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TRANSIT-ORIENTED DEVELOPMENT IN THE UNITED STATES: EFFECTS OF THE BUILT ENVIRONMENT ON TRAVEL BEHAVIOR

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Abstract

New rail transit systems continue to be built in the U.S. at a very expensive price, partly justified on the grounds that they will lead to more sustainable patterns of metropolitan development. Evidence on the effects of more compact urban development and transit-based housing on travel choices in the U.S., however, is relatively thin.

INTRODUCTION

Over twenty rapid rail transit systems have been built in the United States since 1970, yet mass transit continues to lose market share to the private automobile. Between 1980 and 1990, the nationwide share of work trips by drive-alone motorists rose from 64.4 percent to 73.2 percent; during the same period, mass transit's share of work trips fell from 6.4 percent to 5.3 percent (Pisarski, 1992). Still, states like California are poised to spend upwards of US$100 billion over the next thirty years on urban rail transit investments. Critics charge these are wasteful public investments that are driven by pork-barrel politics (Pickrell, 1992; Wachs, 1993), however, proponents argue new rail systems will eventually induce higher density development along rail-served corridors, producing more sustainable urban forms (Vuchic, 1991; Bernick, 1993).

We can only speculate on whether new-generation rail investments will lead to more compact, transit-serviceable metropolises in the U.S. twenty to thirty years in the future. Americans often look toward Europe as a model of coordinated transit and metropolitan development. However, the metropolitan forms of cities like Stockholm and London were established well in advance of the automobile, and centralized planning has played a much stronger role in guiding urban growth in European cities. Given the sprawling landscape of most American cities, critics argue that fixed guideway systems are the wrong technology for luring people out of cars. Noted sociologist Homer Hoyt (1939) observed over a half century ago that urban form is largely a product of the dominant transportation technology during a city's prevailing period of growth. Since many American cities, especially those west of the Mississippi River, grew most rapidly during the 1950s and 1960s, a period of massive freeway construction and suburbanization, new rail systems, critics charge, are too little, too late.

Evidence on the effects of built environments on the travel choices of Americans is fairly scant. Since backers of new rail systems contend these very expensive investments will reshape America's urban landscape, much more empirical evidence is needed for guiding public policy-making. This paper presents some recent findings on the influences of transit-oriented development on transit ridership in the U.S. By "transit-oriented development" we mean urban growth that, because of its relatively high densities, mixed land-use patterns, and pedestrian-friendly urban designs, is conducive to transit riding. The research reported here concentrates mainly on the degree to which residential neighborhoods with mixes of apartments and retail stores, and more traditional urban designs (eg grid-iron street patterns), influence transit usage. The first analysis presented uses data from the American Housing Survey to study the effects of residential densities and mixed land uses on transit commuting in eleven large U.S. metropolitan areas. This is followed by a matched pair comparison of transit modal splits and trip generation rates in two types of residential neighborhoods in the San Francisco Bay Area: transit-oriented (relatively dense, mixed use, and grid-iron street patterns) versus auto-oriented (mainly detached, single-family residences in neighborhoods with curvilinear, non-gridded street patterns). The last section of the paper examines rail-oriented housing development in California in terms of transit ridership rates as well as real estate market performance. This analysis focuses mainly on how proximity to rail stops induces transit usage and commands higher rent premiums. The paper concludes with a discussion of the public policy implications of the research findings.

EFFECTS OF DENSITY AND MIXED LAND USES

A considerable body of research has established that urban densities have a strong influence on mode choices and transit usage in the U.S. (Pushkarev and Zupan, 1977; Newman and Kenworthy, 1989). Less, however, is know about the effects of mixed land uses. Among workers at 57 large U.S. office developments, Cervero (1988) found that every 10 percent increase in floorspace devoted to retail-commercial uses was associated with a 3 percent increase in the share of transit and ridersharing commutes. Most other research has concentrated on how mixed uses influence walk trips; since all transit journeys involve foot travel, to some degree, these findings are relevant to transit travel as well. In a comparison of shopping trips among residents from four neighborhoods in the San Francisco Bay Area, Handy (1992) found those living in two traditional, mixed-use neighborhoods made two to four more walk/bicycle trips per week to neighborhood retail stores than did those living in nearby areas that were served mainly by automobile-oriented, strip retail establishments. Residents of mixed-use neighborhoods, however, averaged similar rates of auto travel to regional shopping malls, suggesting that internal walk trips might not have replaced external auto trips but rather have been supplemental. In a similar study of travel by residents of six communities in Palm Beach County, Florida, Ewing et al. (1994) found that the presence of shopping, recreation, and school facilities within communities significantly lowered vehicle hours traveled (VHT) per capita. While work by Handy and Ewing et al. suggests shopping trips are most strongly influenced by mixed land uses, Frank and Pivo (1994) found having stores between one's residence and job site might have a stronger effect on commuting than on whether one will walk to shops as a substitute for auto trips to shopping malls.

