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LAND USE IMPACTS OF RAPID TRANSIT

A Review of the Empirical Literature

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This paper attempts to consolidate the existing empirical evidence on the land use impacts of rail rapid transit. A framework for organizing the literature is developed based on the objects of study, analytical techniques and methodological approaches used. Thirty-seven studies are reviewed covering transit's impacts on property values, development and vacancy rates, changes in land use types, and population and employment growth. Ten recurring themes in the studies' findings are highlighted. Accessibility to transit tends to effect an average residential property value premium of six to seven percent, but overall land use changes are typically small and require the presence of several complementary factors, such as supportive local land use policies and existing demand for high density development.

With the construction of new light rail systems in cities such as Sacramento, San Diego and Portland, Oregon, as well as a multi-billion dollar heavy rail system in Los Angeles, U.S. cities have been the objects of a renewed interest in the use of mass transit to address urban transportation problems. In the short term, proponents of transit hope that the diversion of automobile drivers to transit will decrease auto usage, and thus congestion and air pollution. In the long term, the hope is that transit systems can effect more intense land use in surrounding areas, increasing transit ridership and thus further decreasing auto usage and pollution.

The basic argument that transportation and land use affect one other is widely accepted. However, the subtleties and complexities of this relationship have been the source of considerable debate. In an attempt to investigate some of these subtleties, researchers over the past twenty to thirty years have asked questions such as: to what extent have rapid transit systems actually affected land use? under what conditions? and how can these impacts be characterized?

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A first major attempt to consolidate the results of such studies was made for the U.S. Department of Transportation in the mid-1970's (Knight and Trygg 1977). The Knight and Trygg Report (as it has come to be known) consists of a series of mostly qualitative case studies, derived mainly from surveys and interviews of public officials and real estate developers, but including some reviews of more quantitative analyses. In brief, the authors conclude that, although significant land use impacts do seem apparent, they are only observed in the presence of several complementary factors, including supportive land use policies and a healthy and active real estate market. Since the original Knight and Trygg Report, a substantial empirical literature has emerged, investigating one or more of the above questions. The studies range in scope, methodology and even ideology. They provide an extensive albeit less-than-consistent view of the land use/transit relationship.

This paper seeks to review this literature in order to consolidate the existing evidence on the land use impacts of rapid transit. It opens with a very brief overview of location theory and then presents a framework for categorizing the studies. The studies are thus categorized and their findings summarized in a set of tables included in this first section. The second section contains a discussion of the main empirical findings. The last section provides an assessment of the apparent mismatch between theory and evidence in the case of transit's land use impacts as well as recommendations for future research.

Location Theory as Conceptual Foundation for the Studies

The body of theoretical models collectively known as "location theory" includes a model of residential location decisions and at least three distinct models of business location decisions. As a whole, these theories provide the most commonly used conceptual basis for examining the linkages between land use and transportation.

The traditional model of residential location is generally considered to have been born from the combined works of Alonso (1964), Muth (1969) and Mills (1972). The Alonso-Muth-Mills model places accessibility to a central market as the main factor being traded off against housing consumption in the location decisions of a city's residents. According to the logic of this theory, corridor-specific transportation improvements (such as highways or rail transit lines) decrease relative commute costs along the corridor, causing land in these areas to become, in effect, "closer" to the central market, and thus, in greater demand and of greater value than land outside the corridor.

The three business location models are the "classical" or Weberian model, central-place theory, and extensions of the Alonso-Muth-Mills model (for detailed discussion see Gomez-Ibañez 1975). The first two models focus on the roles that economies of scale and the transport of the inputs and outputs have on business location decisions (see Weber 1928, Hoover 1948, Isard 1956, and Moses 1958). Extensions of the Alonso-Muth-Mills model describe how decreases in transportation costs to and from an area will increase employment levels in that area, and vice versa, mainly by increasing the real incomes of workers (allowing firms to hire more employees at lower wages) and decreasing rents in surrounding residential areas (allowing firms to expand production and hire more workers at lower costs). Since the focus of the literature reviewed here is the effect of rapid transit improvements (i.e. commute cost reductions) on location decisions and property values, the premises being tested tend to rely more heavily on those of this third group, though they include aspects of all three approaches.

Combining the various approaches to business location with the Alonso-Muth-Mills model of residential location can be seen as either providing a conflicting picture of the net effect that transport cost changes have on land use, or simply describing urban land use patterns in dynamic equilibrium. Decreasing commute costs provide incentives for workers to move, both farther out and along lower-cost corridors. This in turn draws residential service businesses (such as most retail and many personal service providers) into suburban corridors also. The relative increase in suburban property values (and corresponding relative decrease in central city values) makes operating in the city center less expensive and thus provides an incentive for employers and residents to take advantage of these cost savings by moving back into the center.

In either case, location theory alone is an inadequate tool with which to predict, with any reasonable certainty, the impacts of specific transportation improvements on surrounding land use and urban form. However, the body of theory provides an excellent starting point from which to examine the extent to which different theoretical scenarios are played out and the factors involved in each particular scenario. Acknowledging both the shortcomings and usefulness of location theory, let us turn our attention to the empirical record.

A Framework for Organizing the Studies

The studies reviewed here build on location theory by investigating the degrees to which and the circumstances under which transportation improvements actually affect land use. The studies utilize one of two main approaches using two different *objects* of study. The first, and more direct, approach involves comparisons of the types, density and intensity of land use between areas with transit access and those without. Questions asked in this kind of research include: Is the rate of new development greater in transit-accessible areas than in non-accessible ones? Is there a changeover from one type of land use to another (say, from residential to commercial use) around new stations? The second approach involves tracking the impact of transit systems on property values, which are assumed, in turn, to affect the use that the land is put to, and thus, in the aggregate, to define an area's land use pattern.

Nineteen of the thirty-seven studies reviewed here focused exclusively on the impacts of transit on property values, typically using, as a measure of these values, the sales prices for single-family homes. Fourteen other studies left out property value measures altogether and instead focused on densities, types of land use, the propensity of land uses to change as a result of proximity to transit, residents' or developers' attitudes, and land use policy/management changes. Four studies incorporated both "property value" and "land use type" approaches into their studies.

Table 1 organizes the studies according to their approach, with property value studies listed first, followed by land use type and then hybrid studies. The information provided for each study includes sample sizes, definitions of the accessibility measures used and methodological approaches. In addition, a summary and commentary is provided for each study.

In addition to using different objects of study, two main *techniques* are used throughout the studies reviewed. The first involves the use of *cross-sectional* data to either: 1) compare the land use characteristics of transit-accessible urban areas to those without transit access (while holding as many other factors as possible constant); 2) create hedonic price models intended to capture the impact of transit accessibility on property values; or 3) compare the market and policy conditions surrounding "successful" and "unsuccessful" joint development efforts. The second technique involves the use of *longitudinal* (or time-series) data to do before-and-after comparisons of property values and/or land use patterns in the area surrounding a transit improvement.

