail facility. Workman and Brod (1997) used the street network distance of residential properties from a transit station as a measure of accessibility. A study conducted by researchers at VNI Rainbow Appraisal Services (1992) analyzes properties in test and control sites adjacent to a light rail corridor and within a 0.5-mile walking distance. There have been no studies of light rail transit that use travel time savings to measure accessibility levels. However, all but two of the light rail transit studies sampled properties from a study area that was narrowly focused around the rail facility. Other independent variables in these studies were similar: each study used some measure of property characteristics and the quality of the neighborhood in which the properties were located. Three of the light rail transit studies are cross-sectional analyses. Three are longitudinal studies that range from three to thirteen years.

Results

Three of the five studies indicate a positive correlation between access to light rail stations and residential property values. The light rail studies, like the heavy rail and highway studies, generally show that effects are focused within an area close to a transportation facility. Al-Mosaind et al. (1993) found positive land value effects only within a five hundred-meter walking distance. Workman and Brod (1997) found negative land value effects near transit stations and positive effects farther away. The authors attribute this finding to the negative environmental effects (e.g., noise, vibration, and congestion) that are generated by transit facilities. Several other highway and rail-transit researchers cite similar findings (Nelson 1992; Gamble et al. 1974).

In sum, the heavy rail transit studies appear to find evidence that heavy rail transportation facilities have a positive effect on property values. Studies that incorporate a direct measure of travel time savings more consistently found positive property value effects. There also seems to be a relationship, as found in the highway studies, between the size of the study area and positive effects on property values. Three of the heavy rail studies used a distance measure of access and found expected positive relationships between rail access and property values. Each of these studies, however, sampled properties from an area relatively close to the facility. This may explain why light rail transit studies also found the expected positive relationship between property values and distance to light rail facilities. All but two of the light rail transit studies focused on land parcels near the rail facility. The two exceptions found that access was insignificant (Ryan 1997; Landis and Loutzenheiser 1995; Landis et al. 1995). It is plausible that residents or employers beyond a certain distance from both heavy and light rail facilities do not experience relative travel time improvements. Thus, property values where they are located are not bid up.

CONCLUSIONS AND FUTURE RESEARCH

This article improves our understanding of a perplexing body of literature by suggesting that results of transportation facility-property value analyses vary according to the way in which measures of access are specified. The article offers a possible explanation for the fact that so much past empirical work contradicts theoretical expectations. When transportation facilities provide travel time savings, and these savings are accurately measured, property values tend to show the theoretically expected relationship with transportation access. When researchers do not adequately capture changes in travel time, usually because properties that are too far away to experience travel time savings are included in the analysis, results tend to show insignificant property value changes. This article also suggests ways in which researchers can improve their specification of access to transportation facilities. The results of this review suggest that researchers should return to the fundamental question of “how do new (or existing) transportation facilities influence regional and local travel times for various populations of users?” Property value changes should be more directly correlated with changes in travel time than with the distance of residents and employers from a transportation facility.

This review also alerts future researchers about study design issues that should be considered when attempting to measure how transportation facilities affect property values. Measuring accessibility as the distance of a property from a transportation facility may not be an accurate enough reflection of travel times. A study that does not accurately measure changes in travel time will not accurately estimate property value changes. The results of previous research demonstrate that property value effects occur close to a facility, within 1 mile for highways and 0.33 of a mile for rail transit. Another implication of these findings is that transportation-land use research may be more effective when it is directed toward analysis of the travel time changes that accrue to residents or employers within a certain area rather than the analysis of property values or other land use variables. It is likely that the value of the properties where residents or firms are located will be bid up if travel time savings accrue to residents or firms. This type of land-market change may eventually lead to changes in development potential.