Research methods, data, and variables

To explore how mixed land uses and other features of the built environment have influenced transit and pedestrian trip-making, data from the American Housing Survey (AHS) were recently studied. The American Housing Survey (AHS) is the only national survey which compiles data on commuting, neighborhood land-use composition, and household characteristics for individual housing units. Its uniqueness lies with providing data on the presence of non-residential land uses, such as retail shops and public buildings, in the vicinity of surveyed housing units. Land-use mixture, however, is gauged as a simple binary (0-1) variable—ie either non-residential uses exist or not within some defined geographic area. Additionally, the AHS identifies surrounding residential densities using ordinal classifications; specifically, nearby housing is characterized as being either single-family detached, low-rise multi-family, mid-rise multi-family, or high-rise multi-family.

The AHS is conducted every four years on housing units in 44 U.S. metropolitan areas with populations above one million. The only year for which commuting and mixed land use data were compiled in the same survey was 1985; for budgetary reasons, questions regarding the presence of non-residential activities in neighborhood were omitted from the 1989 and 1993 surveys. From the 1985 survey, around 15,200 housing unit records were sufficiently complete to support modeling.

For examining how mixed uses and other features of the land-use environment shape mode choice in American cities, discrete choice models were estimated using maximum likelihood techniques. The following variables were used in estimating utility expressions for transit and walking trips:

Land use variables

- Single-family detached housing within 300 ft of unit (0=no, 1=yes)
- Low-rise multi-family buildings or single-family attached units within 300 ft of unit (0=no, 1=yes)
- Mid-rise multi-family buildings within 300 ft of unit (0=no, 1=yes)
- High-rise multi-family buildings within 300 ft of unit (0=no, 1=yes)
- Non-residential buildings within 300 ft of unit (0=no, 1=yes)
- Grocery or drug store between 300 feet and one mile of unit (0=no, 1=yes)

Control variables

- Residence in the central city of the MSA (0=no, 1=yes)
- Number of private automobiles available in household
- Four-lane highway, railroad, or airport within 300 ft of unit (0=no, 1=yes)
- Public transportation adequate in neighborhood (0=no, 1=yes)
- Distance from home-to-work, oneway in miles

The first four land use variables listed above represent overall neighborhood density within 300 feet of a surveyed housing unit. In general, a neighborhood comprised of detached single-family homes will average 9 or fewer dwelling units (d.u.) per acre. For metropolitan areas over one million population (such as surveyed in the 1985 AHS), single-family residential densities tend to be on the higher side, in the 6 to 9 d.u. per acre range (though quarter-acre lots certainly can be found in planned developments in the suburbs of large U.S. metropolitan areas).

The remaining two land-use variables used from the AHS identify the levels of mixture. One variable signifies the presence of retail shops and other non-residential activities within 300 feet of a surveyed unit—generally a one- or two-block distance. The other variable identifies whether, specifically, a grocery or drug store lies between 300 feet and one mile of a surveyed residence. Thus, the first mixed use variable identifies whether there are non-residential activities in the immediate vicinity whereas the second variable specifies whether there are food and drug stores in the area but beyond a convenient walking distance.

Transit commuting model

A logit model estimated for predicting the probability of transit commuting using the AHS data is shown in Table 1. Controlling for other factors, the model reveals that the odds of transit commuting decline if one lives in a U.S. neighborhood with single-family detached units and rises in settings with attached housing, be they low-rise, mid-rise, or high-rise, all other things being equal. Living in an area with mid-rise (3-6 story) apartments and condominiums was more conducive to transit commuting than any of the land-use variables.

Having retail stores and other non-residential activities in the neighborhood also induced transit commuting. Based on the size of the model coefficient, however, this influence was fairly weak. The presence of a grocery or drug store between 300 feet and a mile of one's residence lowered the odds of transit commuting, ostensibly because an automobile is better suited for linking work trips to grocery and consumer shopping than a bus or train.

Table 1 also reveals that control variables exerted a stronger influence on transit commuting than did the land-use variables. Specifically, the presence of adequate transit services and living in a central city increased transit commuting more strongly than variables measuring the presence of either mid-rise or high-rise buildings, or mixed uses. Increasing vehicle ownership levels had a particularly strong effect on reducing transit commuting.