In general, the studies that focus on land use patterns use a qualitative, case study approach. Although these case studies rely on quantitative data as well as interviews and surveys, they do not use statistical techniques to "control" for confounding factors. In contrast, the property value studies typically use quantitative methods. They include multiple regression analyses using price as the dependent variable and measuring the relationships between these values and several independent variables (such as distance to transit and housing characteristics). They then utilize the remaining independent variables as experimental "controls".

Methodological Issues

Many reviewers have reached similar conclusions to those of Knight and Trygg (1977). That is, they have generally found the presence of land use impacts arising from the development of transit, but to widely varying degrees and in widely varying ways. Most importantly, they all acknowledge the various other factors affecting urban form and note that transit is unable to effect noticeable land use impacts without the presence of at least some of these other factors.

A brief, early review by Meyer and Gomez-Ibanez (1981) found mixed results with respect to transit's impact on property values. They cite one study of Toronto which found no impact on property values once growth was controlled for (Aboucher 1973). However, they also mention another study, this one using rent gradients, which found that land values for areas nearest transit increased more than for those farther away, after controlling for other influences (Dewees 1975). The authors do not support the use of transit as a land use

Table 1
PROPERTY VALUE STUDIES

Author(s) / Study Area / Study Period	*Transit Mode*	*Property Type / Sample Size*	*Research Question*	*Accessibility Measure(s)*
Davis (1970) -- BART (Glen Park Station) [1960-1967]	Heavy Rail - Commuter Rail Hybrid	Single and multi-family residential within study area [609 home sales]	Does access to transit affect property sales prices?	Within 6 blocks of Glen Park Station vs outer parts of district
Boyce, et al. (1972) -- Philadelphia / Lindenwold line [1965-1971]	Commuter Rail	Single-family residential [~12,000 home sales]	Does access to transit affect property sales prices?	Commute cost savings (associated with accessibility to transit)
Lee (1973) -- BART IMPACT STUDY [1950-1972]	Heavy Rail - Commuter Rail Hybrid	Single Family residential	1 - Were annual price increases faster after BART? 2 - Does access to BART increase home values?	1 - Study-defined "BART-affected" areas; 2 - straight-line distance
Allen & Mudge (1974) -- Philadelphia / Lindenwold line [1964-1971]	Commuter Rail	Single-family residential [~2,400 home sales]	Does access to transit affect property sales prices?	Commute cost savings (from accessibility to transit) in control vs impact corridors
Mudge (1974) -- Philadelphia / Lindenwold line [1964-1971]	Commuter Rail	Suburban residential	Does access to transit affect property sales prices? rates of growth of these prices?	1-Commute cost savings (resulting from accessibility to transit): 2-Presence in "transit corridor"
Tang (1975) -- Philadelphia / Lindenwold line [1964-1971]	Commuter Rail	Suburban residential	Does access to transit affect property sales prices?	Commute cost savings (resulting from accessibility to transit)
Dewees (1976) - Toronto [1961 & 1971]	Heavy Rail (subway)	Single and small multi-family residential [~1,800 sales]	Does access to transit affect property sales prices?	Weighted travel time to Bloor Street (transit=1, wait=1.5, walk=1
Skaburskis (1976) -- BART IMPACT STUDY	Heavy Rail - Commuter Rail Hybrid	Single Family residential	Does access to transit affect property sales prices?	linear walking distance
Yang (1976) -- Philadelphia / Lindenwold line [1964-1972]	Commuter Rail	Vacant suburban land	Does access to transit affect vacant land values?	1-Commute cost savings; 2-Presence in "transit corridor"

Study Design/ Methodology	*Results*	*Comments*
Cross-sectional (study defined station area vs. non-station areas) / Non-parametric comparisons	Higher average sales prices and annual % increases within 6 blocks of station, difference is noticeably larger after station site is announced, though study area shows generally faster growth than rest of city even before station site was selected	Impacts are of anticipatory reactions only, since study period precedes station opening; property value study concides with major recession and weak real estate market
Cross-sectional (control corridor vs. impact corridor); / Analysis of Variance - Hedonic Price Model	$149 premium for every dollar saved in daily commute costs; the premium more than doubles after completion of construction and seems to be a transfer in values from nearby control corridor	Did not control for detailed housing characteristics; also used estimates of actual travel time as opposed to perceived travel time
1 - Before & After 2 - Cross-sectional / 1 - Non-parametric statistics 2 - Hedonic Price Mode	1 - Annual price increases were larger after BART than before 2 - No premium was found	
Cross-sectional (control corridor vs. impact corridor); / Hedonic Price Model	$149 premium for every dollar saved in travel costs in impact corridor. Negative premium in control corridor, suggesting that transit line effected an intra-regional transfer in property values	Based on "relative" commute cost savings, not absolute amounts.
1-Cross-sectional (control corridor vs impact corridor); 2-longitudinal (sales trends) / 1-Hedonic Price Model: 2-Non-parametric statistics (ANOVA)	1- ~$400 premium per dollar of commute cost savings found in transit corridor. 2-transit corridor shows faster property value growth after opening of transit line than control corridor	Several important housing characteristics are not included. Commute cost savings (of between $0-$3) based on straight-line distance. Some input figures were gross estimates.
longitudinal (sales trends) / Hedonic Price Model	$1000 sales price premium per dollar of commute cost savings found in transit corridor	Dissertation written under supervision of Boyce. Comments same as Boyce (1972) and Mudge (1974)
Cross-sectional / Hedonic Price Model	$2370 premium per hour of travel time saved for sites within 20 minutes travel time (e.g. 1/3 mile walk)	
Before & After, Cross-sectional / Hedonic Price Model	Proximate houses approx. 8% lower than distant houses, drop is more after BART than before	Testing different functional forms is good, very inexact distance measure (includes a stochastic error term), results pertain mainly to construction period
Cross-sectional (control corridor vs impact corridor); / Hedonic Price Model	$440 sales price premium per dollar of commute cost savings found in transit corridor	Dissertation written under supervision of Boyce. Comments same as Boyce (1972) and Mudge (1974)

PROPERTY VALUE STUDIES (cont'd)

