RESPONSE OF URBAN REAL ESTATE VALUES IN ANTICIPATION OF THE WASHINGTON METRO

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1. INTRODUCTION

It has long been recognised that the provision of public infrastructure has a profound influence on the pattern of urban development and the spatial distribution of urban real estate values. The existence of highways, sewer services and other public facilities influences the behaviour of both suppliers and demanders of residential and commercial properties. The benefits of these facilities and services are, at least in theory, partially or wholly capitalised into urban property values.

As the costs of public goods in general and mass transit systems in particular have increased, there has been a growing interest in the U.S. and elsewhere in the concept of "taxing back" the induced increases in real estate values to help finance public investments. In the context of American mass transit, this concept has been generally labelled "value capture" and has led to the formulation of a broad range of strategies for public recoupment of supposed upward shifts in property values.

Value capture policies (e.g. direct taxation, public acquisition of property before construction with subsequent resale or leasing, and joint public/private development) are predicated on a number of basic assumptions. First, these policies are based on the presumption that benefits accruing to individuals whose properties are enhanced by investments in public infrastructure should be taxed directly rather than being taxed as income or capital gains. Second, it is assumed that some special mechanism other than conventional property taxes is needed to recover transit-related benefits. However, most fundamentally, value capture policy is founded on the presumption that transit systems actually have impact on urban properties and that that impact is large enough to be worth "capturing".

Previous studies (discussed in more detail in the following section) have provided some evidence on the impact of transit systems on urban property values. In particular, the effect of rail transit on values of owner-occupied single-family dwellings has been widely studied. However, the development of well conceived policies needs a

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more detailed understanding of both the dynamics of change in property value and the impact of transit on different types of urban parcels.

The study described in this paper is an effort to clarify these issues. First, it focuses on the response of urban property values in anticipation of the implementation of a heavy rail transit system. Although previous studies (most notably Boyce *et al.*, 1972) have included at least some limited examination of transit-related effects on property values in a suburban market, pre-implementation impacts have not yet been analysed. Second, unlike previous efforts, this study seeks an understanding of the effects that the presence of a major transit investment has on parcels in different segments of the real estate market, i.e., single and multi-family residences and retail establishments. Third, this study explores how different transit system designs and implementation schedules might effect changes in property values in order to provide some basis for assessing how such political decisions influence the potential values to be "captured".

It is important to note that no effort was made in this study to determine whether aggregate property values shifted as a consequence of the construction of Metro. Typically, the effect of transit will be highly localised around stations, and a relatively small number of parcels may have reasonably large shifts in value. The number of remaining properties will be so large that each may have a virtually infinitesimal decrease in value, while total aggregate urban property values may remain unchanged. Attempting to measure these small decreases is likely to be a fruitless exercise unless an enormous and prohibitively expensive sample of real estate transactions is collected.

Any careful analysis of the urban real estate market makes it evident that simple "before–after" studies are inappropriate for analysing changes in property values. Indeed, a methodology which relies heavily upon controls in the sample data (in any temporal or spatial dimension) is likely to be subject to serious methodological problems, since in the real world there is a tendency to violate the assumed control conditions. On the other hand, methodologies which utilise statistical controls *within the model* (e.g., multivariate regression techniques) enable the analyst, at least theoretically, to estimate the effect of the independent variables on the dependent variable.

There are at least two distinct approaches to the econometric modelling of urban property values. The first, a structural approach, would represent buyers' and sellers' behaviour in separate, but simultaneous, market equations. The second approach implicitly or explicitly solves the simultaneous, structural equations for a single reduced form in which price is a dependent variable and only exogenous variables in the structural equations are independent. The result is often termed a hedonic price equation. In this paper, the hedonic price approach is applied to analyse the effects of the recently opened Washington, D.C., Metro rail system.

Section 2 reviews some of the previous literature on the determinants of property values, with particular emphasis on the influence of transport facilities. Section 3 outlines some methodological aspects of the study. In Section 4 the data set used in the study is described and some of the significant assumptions invoked in assembling that data are detailed. In Section 5 the variables used in the models are defined and tabulated. The results of the final models are presented in Section 6, and the basic conclusions derived from those models are discussed in Section 7. The final section discusses some of the implications of the empirical results.