The effects of three variables—density, land-use composition, and vehicle ownership—on transit commuting are summarized in Figure 1. Four land-use scenarios are presented, holding other factors constant. Specifically, the scenarios are drawn for Americans living in a central city where public transit services are adequate and there are no grocery or drug stores within a 300-feet to one-mile radius of their residences. From the graph, we see that density exerts a stronger influence on commuting than the presence of nearby mixed uses. Under the scenario where someone lives in a household with one car, the odds of transit commuting is 0.27-.29 if they live in a neighborhood with mid-and-high-rise apartments and condominiums and 0.08-0.09 if their neighborhood consists of single-family detached homes. The existence of mixed uses has a slightly stronger effect on commuting in higher than lower density neighborhoods. Where workers live in an area with single-family detached units and have two or more cars available, the odds of transit commuting are indistinguishable regardless if non-residential uses are nearby. And regardless of the land-use environment, the odds of transit commuting falls below 6 percent if someone lives in a household with four automobiles.

Walking/bicycling commute model

An even better fitting model predicted walking and bicycling commuting. The model, not shown, found that, consistent with the previous model, densities significantly influence whether someone walks or bikes to work in large U.S. cities. However, in contrast to the transit commuting model,

Table 1 Logit model for predicting probability of transit commuting, 11 large U.S. Metropolitan Areas, 1985

Dependent Variable: Probability of Commuting by Public Transit	Coefficient	Std Error	Probability
Land Use Variables:			
Single-family detached within 300 ft of unit	-0.3163	0.00011	0.0001
Single-family attached/low-rise multi-family buildings within 300 ft of unit	0.2156	0.00015	0.0001
Midrise multi-family buildings within 300 ft of unit	0.7351	0.00018	0.0001
High-rise multi-family buildings within 300 ft of unit	0.0922	0.00107	0.0001
Commercial and other non-residential buildings within 300 ft of unit	0.1730	0.00042	0.0001
Grocery or drug store between 300 ft and 1 mile of unit	-0.0919	0.00049	0.0001
Control Variables:			
Residence within central city of MSA	0.6694	0.00018	0.0001
No. of private automobiles in household	-0.6509	0.00018	0.0001
Public transit services adequate	0.5811	0.00176	0.0001
CONSTANT	-2.1531	0.00078	0.0001

Summary Statistics:
$\rho^2 = .087$
Model Chi-Square = 250,791,441 prob. = .0001
Percent of cases correctly predicted (concordant pairs) = 77.4
No. of cases = 15,258

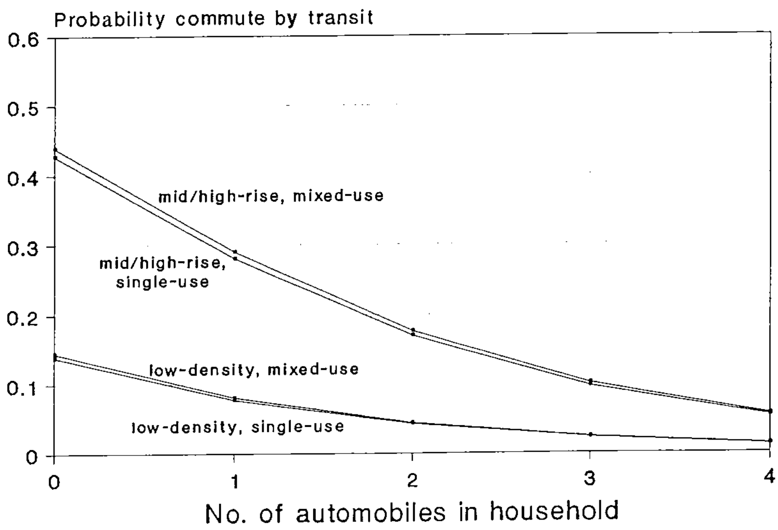

Figure 1 Probability of transit commuting for four land-use scenarios

the presence of mixed-uses has a fairly strong and significant influence on non-motorized commuting. Specifically, having commercial activities in the immediate vicinity of one's residence induces people to walk or bicycle to work, holding factors like trip distance and vehicle ownership levels constant. The existence of a grocery or drug store beyond 300 feet but within a mile, however, deters walk and bicycle commuting, ostensibly because the private automobile is better suited for accessing commercial establishments outside the immediate neighborhood but reasonably closeby.