Author(s) / Study Area / Study Period	Transit Mode	Property Type / Sample Size	Research Question	Accessibility Measure(s)
Falcke (1978a) -- BART IMPACT STUDY	Heavy Rail - Commuter Rail Hybrid	All	Does access to transit affect property sales prices?	Straight-ine distance within study-defined "station areas"
Damm, et al. (1980) -- D.C. Metrorail [1969-1976]	Heavy Rail	Single and multi-family residential and retail [~1,400 sales]	Does access to transit affect property sales prices?	Straight-line distance to station; "station" vs "non-station" sites
Bajic (1983) -- Toronto [1971 & 1978]	Heavy Rail (subway)	Single-family residential [2,000 home sales]	Does access to transit affect property sales prices?	Weighted commute times (differentiating between travel and waiting time)
Allen, et al. (1986) -- Philadelphia / Lindenwold line [1980]	Commuter Rail	Single-family residential [~1,300 home sales]	Does access to transit affect property sales prices?	Commute cost savings (associated with accessibility to transit)
Ferguson, et al. (1988) -- Vancouver ALRT [1971-1983]	Light Rail	Single-family residential [~13,000 home sales]	Does access to transit affect property sales prices?	Straight-line distance to nearest station
Voith (1991) -- Philadelphia / PATCO & SEPTA [1980]	Commuter Rail	Single-family residential [678 census tracts]	Census tract median home values	In or sometimes adjacent to tract with station
Nelson (1992) -- Atlanta / MARTA [1986]	Heavy Rail	Single-family residential [286 home sales]	Does access to transit affect property sales prices?	Straight-line distance to nearest station
Gatzlaff & Smith (1993) -- Miami Metrorail [1971-1990]	Heavy Rail	Single-family residential [~6,000 home sales]	Does access to transit affect property sales prices?	Within same 1 sq. mi. section as station / Straight line distance
Al-Mosaind, et al. (1994) -- Portland / MAX LRT Line [1988]	Light Rail	Single-family residential [235 home sales]	Does access to transit affect property sales prices?	Actual walking distance to LRT stations
Armstrong (1994) -- Boston / Fitchburg Line [1990]	Commuter Rail	Single-family residential [451 home sales]	Does access to transit affect property sales prices?	Location within community with station / travel time to station

Study Design/ Methodology	Results	Comments
Before & After / Hedonic Price Model	Small but statistically significant price premium for residential properties, no effect on residential rents, effect on commercial rents only within ~100 ft.	
Cross-sectional / Hedonic Price Model	Price elasticities of distance of -.06 to -.13; -.19; and -.69 for SF, MF, and retail, respectively	Impacts are of anticipatory reactions only, since data does not cover post-Metro period
Cross-sectional / Hedonic Price Model	$2,237 premium for average house, based on reduction in commute time resulting from opening of subway	Use of average commute time savings very imprecise; good housing characteristics but all neighborhood characteristics are treated as single "zone-specific" dummy variable
Cross-sectional (control corridor vs. impact corridor); / Hedonic Price Model	$443 premium for every dollar saved in daily commute costs (average >$4,500 per house; 7.3% of mean sales price)	Model explains only 40% of variability, likely due to exclusion of data on detailed housing characteristics
Cross-sectional / Hedonic Price Model	C$4.90/ft. premium in 1983 only (authors caution that multi-collinearity in 1983 data preclude meaningful analysis of this coefficient; in 1975, approached significance with C$2.78 premium	Over 50 explanatory variables, very complete but multi-collinearity is a problem for 1983 data
Cross-sectional / Hedonic Price Model	6.4% premium (avg. $5,594) associated with accessibility to rail service	
Cross-sectional / Hedonic Price Model	$1.05/ft. premium in low-income areas; $.96/ft. disamenity w.r.t. distance in high-income areas (significant only at 10% level)	Age and quality of housing not included, neighborhood variables excluded except race and income, results confounded by proximity of low and high income areas to each other.
Cross-sectional / Repeat Sales Indices / Hedonic Price Models (n=902)	Repeat sales indices show no effect / In hedonic models, distance only significant in some models and some corridors	
Cross-sectional / Hedonic Price Model	$4,324 (10.6%) premium for homes within 500m walking distance	Controlled for housing characteristics but not neighborhood characteristics
Cross-sectional / Hedonic Price Model	6.7% premium for homes located within community with commuter rail station	Very complete - 19 independent variables controlling for structure, site, neighborhood characteristics & distance to cbd

LAND USE TYPE STUDIES

Author(s) / Study Area / Study Period	*Transit Mode*	*Property Type / Sample Size*	*Research Question*	*Accessibility Measure(s)*
Knight & Trygg (1977) -- 9 cities across N. America [1960-1975]	Heavy Rail, Light Rail, Commuter Rail	All Types	Densities, rates and timing of land use change, local land use policy changes	n/a
Dingemans (1978) -- BART [1960-1976]	Heavy Rail - Commuter Rail Hybrid	Multi-family residential [80 townhouse developments (14,299 units)]	Does high-density development cluster around transit stations?	Street distance to nearest station
Dyett & Castle (1978) -- BART IMPACT STUDY [1962-1976]	Heavy Rail - Commuter Rail Hybrid		Has BART induced residential development? at higher densities? further into fringe?	Within 1500 feet (density), within communities "affected by BART" (rate and spread of development)
Fajans et al., (1978) -- BART IMPACT STUDY [1965-1977]	Heavy Rail - Commuter Rail Hybrid	n/a	Does accessibility to BART affect population and employment growth rates in nearby areas?	Straight line distance between station and "zone."
Falcke (1978b) -- BART IMPACT STUDY	Heavy Rail - Commuter Rail Hybrid	All	Has BART induced RE speculation in station areas?	Study-defined "station areas"
MTC (1979) -- BART IMPACT STUDY [1960-1977]	Heavy Rail - Commuter Rail Hybrid	All Types [276 workers, 34 stations, 26 developers, 10 station areas, 9 residential zones]	Employment growth, new office construction, property values, residents' attitudes	communities with stations vs. those without, station areas vs rest of city,
Urban Land Institute (1979) -- Philadelphia, D.C., Montreal, Boston, Toronto [1977-1979]	Heavy Rail	Commercial [7 joint development projects]	What are good management, zoning and incentive approaches to joint dev.	Agency-defined "station areas"
Donnelly (1982) -- Atlanta / MARTA; D.C. Metrorail [1970-1982]	Heavy Rail	All types [18 station areas, 100 households, 70 merchants]	Land use changes, resident & merchant attitudes	Agency-defined "station areas", ~ 1/4 mi. walking distance