2. REVIEW OF PREVIOUS STUDIES

Most of the theoretical basis for land price determinants is derived from some variant of models developed by Alonso (1964) and Muth (1966), within which each firm or household faces an urban rent surface over which it individually has no control. Alonso derives a "bid rent curve", which declines with distance to the downtown, reflecting the bids of each household (or firm) for various sites which yield equal utility (or profit). The Alonso model (at least implicitly) provides the conceptual basis for all hedonic price studies. The notion of bid rents extends straightforwardly to include access to multiple centres of urban activity, a differentiated housing stock and other features of urban parcels, though the analytics of clearing the market are often difficult or intractable in more complicated markets.

This theory provides the basis for an important distinction. In a situation with many types of households and firms, the observed prices paid for land reveal only the bid rents of the highest bidder; they reveal nothing about the bid rents of other households or firms except that they were lower. Bid rents reflect the willingness of individuals to pay for a particular attribute such as proximity to the downtown. In contrast, hedonic price models, in which prices are a function of the attributes of the goods consumed and not of the consumer, reflect only the marginal evaluation of the highest bidder. For this reason, hedonic price models (such as the one developed in this study) only reflect the outcome of the market equilibrium process; they are neither demand nor supply curves, but are rather reduced form equations. Virtually all existing studies of the effect of transport infrastructure on real estate prices are limited in this sense. Previous studies of the relationship between location of transport facilities and urban property values have, however, varied widely in the data and methodologies used as well as in the conclusions reached.

Perhaps the most widely-cited work in the literature is by E. H. Spengler (1930). By examining assessed values of land in the vicinity of virtually every rail transit line constructed in New York during the early 20th century, Spengler came to several noteworthy conclusions:

(1) New transit lines tend to shift value rather than to create increased aggregate value. While owners of land in the vicinity of a new transit line may benefit, owners of land elsewhere may be disadvantaged.

(2) Transit lines are only one of the numerous factors influencing land values, and they often cannot outweigh the effects of other factors which are acting to depress land values.

(3) Transit acts to enhance land values in centres of concentration at the expense of outlying areas.

(4) Areas already developed do not generally show a marked increase in land value when new transit lines are opened.

(5) In areas already supplied with a number of transit lines, addition of another one will have only a mild stimulative effect compared with the effect it would have in an area not already supplied with transit.

(6) In newly developing areas with transit service, increased land values are likely to be attributable in large part to the process of subdivision rather than to transit access.

Most more recent studies have relied on either tax assessors' records or actual real estate transactions, and have typically been "before/after" studies (so-called comparative control analyses) or have used multivariate regression. In the U.S., most of these prior studies have focused on the impact of highway facilities. For example, in a cross-sectional study, Adkins (1958) found that land closest to interchanges along a Texas expressway increased in value 300–600%, and that land farther out experienced much smaller, though still positive, increases. Brigham (1964) developed a multiple regression model based on assessment data which confirms a positive relationship between highway accessibility and land value; Burton and Knapp (1959) and Lemly (1959) used comparative control analysis based on sales data, and reached the same conclusion. Although Czamanski (1966) did not study accessibility to highways *per se*, he did find, using multiple regression and analysis of variance, that accessibility to the central business district (CBD) is a prime determinant of land value. Golden (1968) found that increases in land value occurred to a greater degree for properties close to freeway interchanges than in control areas farther away. A University of Kentucky (1975) comparative control study based on survey responses by owners of commercial and industrial establishments concluded that significant increases in land values occurred upon the completion of a six-mile free access bypass. In addition to these studies, there have been numerous observations of changes in prices of properties near to transport systems without any comparative control, including Heenan (1968), Langfield (1971) and Miller (1971).

Two researchers found that the improved accessibility afforded by transit or highways had little or no effect on land values. Eyerly (1965) compared tax records over a period of six years and found that land values in an interchange area increased less than in surrounding areas. Cribbins (1964) used sales prices for parcels sold near three sections of interstate routes in North Carolina in a multiple regression analysis, and found that the highways investigated had no measurable effect on development within the study areas. He concluded that general increases in land value appeared to be determined largely by other forces existing within the localities studied.

Most of the researchers who did not find that transport improvements have a positive effect on land values concluded instead that land values are merely redistributed throughout the region, and that aggregate increases are not actually induced by transport improvements. For example, on the basis of an empirical analysis of the benefits of a highway improvement, Mohring (1961) determined that land value increases in the vicinity of a highway may be balanced by relative decreases elsewhere as activities shift to locations near the highway to take advantage of the improved accessibility.