These relationships are summarized in Figure 2, which, based on the estimated model, plots probabilities of walking to work against commute distances (up to a mile-and-a-half) for four different land-use scenarios. (Low density is defined as neighborhoods with single-family units and low-rise residential buildings.) The graph shows that walking and bicycling tends to be much higher in higher-density, mixed-use settings, almost regardless of distance. For someone residing a quarter of a mile from their job, there is a 0.57 likelihood they will walk or bicycle to work if they live in a dense, mixed-use area; if they live in a neighborhood populated only by single-family homes, however, the odds fall to 0.28. Again, the odds are virtually identical if the neighborhood is low-density with mixed uses versus high-density with single uses. The presence of mixed uses has the strongest influence for journeys to work of one mile or less. Beyond one mile, non-residential uses exert a weaker influence on walking and bicycling, as revealed by the tendency for the curves in Figure 2 to converge beyond one mile. Even at a mile and a half commute distance, however, there is a one-quarter chance that someone laving in a mid/high-rise neighborhood with surrounding stores will walk or bike to work in large U.S. cities.

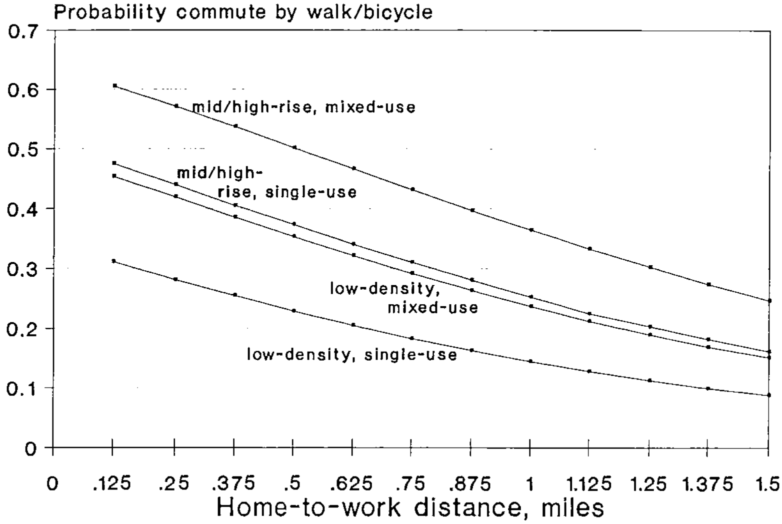

Figure 2 Probability of transit commuting by walking or bicycling for four land-use scenarios

COMMUTING IN TRANSIT VERSUS AUTO NEIGHBORHOODS

To further explore the influence of land-use environments on transit riding and walking, a quasi-experimental comparison was drawn on the commuting characteristics of "transit" versus "auto" neighborhoods in the San Francisco Bay Area that were matched in terms of income and transit service characteristics. Transit-oriented neighborhoods are sometimes referred to by urban designers as "traditional" neighborhoods—typically with a commercial core within walking distance of a majority of residents, a well-connected (often gridiron) street network, narrow streets with curbside parking, mixed land uses, and varying densities of housing (Bookout, 1992).

The San Francisco Bay Area was chosen as a case context for studying travel in transit versus auto neighborhoods, in part because it had one of the world's most extensive streetcar networks, the Key System, in the early part of this century that spawned a number of streetcar suburbs (Demoro, 1985). Thus, many older parts of the region that grew around the Key System have the characteristics of traditional neighborhoods.

Methodology

In the matched pair analyses, "transit neighborhoods" were defined as: (1) initially built along a streetcar line or around a rail station; (2) primarily gridded street systems (over 50 percent of intersections are four-way); and (3) laid out and largely built prior to 1945. "Auto neighborhoods", on the other hand, were defined as: (1) laid out without regard to transit, generally in areas without transit lines, either present or past; (2) primarily random street patterns (over 50 percent of intersections either three-way, "T" intersections, or cul-de-sacs); and (3) laid out and built up after 1945. Additionally, four control criteria were invoked—variables on which the auto neighborhood should not vary significantly from those of the transit neighborhood. Relative to the transit neighborhood, the matched auto neighborhood needed to: (1) have no more than 10 percent variation in median household income; (2) have reasonably comparable levels and types of transit services; (3) have reasonably similar topographic features; and (4) be no more than four miles away. Applying these criteria, the number of candidate neighborhood pairs in the San Francisco Bay Area was whittled down from over 400 to just seven. (See Figure 3 for the names and locations of the seven neighborhood pairs.)