Study Design/ Methodology	*Results*	*Comments*
Before & After, Cross-sectional / Case Studies	Some densification, but only where other favorable forces (healthy real estate market, supportive land use policies). No evidence of regional growth impacts.	No explicit comparisons of station areas with other parts of city, therefore, other important factors, which may have been left out, have not been controlled for.
Cross-sectional / Non-parametric statistics	~ 25% of townhouses within 2 mi. of nearest station, ~ 55% between 2 and 5 mi., ~ 20% over 5 mi. away, average of 4.5 mi. -- no clustering found near stations	Blames failure on lack of developable parcels, public opposition, and incomplete policy approach (carrots but no sticks, land use not part of transport planning process)
Longitudinal / Non-parametric statistics, Key informant interviews	Small increase in development near stations and some spread further into fringe areas, no evidence of higher densities.	Study areas to large to reveal subtle impacts. Most of the increased activity was in areas that were "in the path of development" anyway (authors acknowledge this).
Longitudinal / Regression analyses, Non-parametric statistics, Key-informant interviews	Rates of employment growth and housing development affected, suggesting BART impacts location decisions of small, multiple-worker households.	Many left-out variables in regressions. "Zones" too large to detect station-area impacts. Much growth "in path of development" anyway.
Cross-sectional / Key Informant Interviews, Regression Analyses	BART has induced some speculation, not extensive, in certain station areas. Authors suggest unrelated RE market demand may explain differences.	Serious potential for LOV bias in overly-simple regression models (distance is only explanatory models)
Before & After / Delphi Interviews, surveys, shift-share analysis, non-parametric statistics	BART caused land use policy shifts, mostly pro, some anti-development; some office clustering, no residential clustering or res. location impacts, no evidence of regional growth effects, little impact on retail	Likely too early in systems life to study land use impacts, no use of parametric controls to isolate important factos, several parts of study coincide with major recession and weak real estate market
Before & After / Case Studies (key informant interviews, descriptive statistics	Need lead agency with decision-making power, land assembly and site preparation in advance by public sector, good design, zoning and density bonuses	Good descriptive studies, no "joint development vs other" comparisons. Trade group expectedly calls for public sector risk sharing
Before & After / Case Studies (mostly Delphi interviews)	In DC, land use plans changed to incorporate higher-density, mixed-use nodal dev. downtown & around stations, fewer freeways	*Results cont.* - In Atlanta, residents generally satisfied with Metro service and visual impacts, unhappy with noise and traffic

LAND USE TYPE STUDIES (cont'd)

Author(s) / Study Area / Study Period	*Transit Mode*	*Property Type / Sample Size*	*Research Question*	*Accessibility Measure(s)*
Dunphy (1982) -- D.C. Metrorail [1970-1980]	Heavy Rail	Residential (except single-family detached)	What proportion of new residential building permits were issued within "station areas?"	Station areas are within 15 minutes walking time or .7 miles straight line distance of a station.
SANDAG (1984) -- San Diego Trolly [1980-1984]	Light Rail	Residential, Commercial, Industrial [10 leasing agents and developers]	Suburban vs Centre City dev. decisions	Within ~1/3 mi. of stations ("land use impact area")
Ayer & Hocking (1986) -- Chicago O'Hare Extension; Miami Metrorail [1970-1985]	Heavy Rail	Commercial [6 private developments, 4 joint development projects, 3 public developments]	How were land use types and development rates affected by opening of new transit stations?	"Station areas" defined variously, typically within 1 mile or less of station
CATS (Chicago Area Transport Study) (1986) -- Chicago O'Hare Extension [1970-1985]	Heavy Rail	All	How were land use types and development rates affected by opening of new transit stations?	Within 1 mile of transit station
Harrold (1987) -- Baltimore Metro [1983-1985]	Heavy Rail	Residential, commercial	How is the rate of building permits affected by the presence of a transit line?	Presence in transit corridor vs other parts of city
Northern VA Planning District Commission (1993) -- N. VA Commuter Rail [1984-1992]	Commuter Rail	Residential	What influence did coming of rail line have on location choices of home buyers, developers and local gov.'s?	"Station nodes," "Primary catchment areas," "Secondary catchment areas."

Study Design/ Methodology	*Results*	*Comments*
Cross-sectional / Non-parametric statistics	No direct correlations found between locations of new development and transit stations. Around 7% of newpermits were authorized for areas around operating stations, another 12% were for future station areas, leaving over 80% outside of Metro access.	With no baseline housing density provided, can't tell whether Metro is attracting more housing than would otherwise have been built in these areas.
Before & After / Surveys	Trolly "important" factor in suburban-station development decisions but not in CBD stations	Only looks at first three years, does not explicitly compare with baselines or othe parts of the city, making it difficult to correlate development with presence of trolley.
Non-comparative / Case Study (mostly non-parametric statistics and key informant interviews)	Rapid transit tends to induce speculation (in Miami total assessments within 1000 ft of stations increased by 30% during three-year construction period) and speed up developmet process, thereby inducing "new" growth within any given time period.	Analysis is vague and promotional. Little attempt is made to control for confounding factors or to compare experimental with control sites. Results read more as joint-development "how-to" manual than analytical assessment.
Before & After / Non-parametric statistics	Vacant land around stations was developed at the same rate before 1980 as it was afterwards. However, before 1980, 64% of development was resiential, but after 1980, only 7% was.	Line did not begin operation until 1983 (first segment) and 1984 (comlete system), and development can not be attributed to transit only since timing coincided with expansion of airport and freeway improvements.
Cross-sectional / Non-parametric statistics	Transit corridor showed higher rate of new residential permits than rest of city, but results were mixed for commercial permits.	Results not placed in context of area's growth trends, very difficult to know if transit followed growth or vice-versa.
Before & After (this baseline study constitutes only the 'before" part) / Surveys	Before operation, 6% of home buyers said access to transit had "some" or "major" impact on location choice. Afterwards, this had grown to 43%.	

HYBRID STUDIES

Author(s) / Study Area / Study Period	Transit Mode	Property Type / Sample Size	Research Question	Accessibility Measure(s)
Quackenbush, et al., (1987) -- Boston / MBTA Red Line Extension [1978-1986]	Heavy Rail	All	How were land use types and housing prices affected by opening of new transit stations?	Study-defined "station areas"
Cervero & Landis (1993) -- D.C. Metrorail; Atlanta / MARTA [1978-1989]	Heavy Rail	Commercial [10 suburban office developments]	Rates of absorption & vacancy, % of regional growth, rent, size of development	"Station" vs "non-station" sites as defined by transit agencies
Cervero & Landis (1995) -- BART [1970-1990]	Heavy Rail - Commuter Rail Hybrid	All Types [34 "super-districts", 152 zip codes, 25 station areas, 33,291 parcels]	Population & employment growth, employment density, land use change, development rates	BART corridors vs freeway corridors; station areas vs. freeway interchanges
Landis, et al. (1995) -- BART, San Diego LRT, San Jose LRT, CalTrain, Sacramento LRT [1965-1990]	Light Rail, Heavy Rail - Commuter Rail Hybrid	Single-family residential, commercial [~2600 SF, >4,500 commercial lots, 13 stations]	Property values, land use change	Street distance, "station areas" vs "non-station areas"