Studies of the effects of transit on property values have been far fewer, and often more modest in scope, than their highway counterparts. In analysing properties with varying proximity to a bus system, Downing (1973) found that land values are highly dependent on accessibility. Boyce *et al.* (1972) and Allen and Mudge (1974) showed that land value increases due to the existence of a fixed heavy rail system were balanced by decreases outside the area. In a historical review of rail transport in developing countries, Gauthier (1970) concluded that areas close to rail stations experience increases in land value at the expense of areas farther away, since resources and production may become more concentrated in centres, while serious development lags occur elsewhere.

3. METHODOLOGY

These previous studies all provide at least a preliminary basis for specifying a model of property value. However, given their diversity in methodology and objectives, the process of model specification in this study was largely an iterative one. Different variables and functional forms were considered.

In some cases it was impossible to distinguish (on either theoretical or statistical grounds) one model from another, and more than one model was retained for later use. Obviously, the primary consideration in the specification of a model was *a priori* theory about how land values are determined. In addition, prior conceptual development by Boyce and Allen (1976) and Dornbusch (1976) also provided some basis for model specification. Existing theory and intuition about the process by which land values are determined are, however, of limited use in choosing among various functional forms of hedonic price models. In cases for which no *a priori* grounds for selection appeared reasonable, the choice of model specification was based on statistical considerations (goodness-of-fit and statistical significance of the estimated parameters) and on analysis of functional form (using a statistical procedure developed by Box and Cox (1964) to test the appropriateness of alternative functional forms).

Suppose one is considering a particular variable y in a regression model $f(y) = X\beta + \varepsilon$. However, suppose that one is uncertain whether the specification of $f(y)$ should be linear, logarithmic, quadratic or in some other form. Box and Cox examine a "family" of transformations with the following specification:

$$y^* = \begin{cases} \dfrac{y^\lambda - 1}{\lambda gm(y)^{-1}} & \text{for } \lambda \neq 0 \\ \dfrac{\log y}{gm(y)} & \text{for } \lambda = 0 \end{cases}$$

where: $gm(y)$ is the geometric mean of y and
λ is a parameter to be estimated.

The parameter λ allows for representation of a wide range of functional forms. Note that as $\lambda \to 0$ the expression $y^\lambda - 1/\lambda\, gm(y)^{\lambda-1}$ converges to $\log \lambda/gm(y)$. If $\lambda = 1$, then the form of the regression is linear; if $\lambda = 0$, then it is log-linear. Moreover, "intermediate" function forms such as $y^2 = X\beta + \varepsilon$ can be represented by a value of λ equal to 2.

The value of λ can be estimated either directly by maximum likelihood (typically assuming normally distributed disturbances) or by searching over different values of, and estimating the parameters of, the equation $f(y) = X\beta$ by ordinary least squares for each value and choosing the λ which minimises the sum of the squared residuals. The latter technique has the distinct advantage of not requiring a non-linear model estimation procedure, and was therefore used in this study. Moreover, if it is supposed that the disturbances satisfy the usual assumptions of the linear model (i.e., that they are independent, heteroskedastic normally distributed), then the two estimators are identical.

4. DATA

There are significant problems associated with obtaining reliable data about urban real estate transactions. Acquiring a complete history of transactions for any large group of parcels was not feasible in the context of this study. Instead, a series of cross-sectional data samples for the period 1969–1976 was used.

Three distinct data sets were developed:

(1) Owner-occupied single-family dwellings,
(2) multi-family buildings, and
(3) retail establishments.

In each case, the sample was restricted to Washington, D.C., proper, in order to avoid the problems of differing conventions for recording real estate transactions in the various jurisdictions of the region.

The first source of data was the Metropolitan Parcel File (MPF), which contained a number of valuable pieces of data on virtually all parcels in Washington, D.C. In addition to having exact premise addresses, it also contained a number of geocoding identifiers, including U.S. Census block and tract numbers for 1970, Transportation Planning Board zone numbers, and certain parcel descriptors such as area and number of units on the parcel.

The second source of data was the Lusk directory, which contained extensive information on recorded transfers of all property in Washington, D.C., from 1969 to 1976.[1] In addition to the amount of the transaction for a specific parcel, date of sale, mortgage interest rate, name of new owner, local block and lot descriptions, it gave assessment data and land use type. Parcels sold were isolated by sampling from the 1974 Metropolitan Parcel File (MPF) and checking each address for transactions, using the Lusk listing for 1969 to 1976.[2]

A third important source of data, the U.S. Census, provided information about the neighbourhood around each parcel.