Research findings

The 1990 modal shares and trip generation rates for work trips for the paired neighborhoods are summarized in Tables 2 and 3. Pedestrian/bicycle modal shares and trip generation rates were in all cases higher in transit neighborhoods than in auto neighborhoods. Moreover, all transit neighborhoods except one (Palo Alto) generated more transit trips and had higher shares of commutes by transit than their automobile counterparts. Palo Alto, however, had three times the share of residents walking or cycling to work as its paired neighborhood. In all, the evidence is fairly persuasive in the Bay Area—controlling for income and to the extent possible, transit service levels, transit-oriented neighborhoods averaged far lower shares of auto-commuting than nearby auto-oriented neighborhoods. Though there was considerable variation among the pairs, on average, the Bay Area's transit-oriented neighborhoods generated around 70 percent more transit trips and 120 percent more pedestrian/bicycle trips than nearby auto-oriented neighborhoods.

TRANSIT-BASED HOUSING, RIDERSHIP, AND RENTS

A final empirical analysis was conducted that explored recent evidence on the degree to which multi-family housing built near California rail stations has induced transit ridership and commanded rental premiums. In the U.S., California has become a national leader in attracting multi-unit housing construction near rail stops (Bernick, 1993). From 1985 to 1994, 26 large-scale apartment and condominium projects with over 6,500 dwelling units were built within one-quarter mile of California urban rail stations. Many of these projects were leveraged by local governments, using such mechanisms as tax-exempt bond financing to build complementary infrastructure, the exercise of eminent domain powers to assist with land assemblege within redevelopment districts, and the enactment of density bonuses to encourage intensification.