Study Design/ Methodology	Results	Comments
Before & After / Non-parametric statistics.	Industrial land uses declined in favor of office space, parking and open space. House price trends were mixed and not well explained.	Authors note that areas showing faster price increases started at lowest levels and that many of the land use changes would have occurred anyway.
Cross-sectional (transit-developments vs. highway-developments) / Matched-pair comparisons using difference of means tests	$2-3.50 (13-18%) rent premium for transit in 3 of 4 comparisons (stat. sig. at 95% in only 1); mixed, insignificant results everywhere else.	Quasi-experimental approach does not control for structural, site and neighborhood characteristics, nor does it account for variations in leasing methods
Cross-sectional (transit station vs. highway interchane areas, control corridors vs, impact corridors) / Non-parametric statistics, matched-pair comparisons, logit and linear regression models.	Except in CBD, population and employment grew faster in non-BART areas, some employment densification seen around stations. More land use change around BART stations than freeway interchange matched pairs	Overall rich analyses. However, non-parametric statistics and matched-pairings are blunt instruments as no effort is made to control for other variables (such as site-specific characteristics).
Cross-sectional / Hedonic Price Models, Logit Models, Analysis of Variance	~ $2/meter premium for homes in BART and San Diego, none elsewhere, mixed for commercial property, some positive impact impact on rate and type of land use change	Very complete. Hedonic and Logit models control for major variables, first study to use quantitative inter-system comparisons, and GIS for distance measure

strategy, mainly because they find that land use policies, such as zoning, can do more than transit to affect urban form.

Most other reviewers agree with Meyer & Gomez-Ibanez (1981) that coordinated land use policy is more likely to elicit desired land use patterns than is transportation planning. However, in defense of using transportation planning nevertheless, they point out that the development of a transit system often catalyzes changes in land use policy, which in turn affects land use patterns. In San Francisco, Atlanta and Washington, D.C., the development of heavy rail systems prompted the provision of zoning allowances for greater density near several stations (Callow 1992; Webber 1976). However, the opposite effect, (involving down-zoning of station areas in order to preserve their existing character) has also been observed, often in the same regions (Knight and Trygg 1977; Shunk 1995; Webber 1976), suggesting that neighborhood and municipal level attitudes temper a region's ability to produce coordinated, transit-supportive land use policy, and thus to affect urban form.

With respect to transit's impact on property values, two recent reviews should be highlighted. Huang (1994) and Landis, et al. (1995) both review studies that predominantly used hedonic models of single-family home prices. Both note the use of a variety of functional forms and variables throughout these models. Both find that virtually all of the models suggest some positive premium associated with proximity to transit, though again, the extent of this impact varies widely from study to study. However, Huang chooses to focus on the reasons why the results vary so widely: methodological differences, differences in the cost and performance characteristics of the transit systems studied; while Landis stresses that when isolated, the impacts were often small, stating that "no contemporary study finds that recent transit investments have had significant development or price impacts at any level" (Landis et al. 1995:25).

In addition to the methodological issues summarized above, one of the most important problems associated with any of the methods in the cases under study is the difficulty in controlling for the multitude of factors besides transportation which affect land use. It is very difficult to isolate the impacts of proximity to a transit station from other locational characteristics. Thus, the impact of a transit station in the amount of development or home prices would be difficult to determine.

In the cross-site land use studies, attempts are made to control for confounding variables by choosing sites that are similar except for their transit accessibility. Obviously, finding similar sites is not easy. Chances are that with multiple factors such as the regional economy, a project's design, neighborhood characteristics, local government land use policies and a myriad of others, enough differences can be found between any two sites to decrease our confidence that observed traits are a result of transit. Using the same site and studying it over time (as in the before-and-after studies) successfully controls for many of these confounding variables (especially the site specific ones). However, this improvement is tempered by the fact that other confounding variables (e.g., changes in technology, macroeconomics, tastes, etc.) get added to the picture over time.

Unlike the cross-site land use studies and before-and-after studies, which are considered quasi-experimental methods, hedonic pricing models are formal hypothesis testing methods. The multiple regression techniques in these models use statistical methods to control for the effects of confounding variables, which, in theory, solves our confounding variable problem. Despite this apparent precision, however, these models should be used with several caveats. First, they can suffer very serious measurement problems as they attempt to create a static image of a dynamic process. Secondly, they rely on standardized, comparable, quantitative data, which is often very difficult to find. Since there is so much important information that cannot be (or at least has not yet been) encapsulated into tidy quantitative bites, researchers are often pressed to use blunt proxies for this information (such as straight-line distances instead of total travel costs).

Finally, and most importantly, these models are often misused. The models must be constructed and interpreted carefully. Subtle but profound problems can arise from the inclusion of too few, too many, or the wrong variables, less-than randomly selected observations, and the myriad of logistical problems associated with data-intensive research. For example, probably because the information is so much easier to come by, most studies use either straight-line or street distance of a home to the nearest transit station as a proxy for the potential benefits provided by proximity to the station. The underlying assumption is that distance correctly captures time savings. However, theoretically, a more accurate approach would be to calculate the actual travel cost savings for each home under study. Allen et al. (1986) attempt this, but end up with a model with far less explanatory power that most of the others. Other researchers have attempted to solve the distance problem without going quite as far. Boyce et al. (1972) and Allen (in some of his earlier work) used relative travel cost savings, while Dewees (1976) and Bajic (1983) rely on travel time instead of distance. In fact, Dewees specifically compared travel time to distance and concluded that travel time was the more accurate proxy.

Methodological problems in general, and variable control problems specifically, play out differently for different types of studies, making some approaches more appropriate than others for any given investigation. They also make it universally difficult to establish firm conclusions in this type of research. However, some recurring themes do emerge, as discussed in the following section.

Empirical Findings

Most of the studies reviewed in this paper found some level of land use change resulting from transit improvements. However, the extent of the impacts varied from study to study and the results were often accompanied by a caveat: that the impacts were generally small and indirect, and that they required the presence of several complementary factors. In addition, in many of the case studies, the authors are unable to distinguish the effects of transit from other unrelated market forces. And just as importantly, causality can not be assumed even where development effects are clear, since transit lines are typically planned in "growth" corridors to begin with.

Small impacts on development patterns

Landis et al. (1995) studying over 4,500 plots of land in BART districts, used logit models to estimate the probability that a given lot would change uses from, say, vacant to residential or residential to commercial, and then compared these probabilities for land within and outside of study-defined station areas. The authors found that, between 1965 and 1990, lots located within station areas had a higher probability of changing land uses than lots located elsewhere. A case study of the Miami Metrorail system (Ayer & Hocking 1986) found, using interviews and comparative statistics, that during construction of the rail system, the land development process was accelerated (compared with pre-construction rates) for sites within 1000 feet of a rail station. In this way, the authors conclude, speculation induces "new" development in any given time period. Knight and Trygg (1977), using similar research methods, found that although accessibility had been improved in some travel corridors, demand for new development was the driving force behind the land use intensification that occurred.