For each Metro rail station in the District of Columbia, a surrounding impact area was defined. The characteristics of the station areas were used as estimates of the general conditions in the surrounding neighbourhood. In all cases, the statistics describing the neighbourhood (mean income, housing quality, etc.) were calculated from census tract and block data from 1970.

It often happened that a particular parcel in the sample was located outside a station area. The neighbourhood socio-economic data used for these parcels corresponded to the census tract in which the parcel lay. Metro-related data (e.g. distance to a Metro station) were determined by assigning the closest Metro station to the transacted parcel. In some cases, the census data was insufficient to obtain reasonable estimates of the housing stock and percentage of population which was not white. There were always stations in which there were very few residents, and counts were consequently either not published for disclosure reasons or simply not meaningful. All parcels from such stations were omitted from the final sample.

Apart from the parcel and neighbourhood data provided by the MPF, the Lusk

[1] These directories were rented from R.S. Lusk and Sons, Inc.

[2] Parcel files from 1970, 1972, 1973 and 1974 were provided by the Metropolitan Washington Council of Governments.

directories and the census, a number of other minor data sources were used to construct part of the base. These were:

(1) 1972 Regional Employment Census (conducted by the Washington Council of Governments)—for retail and total employment on the census tract level.
(2) U.S. Census Maps—for measurement of census tract areas and the distance from each sampled parcel to the nearest Metro station. This distance was approximated as the mean distance to a census block of the parcel.
(3) Washington Metropolitan Area Transit Authority (WMATA) planning documents—for estimates of the opening dates for various stations in the WMATA system. Data on the number of years expected to elapse before the completion of the nearest Metro station was obtained from the original Metro construction schedule and its subsequent revisions.[3]
(4) Bureau of Labor Statistics—for housing and consumer price indices for Washington, D.C. These were used to deflate transaction prices to a constant dollar level (1969). The deflator was calculated on the basis of an average of the housing and overall prices for the Washington, D.C., Metropolitan area.[4]

The three final data sets (single-family, multi-family and retail) used in model estimation were formed by integrating all the above data into separate files. Tabulation of the data indicated that about 30% of the observations for multi-family dwellings lacked values for the number of dwelling units. Rather than eliminate these observations, it was decided to estimate the number of dwelling units from other, properly coded, variable values. This was done by regressing the number of dwelling units on some of the other variables, using only the 531 observations for which dwelling unit counts were available. In the final sample, a regression with only lot size as an independent variable was used to estimate the missing data.

Tables 1, 2 and 3 provide summaries of the main characteristics of the samples for single-family dwellings, multi-family units and retail establishments respectively. In each table, the sample mean, standard deviation, and range of the variables are given. In the case of the sample for multi-family buildings, the statistics for the number of dwelling units include those parcels for which the value was estimated from the area of the lot.

5. DEFINITION OF VARIABLES

The dependent variable of interest is, of course, the transaction price of a parcel, deflated to 1969 dollars. In order to understand the variation of this price from parcel to parcel, we defined a set of explanatory variables to be included in the regression

[3] The number of years to completion for any transaction depended upon the station area and the date of the transaction. If a parcel were transacted in a year of a construction schedule change, but before the change was announced, the parcel was assigned the number of years to completion based on the old schedule. If the transaction occurred during or after the month of the schedule change, the number of years to completion is that of the new schedule.

[4] U.S. Department of Labor Statistics were used to develop Washington, D.C.-specific cost of living indices. The implicit assumption is that all three real estate sub-markets defined in this study experienced equal inflation over the interval studied.

TABLE 1

Summary of Single-Family Dwelling Sample

Variable	*Mean*	*Standard Deviation*	*Range*
1. Deflated transaction price (1969 dollars)	$30,746	$17,954	$2,090–$124,150
2. Distance to nearest Metro station (miles)	0.3	0.6	0.1–1.2
3. Number of years until station completed	3.7	2.0	0–9
4. % dwellings owner occupied in station area	23.2%	15.69%	2–71%
5. % substandard dwellings in station area	3.3%	3.49%	0–11%
6. % non-whites in station area	59.6%	33.78%	2–99%
7. Annual income in station area	$12,255	$5,029	$5,021–$26,480
8. Distance to Metro Centre (miles)	2.53	1.18	0–6.3
9. Parcel lot area (sq. feet)	1,917	1,297	532–15,168
10. Total employees per sq. ml. in station area	14,630	18,092	831–79,463
11. Retail employees per sq. ml. in station area	1,148	1,079	0–5,009
12. Population per sq. ml. in station area	27,220	12,439	6,217–49,675