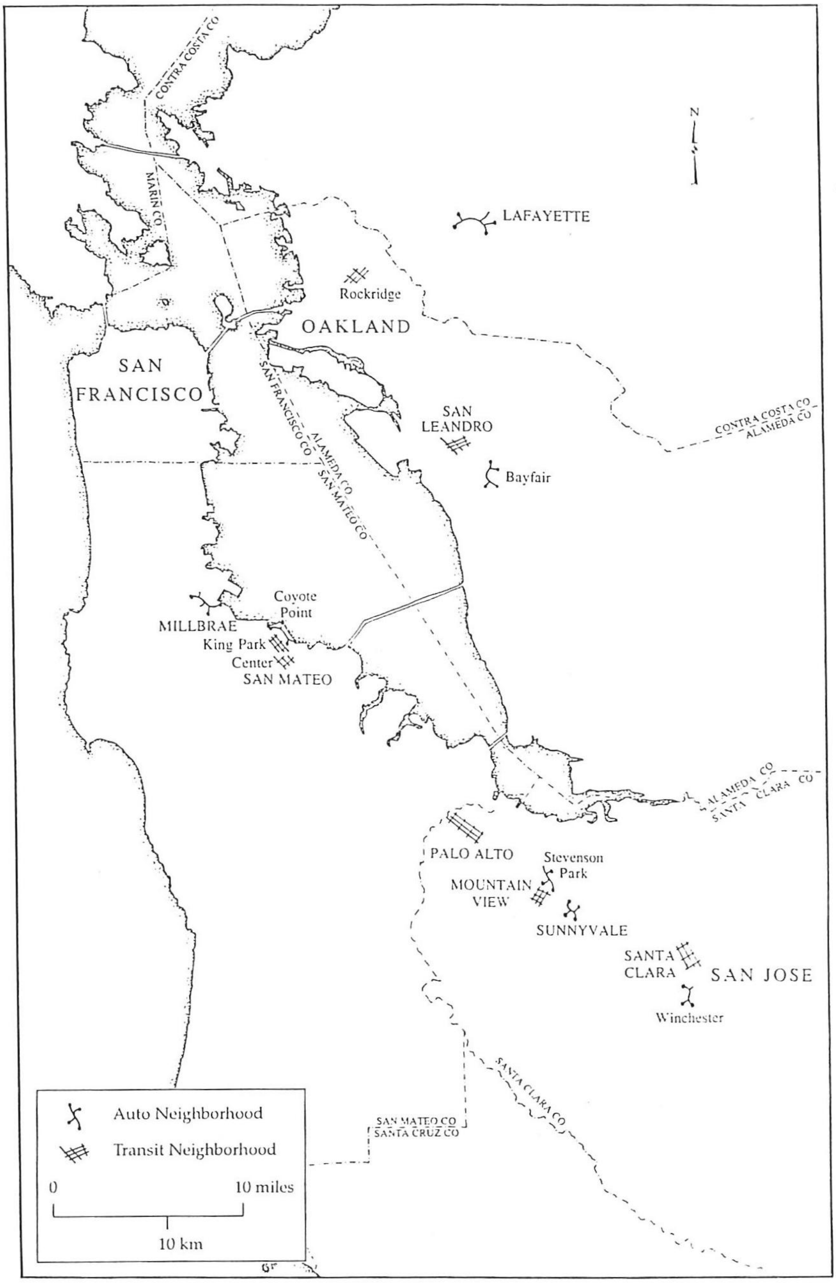

Figure 3 Paired transit and auto neighborhoods in the San Francisco Bay Area

Table 2 Work trip modal splits among Bay Area neighborhoods, 1990

		Drive Alone %			Transit %			Pedestrian %		
Transit Neighborhood	Auto Neighborhood	TN	AN	Difference*	TN	AN	Difference*	TN	AN	Difference*
Palo Alto	Mountain View-Stevenson Park	69.8	82.4	12.6	3.5	4.2	0.7	14.8	4.2	10.6
Santa Clara	San Jose-Winchester	70.1	84.3	14.2	3.7	1.4	2.3	13.4	2.9	10.5
San Mateo-Center	San Mateo-Bayshore/Point	71.9	73.9	2.0	9.5	5.1	4.4	5.3	2.1	3.2
Oakland-Rockridge	Lafayette	48.7	66.2	17.5	20.3	15.2	5.1	16.4	3.2	13.4
Downtown Mountainview	Sunnyvale-Mary Ave	78.9	82.9	4.0	4.6	1.3	3.3	7.1	2.9	4.2
San Mateo-King Park	Millbrae	57.9	73.5	15.5	12.8	7.5	5.3	9.3	8.1	1.2
San Leandro	Bayfair	70.2	73.0	2.8	13.8	10.4	3.4	6.5	2.3	4.2

Note TN=Transit Neighborhood; AN=Auto Neighborhood
*Percentage point difference.

Data Source: 1990 US Census, STF3-A

Table 3 Work trip generation rates among Bay Area neighborhoods, 1990

		Drive Alone Generation Rate**			Transit Generation Data**			Pedestrian Generation Rates**		
Transit Neighborhood	Auto Neighborhood	TN	AN	Difference*	TN	AN	Difference*	TN	AN	Difference*
Palo Alto	Mountain View-Stevenson Park	783	970	186	40	50	10	100	33	67
Santa Clara	San Jose-Winchester	943	980	37	49	16	33	153	11	142
San Mateo-Center	San Mateo-Bayshore/Point	691	1,174	483	92	83	9	49	26	23
Oakland-Rockridge	Lafayette	669	855	187	278	197	81	79	32	46
Downtown Mountainview	Sunnyvale-Mary Ave	975	1,161	186	57	18	39	74	29	45
San Mateo-King Park	Millbrae	996	894	102	221	92	129	145	95	51
San Leandro	Bayfair	619	813	194	122	117	5	51	21	30

Note: TN=Transit Neighborhood; AN=Auto Neighborhood
**per one thousand housing units

Data Source: 1990 U.S. Census, ST F3-A

Sociodemographic and commuting characteristics of rail-based households

In order to profile the residents of California's transit-based housing and their commuting habits, surveys were conducted in 1992-1993. Data were compiled for over 800 households in 28 large-scale housing projects near California rail stations (Cervero, 1993). From the surveys, many tenants were found to be unmarried, young professionals, with typically just one car per household. In twelve housing projects near the Bay Area Rapid Transit (BART) system, for instance, there was an average of 1.66 people and 1.26 vehicles per household, compared to an average of 2.40 people and 1.64 vehicles for all other households located in the same census tracts. Over 70 percent of surveyed households near BART had one or no vehicles, compared to 48 percent of households in the same census tracts.

What most distinguished residents of housing near California rail stations was their tendency to work downtown and in other locations well served by transit. In the case of seven apartment and condominium complexes that were surveyed near two BART stations in the East Bay suburbs outside of Oakland, 47 percent of employed residents worked in downtown San Francisco or Oakland, compared to just 11 percent of employed residents in the surrounding census tracts. In a study of residential location choice in greater Philadelphia, Voith (1991) found similar examples of residential sorting, wherein people gravitated toward locations with comparative accessibility advantages to job sites. Like BART, Philadelphia's rail system radially connects suburban communities to the CBD.