Other studies have also concluded that the presence of transit stations has had a positive effect of land development rates. However, in many of these studies, the effects of transit can not be distinguished from those of other forces. For example, several studies which were conducted as part of the BART Impact Study in the 1970's found small increases in development rates around stations. Dyett & Castle (1978) and Fajans (1978), each using some combination of regression analysis, descriptive statistics and interviews, found a small increase in the rates of residential development around BART stations. However, in both studies, the authors acknowledge that the development could, at least in part, be explained by other real estate market trends and that much of the growth they observed was "in the path of development" anyway (Dyett & Castle 1978). A more recent study of the Baltimore Metro (Harrold 1987) comparing the issuance rates of residential permits from 1983 to 1985 found that the transit corridor showed a higher rate of new permits than other parts of the city. However, the simple cross-sectional approach of the study makes it impossible to know whether growth followed transit or vice-versa.

There were also a few studies that found no discernible impacts on residential development patterns. Dingemans (1978) plotted the distance between townhouse developments in Contra Costa County, CA and the nearest station on BART's Concord line. He found that, among those units developed between 1960 and 1976 (which includes periods of planning, construction and operation for the transit line), there was no pattern of clustering around BART stations. In fact, only 25 percent of units were within two miles of a station, and the average distance was 4.5 miles. Another approach was used by Dunphy (1982) to study the development impacts of the Washington, D.C. Metro. Here the author found that 80 percent of residential permits issued between 1970 and 1980 (which again included periods of planning, construction and operation) were for areas outside of Metro access (15 minutes walking time). Again, both of these studies suffer from an inability to control for confounding factors. For example, the former made no attempt to compare observed townhouse distributions with those existing pre-BART, and the latter failed to compare observed permit issues with pre-Metro patterns.

Larger impacts on residential property values

Property value studies tend to show greater impacts than the intensity studies, though these results vary even more widely. At one extreme is a before-and-after study of the Miami Metrorail system (Gatzlaff and Smith, 1993), which found that residential values were, "at most, only slightly affected by the announcement of the new rail system." At the other extreme, a hedonic price study of the Portland light rail system found a greater than ten percent premium in the value of residential property associated with access to the transit line (Al-Mosaind, 1994). Similarly, a recent BART study, looking at multi-unit suburban projects, found that rents for one and two bedroom units within 1/4 mile of a BART station averaged $1.20/sq. ft./month, whereas those further away averaged $1.07/sq. ft. month, a difference of over ten percent (Cervero 1994b).

Most property value studies focusing on single-family homes have revealed premiums for proximity to transit which are in the six to seven percent range. Allen et al. (1986) find a $443 premium for every dollar saved in actual commute costs (which was 7.3 percent of the average sales price of a home). Armstrong (1994:88) found a 6.7 percent increase in the price of a home "by virtue of being located within a community having a commuter rail station." And Voith (1991) found that homes located within or adjacent to a census tract containing a transit station enjoyed, on average, 6.4 percent higher sales prices.

Mixed results with commercial property values

Two separate studies investigating property value impacts of transit in Washington, D.C. and Atlanta (Callow 1992; Cervero & Landis 1993) reached mixed conclusions regarding the impacts of transit. As part of a broader national inventory of joint development projects, Cervero and Landis apply a quasi-experimental approach comparing four pairs of office developments, with each pair containing a transit-accessible development and a highway-accessible control. In each case, the transit-accessible case was part of a station "impact zone" as defined by the transit agencies or local planning authorities. The control sites were those considered competitors of the transit-accessible sites by local developers. The authors find that transit developments had higher rent premiums in three of the four, and higher absorption rates and growth rates in two of the matched pairs. Looking deeper into these mixed results, Cervero and Landis conclude that those transit developments which command rent premiums and reveal higher growth and absorption rates are in areas with healthy real estate markets and where complementary land use policies are in place.

Smaller impacts with light rail

It is important to note that most of the systems studied above were heavy rail systems. Knight and Trygg mentioned the importance of studying other types of systems (such as light rail) but were limited by data availability from doing so. According to location theory, the extent of land use impact depends greatly on the marginal improvement in accessibility afforded by the transit system. Thus, lower-performance systems such as light rail, busways and people movers should show even smaller impacts. Subsequent research has supported this notion, with the most direct evidence coming from Landis et al. (1995), who compared land use impacts across five transit systems in California (BART, San Diego LRT, CalTrain, Sacramento LRT, San Jose LRT) and found that system characteristics mattered. In particular, price premiums around $2/meter were observed for single family homes in areas with what the authors described as regional, high-performance transit systems (such as BART and San Diego) but the authors found no significant effects for the other three systems.

Impacts stronger in suburbs than central city

Another common conclusion was that these impacts, however small, were typically stronger in the suburbs than in the central city. This should come as no surprise. Location theory leads us to expect the greatest land use change to occur where the marginal reduction in travel cost brought on by the transportation improvement is greatest. The BART studies found that the greatest land use changes occurred at the outermost areas of the system, where the greatest changes in accessibility were to be found (Dyett & Castle 1978; Fajans 1978; Falcke 1978a; MTC 1979). Analyses of the impacts of the Lindenwold commuter rail extension in Philadelphia indicated that the extension had facilitated out-migration of both residences and offices, and was believed to have sped the decline of business activity in Camden, a depressed inner city area (Boyce 1980). In addition, a 1984 impact study of the

San Diego Trolley light rail system, which surveyed the developers of new projects around transit stations, found that, on the whole, suburban developers considered the trolley station as an important factor in their location decisions, but central city developers did not (SANDAG 1984).

The only real evidence to the contrary comes from the "BART at Twenty" studies. Cervero and Landis (1995) find that in the central city, areas served by BART showed faster population and employment growth than non-BART areas, whereas this trend is reversed in the suburbs. Again we see the importance of other factors here. The authors note that the suburban BART corridor studied was competing against a suburban freeway corridor, while there were no competing freeway improvements to be found in the central city. In addition, residents of the suburban areas were more likely to downzone around their BART stations than to allow for higher density development, whereas the land use policies in the central city were almost uniformly pro high density development.