Sample size = 286

TABLE 2

Summary of Multi-Family Building Sample

Variable	*Mean*	*Standard Deviation*	*Range*
1. Deflated transaction price (1969 dollars)	$60,796	$192,404	$1,108–$2.6 × 10⁶
2. Distance to nearest Metro station (miles)	0.6	0.4	0.1–2.0
3. Number of years until station completed	3.7	2.1	0–9
4. % dwellings owner occupied in station area	25.1%	13.6%	2–81%
5. % substandard dwellings in station area	2.4%	3.3%	0–44%
6. % non-whites in station area	72.3%	31.1%	2–100%
7. Annual income in station area	$10,428	$3,410	$5,021–$26,480
8. Distance to Metro Centre (miles)	0.4	0.3	0–7.7
9. Parcel lot area (sq. feet)	5,138	11,536	1,012–273,295
10. Total employees per sq. ml. in station area	9,020	19,155	617–266,983
11. Retail employees per sq. ml. in station area	1,006	1,332	0–18,646
12. Population per sq. ml. in station area	27,310	14,916	3,623–63,443

Sample Size = 771

models. These explanatory variables can be usefully grouped into three categories: transit system-related, demographic and parcel-specific. The names and a short description of each variable are given in Table 4, but a brief commentary on some of them is appropriate. In effect, the inclusion of each variable represents a hypothesis about the way in which property buyers and sellers evaluated market conditions in Washington, D.C.

The first group of variables has, naturally, the most direct bearing on transport

TABLE 3
Summary of Retail Establishment Sample

Variable	*Mean*	*Standard Deviation*	*Range*
1. Deflated transaction price (1969 dollars)	$54,422	$82,622	$500–$829,472
2. Distance to nearest Metro station (miles)	0.2	0.2	0.0–1.4
3. Number of years until station completed	3.0	2.2	0–9
4. % dwellings owner occupied in station area	27%	13%	*
5. % substandard dwellings in station area	8%	27%	*
6. Annual income of residents in station area	$9,322	$3,416	$5,021–$26,480
7. Distance to Metro Centre (miles)	1.92	1.40	0–6.3
8. Parcel lot area	2,879	6,090	613–56,016
9. Total employees per sq. ml. in station area	41,199	60,748	617–266,984
10. Retail employees per sq. ml. in station area	4,265	6,578	0–22,165
11. Population per sq ml. in station area	24,625	16,021	2,207–63,442
12. Parcel floor area	2,520	2,862	400–19,589

Sample Size = 353
Note: 17% of the observations in this sample were transacted before 1969.
*Not available.

policy, since changes in them could affect the distribution of land values and ultimately land uses. Proximity to a Metro station would be expected to increase the price of a parcel, as most people would enjoy the convenience of not having to walk great distances or first take a bus before riding the rail system. In addition to distance, a dummy variable, PXDUM, was also defined to capture any negative effects of being too close to a station. That is, it was hypothesised that the value of those parcels within 0.1 mile would be degraded to some extent because of increased pedestrian and vehicular traffic and the resulting increases in noise and air pollution. Similarly, dummy variables for a station's being above ground and for its having park-ride facilities were defined so that any negative impacts associated with these characteristics could be included in the regression. Because the Metro system had not yet been completed, it seemed obvious that those parcels whose nearest station was about to be opened would tend to be more influenced than those where the opening of a station was much further in the future. This is reflected in the variable, YR, the number of years until the station was to be opened.

Note that there is no measure of highway access included in Table 4. This is because the study area was limited to the city of Washington, where variations in average travel speed are far smaller than variations in transit access. If the study had been extended to include the sections of Maryland and Virginia which are part of the metropolitan area, some auto-level-of-service measure would probably have been essential.

In the second group, variables were defined to represent the demographic characteristics of the neighbourhood in which a parcel was located. It is well known in the real estate market that the environment surrounding a property often plays a large part in determining the final price, regardless of the condition of the parcel in question.