With such high shares of transit-based apartment dwellers working in downtowns and other rail-served destinations, these projects should generate high rates of rail commuting. From the survey of 815 rail-based housing units (and over 2,500 recorded trips made by the tenants of these units), we found that Californians living within a quarter mile of an urban rail system were around three times as likely to commute by rail transit as the average worker living in the same city. One-third of employed-residents living in apartments and condominiums near BART stations commute by rail, compared to 8 percent of all commuters living in the three BART-served counties (San Francisco, Alameda, and Contra Costa). The two most important determinants of rail usage are trip destination and whether parking is free. This is underscored in Table 4, which presents a logit model that predicts transit commuting by tenants of rail-based projects in the San Francisco Bay Area. Among those living in multi-family projects near BART stations and heading to San Francisco job sites with no free parking, the model predicts that nearly nine out of ten work trips are by BART (holding other factors constant). If they can park free in downtown San Francisco, around 60 percent commute by rail. For commutes to second- and third-tier urban centers like Oakland and Berkeley, around half are by BART. For all other destinations (where often workers park free), on average only 6 percent of commute trips by station-area residents are by rail.

Table 4 Binomial logit model for predicting likelihood of residents of rail-based housing commuting by rail transit, work trips and all systems

Dependent Variable: Probability of Commuting by Public Transit	Coefficient	Standard Error	Significance
Free Parking[a]	-2.467	.232	.000
San Francisco Dummy[b]	2.089	.364	.000
East Bay Primary Center Dummy[c]	0.610	.312	.050
Vehicles Available[d]	-0.725	.186	.000
Transit Allowance[e]	0.815	.260	.002
Company Car Access[f]	0.567	.331	.047
Constant	-0.066	.311	.831

Summary Statistics:
Number of cases = 1,913
Chi-Square = -2 (log likelihood ratio) = 262.78, p = .0000
Pseudo-R-Squared = 1 - (likelihood ratio) = .618
Percent of all cases correctly predicted by model = 89.9
Percent of rail trip cases correctly predicted by model = 68.4

Notes:

[a]1=Free parking at workplace; 0=paid parking at workplace.

[b]1=San Francisco destination; 0=other destination.

[c]1=Destination is primary East Bay employment center — Oakland, Berkeley, Walnut Creek, or Pleasant Hill; 0=other destination.

[d]Number of vehicles available for use by household members.

[e]1=Employer helps pay transit expenses; 0=employer provides no assistance.

[f]1=Employer makes available company car; 0=no company car available.

Clearly, clustering housing around rail stops will do little good if, as during much of the 1980s throughout metropolitan America, job growth occurs mainly along suburban freeway corridors. Both ends of work trips—housing and job sites—must be within reasonable proximity of stations if clustered growth is to pay significant transportation and environmental dividends.

Rail-based housing and rents

If rail-based housing projects provide accessibility benefits, this should be reflected in rent levels. Comparisons were recently made between 1994 rents at multi-unit projects within a quarter mile of the suburban BART station that has seen the most multi-family development—Pleasant Hill—versus otherwise similar projects in Pleasant Hill and the nearby cities of Walnut Creek and Concord that were beyond a quarter-mile walking distance of a rail stop. 1994 rents per square foot for one-bedroom/one-bathroom units near the Pleasant Hill station were US$1.20, compared to an average of US$1.09 for similar projects (in terms of size, age, and amenities) in the same geographic submarket but away from BART. Two-bedroom/two-bathroom units near the Pleasant Hill stations leased for around US$1.09 per square foot compared to around US$0.94 per square foot for comparable units away from BART. These findings translate into a 10 to 15 percent rent premium associated with being near BART.

Table 5 presents a hedonic price model that estimates the rent premium commanded by rail-based housing in the San Francisco Bay Area. The model, estimated using ordinary least squares techniques, shows that units within a quarter-mile of the Pleasant Hill BART station rented for around US$34 more per month than otherwise comparable units farther away from BART, controlling for the influence of unit size, amenities, and other factors. More bathrooms, bedrooms, and amenities like playgrounds and weightrooms likewise increase monthly rents. Table 5 also reveals that units in more compact projects rent for more than comparable units in lower-density ones. Project density, it should be noted, reflects units per acre within a complex as opposed to the density of the surrounding neighborhood. The rental premium associated with compact projects could reflect the benefits of tenants being closer to pools, playgrounds, and other amenities, as well as living in a communal setting. The rail-based projects used in this analysis, moreover, were comparatively dense, suggesting some interaction between these two factors—closeness to stations and project density.