Mixed results in high income areas

If marginal improvements in accessibility are a key factor in determining impacts, it follows that the impacts of transit should be less pronounced where, say, transit is not used much. Some researchers have hypothesized that transit's impacts would be reduced in high income areas for this very reason. One early study (Boyce, et al. 1972) noted that land use impacts varied both by distance and income, with lower and middle income areas showing higher price impacts, suggesting that transit accessibility is less important to higher income households. Other results were even more extreme. In a hedonic price study of 286 homes in Atlanta, Nelson (1992) found that the sales prices of single family homes in low and moderate income areas were on average $1.05 higher for every foot the house was closer to a MARTA rail station, whereas sales prices were $.96 lower per foot of station proximity in high income areas. The significance and substantiality of these results, particularly of the change from an increase to a decrease in home values, must be tempered by information regarding three aspects of the study. First, straight-line distance, and not some more accurate measure such as walking distance or time, was used as the measure of proximity. Second, housing characteristics (i.e. age and quality) and neighborhood characteristics (except for racial and income distributions) were left out of the regression equations. Third, the comparisons were made between high and low income areas which often bordered the same transit station, and thus, bordered each other. Therefore proximity to transit in the high income area also meant proximity to the low income area. Falling home prices could have been due to increasing proximity to the neighboring low-income community, and not the transit station.

Impacts due to real estate speculation

There is some evidence that property value impacts at least are speculative; in other words, that these impacts are detectable as early as the planning and construction phases of a transit system. One case study, which was part of the BART Impact Study, concluded through interviews with real estate developers that BART had induced some, though not extensive, speculation in certain station areas (Falcke 1978b). This conclusion is weakened, however, by the authors' suggestion that those station areas which showed speculative activity may have been the objects of unrelated market demand at the time. More convincing evidence comes from a case study of the Miami Metrorail (Ayer & Hocking 1986), which found, using interviews and comparative statistics, that value assessments for real estate within 1000 feet of Metrorail stations increased by an average of 30 percent during the construction period alone.

Impacts are intra-regional shifts

From the earliest studies the evidence indicated that development around transit stations was the result of intra-regional shifts. As early as 1972, studies of the Lindenwold line found positive impacts on residential property values (Boyce et al. 1972). However, the authors concluded that there existed some evidence indicating that these increases were at least partially shifts from unserved areas. Knight and Trygg make the same point in their study. None of the subsequent studies reviewed here seriously challenged this notion, and most did not even mention it. No one has found any evidence suggesting that transit investments can lead to net new economic or population growth for the region as a whole.

Changeover to commercial uses

Several studies have looked at how land use type is affected by transit. Most suggest that over time, commercial uses tend to replace residential and industrial uses near transit stations. Before-and-after studies of Washington, D.C.'s Metrorail found that the only observable land use impacts involved revitalization efforts or the development of mixed-use projects in areas previously planned for warehouse or industrial use (Donnelly 1981; Dunphy 1982). In addition, a Chicago Area Transportation Study (CATS) investigation of the O'Hare Road transit extension in Chicago found that the area served by the extension developed at the same rate between 1980 and 1985 (which corresponds to planning, construction and the first year after opening) as it had between 1970 and 1980 (before the extension was considered) (CATS 1986). However, during this same time, the percentage of new construction which was residential went from 64 percent before the extension to only seven percent afterwards. Clearly, almost all the new construction was now commercial.

Commercial impacts vs. residential impacts: mixed results

Lustin's overview of joint development in the Northeast corridor (1983) reported that private developers found commercial transit-oriented projects significantly more attractive than either retail or residential ones. A study of the impacts of the Red Line extension in Boston found that the largest increase in land use was for commercial land, residential uses increased slightly, and industrial uses declined along the extension corridor (Quackenbush 1987). An MIT study modeling property values in Washington, D.C. found that distance from a Metro station was a statistically significant determinant of commercial property values, and that these values declined quite rapidly with increased distance from the stations (Damm et al. 1980). In this same study, the authors found, using a hedonic price model, that the elasticity of price with respect to distance from transit was as much as 3-4 times higher for retail uses than for residential uses, indicating a much greater impact on commercial than on residential land.

On the other hand, a few studies find that transit has a greater impact on residential property than it does on commercial. In a study of Baltimore's heavy rail line, Harrold (1987) found that residential permits increased more rapidly in the new rail corridor than in other parts of the city, but evidence on commercial uses was mixed and inconclusive. Landis et al. (1995) conduct one of the few studies in which hedonic price models were used to estimate impacts on both residential and commercial land. They find no price premium for commercial real estate, but do find a tendency for vacant land to be put to residential use and for residential land to be converted to commercial uses. However, they are also unable to attribute any land use changes to station proximity alone, once other factors were accounted for.

Necessary conditions and complementary factors

Most of the studies mentioned above go beyond simply characterizing the impacts of transit by attempting to identify the conditions necessary for the emergence of these impacts. Starting again with Knight and Trygg (1977), the major conditions they identified were the availability of capital and demand for new high-density development, land use policy measures such as high-density zoning allowances, and public sector involvement (such as provision of infrastructure or land assembly and development). Toronto, the city considered to have experienced some of the most significant transit-related land use impacts in North America, was used repeatedly as an illustrative case. In his case study of Toronto, Pill (1988) indicates that Toronto has a history of granting zoning bonuses around transit stations; a joint development policy in which air-rights are granted to private developers; region-wide growth control policies; and a very high performance transit system. In addition, and possibly most importantly, he points out that Toronto's "success" occurred throughout the period that the region's economy was booming and its population doubled.

A before-and-after study of the Red Line extension in Boston found that residential property values at two of the three new stations (Alewife and Porter Square, but not Davis Square) increased faster than the regional average between 1980 and 1985, but that these areas had lower than average base prices, which "may have influenced the trends" (Quackenbush 1987). The study notes that Boston was growing rapidly during these years and that these areas would likely have seen growth anyway. The extension, they explain, "encouraged and quickened" much of the development in these areas.

Most observers agree that both market conditions and public sector involvement need to promote transit-oriented development before significant impacts can be observed. However, there is substantial disagreement as to whether the market or policy conditions are more important. One team of researchers have gone as far as to say that "if there is no underlying demand for high-density development, then almost no combination of public policies will elicit a compact urban structure..." (Meyer and Gomez-Ibanez 1981:121). In some cases, even a booming real estate market was not enough to attract higher-density development around transit stations. One early study of BART looked at the location patterns of townhouses in suburban Contra Costa County (which is served by BART) (Dingemans 1978). The researcher found no evidence that the boom in townhouse construction during the 1970s showed any clustering around the several transit stations located there. He concluded that the main cause of this failure was design-specific and resulted from the lack of assembled, developable land.

Summary of Empirical Findings

1. Land use impacts of transit are observed, but they tend to be small, in general, for heavy rail systems and even smaller for light rail systems (Knight & Trygg 1977, Dingemans 1978; Dunphy 1982; Harrold 1987, Landis et al. 1995).