The article also provides an alternative framework that informs the debate over the direction and magnitude of the transportation-land use connection. When transportation facilities influence travel times for resi-

TABLE 4. Second Generation Rail Transit Studies (light rail)

Author	Study Area / Transportation System	Size of Study Area	Study Period / System Opening	Dependent Variable	Access Variable	Access Variable Significant?		
VNI Rainbow Appraisal Service, Inc. 1992	San Diego County, CA South and East Lines, San Diego Light Rail System	Within one-half mile of station	1989-91 / 1986	1. Mobile home sales price 2. Condominium sales price 3. Single-family residential sales price 4. Apartment sales price 5. Motel / hotels sales price 6. Retail center sales price 7. Office building sales price	a. Adjacent to rail line b. Adjacent to rail station c. Within one-half mile walking distance of station	1a. *ns* 1b. *ns* 1c. *ns* 2a. *ns* 2b. *ns* 2c. *ns* 3a. *ns* 3b. *ns* 3c. *ns* 4a. *ns* 4b. $2,920 premium 4a. *ns*	5a. *ns* 5b. $3,500 / room premium 5c. *ns* 6a. *ns* 6b. $25 / square foot premium 6c. *ns* 7a. *ns* 7b. *ns* 7c. *ns*	
Al-Mosaind et al. 1993	Portland, OR MAX, East Burnside Line	Within 500 meters of a station	1988 / 1986	Single-family residential sales price	1. Within 500 meters of rail station 2. Straight-line distance to rail station	1. 4,324 2. –21.75		
Landis et al. 1995	1. Sacramento, CA Sacramento Light Rail System 2. San Diego, CA San Diego Light Rail System 3. San Jose, CA San Jose Light Rail System	1. Mean distance of properties to station is 6.8k, to freeway interchange 3.5k 2. Mean distance of properties to station is 28.9k, to freeway interchange, 3.8k 3. Mean distance of properties to station is 8.5k, to freeway interchange, 2.7k	1990 / 1. 1986 2. 1981, 1986 3. 1988	Single-family residential sales prices	a. Roadway distance to nearest rail station b. Roadway distance to nearest highway interchange c. Adjacency to rail right-of-way d. Adjacency to highway right-of-way	1a. *ns* 1b. *ns* 1c. *ns* 1d. *ns*	2a. –1.85 2b. –2.72 2c. *ns* 2d. *ns*	3a. 4.41 3b. –2.61 3c. *ns* 3d. *ns*
Landis et al. 1995 (same study as above, different dependent variable)	San Diego, CA / San Diego Light Rail System	Within one-half mile of station	1990 / 1981 and 1986	Commercial sales prices (office, retail, industrial, auto, parking, vacant)	a. Within one-quarter mile of station b. Within one-half mile of station	a. *ns* b. –0.22 (retail uses) –0.46 (industrial uses)		

Workman and Brod 1997	1. San Francisco, CA Pleasant Hill BART Station 2. Portland, OR East Burnside Line, 148th Ave. Station, 162nd Ave. Station, 172nd Ave. Station	Within a one-mile radius of station	1. 1984-96 / 1972, 1975 2. 1995	a. Single-family residential sales prices b. Single-family residential sales prices for properties farther than 2,500 feet from station	i. Street network distance to nearest transit station ii. Street network distance to nearest highway interchange	1ai. –15.78 1aii. 7.94	2ai. 1.41 2bi. –0.7527	
Ryan 1997	1. South Bay region of San Diego, CA 2. East County region of San Diego, CA 3. Central City region of San Diego, CA San Diego Light Rail System (South, East, and Bayside Lines)	1. Within 6 miles of freeway or station 2. Within 9 miles of freeway or station 3. Within 2 miles of freeway or station	1986-95 1. 1981 2. 1986 3. 1991	a. Office asking rents b. Industrial asking rents	i. Straight-line distance to nearest rail station ii. Straight-line distance to nearest highway interchange	1ai. *ns* 1aii. –0.104 1bi. *ns* 1bii. –0.043	2ai. 0.054 2aii. –0.042 2bi. *ns* 2bii. *ns*	3ai. *ns* 3aii. –0.066 3bi. 0.033 3bii. 0.034

NOTE: *ns* = not significant.

dents or employers, it is reasonable to expect property values to adjust to reflect those travel time changes. The direction and magnitude of this adjustment depends on the direction and magnitude of the travel time changes brought about by the transportation facility. Thus, before a clear understanding of the relationship between transportation and land use can be established, investigators need to have a clear understanding of the relationship between transportation facilities and travel time changes.

Finally, useful information for planning future rail-transit systems is provided. The fact that property value effects (and travel time effects) are focused within areas close to transportation facilities has important implications for how rail systems are designed. Given the amount of evidence pointing to small property value (or travel time) impact areas, it is crucial for transportation engineers and planners to design systems that penetrate existing activity centers. Efforts should be made to design rights-of-way that connect to existing activity centers rather than to expect rail systems to attract concentrations of activity.

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