Table 5 Hedonic price model for multi-family rental units in the Eastern Suburbs of the San Francisco Bay Area, 1994

Dependent Variable: Rent per month, in dollars, 1989	Coefficient	T-statistic	Significance
BART station within one-quarter mile (1=yes, 0=no)	34.101	1.526	.133
Size of unit (sq. ft.)	.427	6.497	.000
No. of bedrooms	29.488	1.497	.141
No. of bathrooms	42.039	2.657	.011
Playground on-site (1=yes, 0=no)	30.461	1.689	.097
Weight room on-site (1=yes, 0=no)	66.544	4.721	.000
Project density (units/acre)	.397	1.380	.174
Project age (in years, from 1991)	-10.971	-6.200	.000
Project in Concord (1=yes, 0=no)	-129.842	-8.878	.000
Proportion of total units in project of unit type	-44.545	-1.567	.124
Laundry room on-site (1=yes, 0=no)	-21.221	-1.105	.275

Summary Statistics:
Number of observations = 60
R-Squared = .919
F statistic = 49.331
Significance F = .000

CONCLUSION

This paper has presented empirical evidence on how the built environments of U.S. cities have shaped travel behavior, and in particular, levels of transit commuting. In general, the research shows that transit riding and walk/bicycle trips tend to be higher in denser, more mixed use settings, even in a U.S. context where most rail transit investments post-date World War II. Transit-oriented and pedestrian-friendly urban designs, such as gridded street networks and rail-based housing, are also associated with relatively high rates of transit usage. Still, the elasticities between changes in land-use environments and transit riding are fairly low. The research findings, for instance, suggest that a doubling of densities and land-use mixes within residential neighborhoods are associated with increases in transit modal splits of less than 10 percentage points. Since transit carries fewer than 10 percent of all commuters in the overwhelming majority of U.S. cities, drastic changes in the land-use environment would appear unable to induce big changes in trip behavior. Clearly, transit-oriented development, in and of itself, is no panacea to the traffic congestion woes and environmental problems of U.S. cities. Transit-supportive growth can certainly increase transit usage and reduce automobile dependency; however, it would likely have to be accompanied by other policy reforms, like appreciably higher fuel prices and congestion pricing, if the travel choices of Americans are to be significantly altered.

Whether rail transit investments are justifiable on the grounds that they can lead to more sustainable patterns of metropolitan development remains a hotly contested issue. Disagreement also remains over whether market forces or more proactive centralized planning are best suited for bringing about transit-oriented growth. Regardless of how it is brought about, this research shows that denser, mixed-use, and pedestrian-oriented development near rail stops in U.S. can induce transit ridership, even in more traditional suburban settings.

Governments can play an important role in encouraging transit-oriented development without employing heavy-handed tactics. Because, as shown in this research, rail-based U.S. households tend to own relatively few cars and frequently patronize transit, zoning standards could be relaxed to allow just one parking space per unit at complexes near rail stations. (A "one size fits all" mentality of two off-street parking spaces is a near universal standard in the U.S. [see Shoup, 1995]). Reducing parking standards for rail-based dwellings would lower construction costs by an estimated $12,000 per unit in the Bay Area (the typical cost of a tuck-under, podium parking space), and also create a more pedestrian-oriented environment. Tenants with more than one car might be given the option of leasing a second space. Another strategy would have banks grant those living in rail-based condominiums an "efficient-location" loan for home purchases. If rail-based housing lowers transportation costs (mainly in the form of only having to own one car), then these savings might be subtracted from principal, interest, taxes, and insurance expenses when calculating mortgage qualifications. This acknowledges that lower transportation costs frees up more money for housing consumption. Such loan adjustments could further attract prospective homebuyers to transit-oriented locations.

In close, the weight of evidence to date suggests that transit-oriented development and traditional communities do yield transportation benefits, though to widely varying and sometimes modest degrees. In the absence of many examples of large-scale transit-oriented development in the U.S., our understanding of how such environments shape travel behavior will necessarily remain partial and subjective. Indeed, a critical mass of dense, mixed use neighborhoods within any one metropolitan area might be a prerequisite for meaningful transportation and environmental dividends to accrue. Perhaps what will matter most are the public policies that accompany planning and design initiatives aimed at reducing automobile dependency in U.S. cities. Traditional neighborhood designs, transit-oriented villages, and walkable communities that are matched by significantly higher prices for automobility and parking, for instance, could very well have far greater impacts on travel behavior than what has been suggested by this and other research. Finding the right mix of urban design and public policy initiatives will remain a significant challenge to the building of more sustainable communities of the future, in both the U.S. and elsewhere.

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