2. There are some indications - though overall the results are mixed - that the impacts are smaller in high income areas (Boyce et al. 1972; Nelson 1992).

3. Access to transit carries with it an average price premium of around six to seven percent for single family homes (Allen & Mudge 1974; Bajic 1983; Allen et al. 1986; Voith 1991; Al-Mosaind 1994).

4. The impacts of transit accessibility on commercial property values are mixed and inconsistent (Callow 1992; Cervero & Landis 1993).

5. The greatest land use impacts can be seen towards the end-of-the-line stations -sometimes at the direct expense of the central city - because the fringe areas tend to start out as the least developed and least accessible and therefore leave the most room for development (Dyett & Castle 1978; MTC 1979; SANDAG 1984).

6. Transit-oriented development (TOD) tends to represent a transfer from other parts of the

metropolitan region, as opposed to net new growth for the region (Boyce et al. 1972; Knight & Trygg 1977).

7. Around transit stations, commercial uses tend to replace residential and industrial uses over time, but residential growth is most noticeable in transit corridors (Donnelly 1981; Dunphy 1982; CATS 1986; Quackenbush 1987).

8. Within the few studies that attempt this direct comparison, the evidence is mixed with respect to whether proximity to transit affects commercial or residential uses more profoundly (Damm 1980; Lustin 1983; Harrold 1987; Quackenbush 1987, Landis et al. 1995).

9. Almost exclusively, transit systems' impacts on land use are limited to rapidly growing regions with a healthy underlying demand for high-density development (Knight & Trygg 1977; Quackenbush 1987; Pill 1988).

10. Public sector involvement (including, for example, land assembly, the provision of high-density zoning allowances, restrictions on parking, and financial incentives for TOD) are also common enough to be considered necessary *In fact one of the biggest impacts of transit seems to be that its existence often leads to changes in policy, which then affect land use* (Knight & Trygg 1977; Falcke 1978b; MTC 1979; ULI 1979; Donnelly 1982; Cervero & Landis 1993)

Conclusion

Findings 9) and 10) describe crucially important factors in successful transit-oriented development. Many of the studies reviewed suggest that the effects of these factors may often outweigh the effects of the transit improvement per se, yet this issue is not addressed in classical location theory (Alonso 1964; Mills 1972). If transit has only a small effect on location choices, why is this the case? And what does it imply about the focus of location theory on accessibility?

First, transit improvements constitute only a subset of all transportation improvements. The increment of accessibility provided by transit is small and its availability is often limited. Indeed, transit might simply be so limited that, in the aggregate, people don't really care whether or not it is accessible. Generally speaking, our expectations of the land use impacts of transportation improvements are based on observations from early cases of major investment (such as turn-of-the-century transit projects and early post-war highway construction). These improvements were made in areas with much lower overall accessibility than we find in our cities today. Therefore, their impacts were relatively much larger. In the present context, overall levels of accessibility in cities are so high that even the largest transportation projects will seem marginal.

This point was first made by Garrison in his discussion of the growth dynamics of public facility systems. "Most of the nation's roads are already paved, so no dramatic increase in accessibility to new areas is likely" (Garrison 1978:259). More recently, Giuliano (1995) states that "the transportation system in most U.S. metropolitan areas is highly developed, and therefore the relative impact of even major investments will be minor." And Landis et al. (1995:25) borrow from the language of industrial geography to explain the changing relationship between transportation and land use as that of a "product-cycle" curve (Vernon 1966):

> "The spatial effects of transportation technologies are greatest when those technologies are new, and then decline over time. New transportation technologies...alter accessibility... [generating] areas that are...under-priced. Once the higher value of such areas becomes apparent...[they] are quickly developed...Once this diffusion period is past, and the technology established, additional transportation improvements (within that same technology) will have only small impacts - so small that they may ultimately be marginalized by land use policies designed to preserve the status quo."

In addition, early transit and highway extensions were predominantly built in undeveloped areas and often specifically for the purpose of bringing more land into development. Today's transportation improvements generally appear in already developed areas, where drastic land use changes can not be expected (MTC 1979; Giuliano 1995). In fact, the availability of developable and easily assembled land emerged, throughout many of the studies in this review, as one of the most powerful "complementary factors" necessary for successful joint development.

That land use impacts of transit are observable is not seriously debated. Access to transit systems does seem to affect property values and land use patterns, albeit more so for some uses of land, in some of the observed places, a portion of the time, and to varying degrees. Equally important is the fact that these land use impacts of transit are not accidental, nor automatic.

In general, the only substantial impacts of transit on land use are those that have been planned, and this planning entails a substantial investment of public sector resources and coordination. In addition, the truly sizable impacts have been observed only in areas and during times when populations and regional economies (especially real estate markets) were booming. This is not to say that observed growth would necessarily have occurred anyway, or that even if it had, its spatial footprint would have been the same, but rather, that transit seems, at best, to increase transportation capacity marginally and then to help (as part of a much larger set of factors) to guide growth into certain areas.

Based on this review, a few suggestions for future research can be made.

1) Comparisons should be made both across regions and across system types (e.g. heavy rail, light rail, busways, etc.)

2) Quantitative and qualitative methods should both be used. Regression and logit models are best able to separate the effects of other, confounding variables from those of the variables of interest. Yet they are least able to provide rich explanations of complex relationships, such as those between transit accessibility and land use patterns.

3) A serious effort should be made to control for as many confounding factors as possible, either by including data on these factors in quantitative models, or by broadening the scope and deepening the analysis in case studies. In addition, case study approaches must seek to be more comparative and critical in their attempt to explain the nuances of the land use-transit relationship.

4) In this variable control effort, particular emphasis should be placed on controlling for variables that have been left out of

the research to date. These are: 1) the health of the regional economy and real estate market, and 2) the types of land use and joint development policy practices commonly found in the region. In quantitative models, dummy variables representing levels of regional economic growth, real estate market activity and complementary land use policy should be added to the traditional list of housing and neighborhood attributes as independent variables. In case studies, more direct comparisons should be made among regions in varying states of economic health and with different levels of policy commitment.

At this stage, the evidence seems to indicate that, on its own, the development of a transit system can have only a minor impact on the ensuing land use patterns of an area, and that the use of transit to change the land use patterns of slow-growing, already built-up metropolitan regions with highly-developed transportation systems will inevitably entail a substantial and long-term commitment of public resources and planning efforts. In general, then, building new transit systems and expecting them to attract development on their own does not make sense. However, this same evidence suggests that the use of transit as part of an overall regional strategy to guide growth can be warranted, assuming this strategy takes into account factors such as economic conditions, current travel behavior and the characteristics of the system itself, while incorporating land use policies and innovative design approaches.

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