TABLE 4

Variables in the Models

Name	*Variable Type and Definition*
	DEPENDENT VARIABLE:
DPRICE	TRANSACTION PRICE, DEFLATED TO 1969 DOLLARS
	EXPLANATORY VARIABLES
GROUP ONE: TRANSIT SYSTEM-RELATED	
DIST	Straight line distance to nearest Metro station (in miles)
PXDUM	Proximity dummy: {1 if parcel is located within a specified distance to station; 0 otherwise
YR	Number of years to completion
SS	Dummy variable: {1 if station is above ground; 0 otherwise
PR	Dummy variable: {1 if station has park-ride lot; 0 otherwise
GROUP TWO: DEMOGRAPHIC	
OWNER	% owner-occupied dwellings
HOUSE	% substandard housing
NWHITE	% non-white
INCOME	Mean income ($/yr)
EDEN	Total employment density (employees/sq. ml)
RDEN	Retail employment density (employees/sq. ml.)
PDEN	Population density (persons/sq. ml.)
GROUP THREE: PARCEL-SPECIFIC	
DISTM	Distance by transit to Metro Centre (in miles)
LOTA	Lot area (sq. ft.)
FLAREA	Floor area of parcel's improvement (sq. ft.)
TOTV	Total assessed valuation ($)
LANV	Assessed valuation of land ($)
ZDUM	Zoning dummy: {1 if parcel's zoning class and property type are identical; 0 otherwise
CBDDUM	CBD dummy: {1 if parcel is located in CBD; 0 otherwise
NBDU	Number of dwelling units
DUDUM	Dwelling unit dummy: {1 if NBDU was actually recorded for observation; 0 otherwise
PRE	Pre-1969 dummy: {1 if transaction was pre '69; 0 otherwise

While the seven variables defined are by no means exhaustive, they represent most of the major dimensions along which the environment of a property could reasonably be measured. Mean income and the percentage of substandard housing, as measures of neighbourhood quality, should be straightforward. Decreases in the percentage of owner-occupied dwellings in an area should probably have a depressing effect on the values of single-family dwellings. Its effect on multiple-family structures is somewhat less clear, since renters may or may not seek areas with predominantly rental housing. The percentage non-white was, from the beginning, a variable about which there was no *a priori* expectation; nevertheless, it could play some part in influencing the final market price. Likewise, it was not clear how the density-related variable would affect prices in specific markets.

The third group of variables corresponded to hypotheses about the attributes of specific parcels independent of who lived there or of their proximity to the Metro system. The rationale behind any of these (e.g., lot area, condition of structure) should be obvious. In specifying the zoning variable, it was hypothesised that consistency of zoning class and property type within an area was viewed in the marketplace as desirable. Parcels located in the central business district enjoy proximity to at least two Metro stations (i.e., within $\frac{1}{2}$ mile), and should therefore have greater value than equivalent parcels outside. A dummy variable (DUDUM) was defined in order to test whether the missing data on the number of dwelling units was the result of some systematic coding errors that were correlated with the disturbance terms in the price models for multi-family buildings. In the models of prices for retail establishments, information from 1966 to 1968 was also used; consequently, a dummy variable PRE measured any systematic differences between the 1966–69 and 1969–76 intervals.

6. MODEL ESTIMATION RESULTS

a) Single-family dwellings

A series of preliminary models were developed on the single-family dwelling sample to explore a variety of hypotheses about particular coefficients. As a result of these analyses, the variables expressing the percentage of non-whites, the employment density and the population density were dropped from further consideration.

A reciprocal form for the distance to station (DIST) variable was specified to reflect the hypothesis that the linear form understates the effect of proximity to a station for near and distant parcels, and overstates it for the middle range. The proximity dummy variable (PXDUM) was introduced to capture any special effects of a parcel's being extremely close to the station. Thus, the measurement of the distance-to-nearest-Metro-station influences is:

$$\alpha \text{DIST1} + \beta^{*}\text{PXDUM} \text{ where DIST1} = 1/(\text{DIST} + 1).$$ [5]

Various models were estimated using the reciprocal for distance, with and without the park-ride, CBD, and proximity to station variables. The results of these models confirm the intuitive judgement that the reciprocal form for distance explains the decline of housing price with distance to station better than the linear form. The proximity during variable coefficient was small and statistically insignificant when used with the reciprocal form for distance. This suggests that the reciprocal form seemed to measure a substantial amount of the proximity effect, while the linear form represented a mis-specification for short distances.

[5] The shifting of distance in the denominator was to avoid the possibility of dividing by zero.

The modified park-ride variable (PR) proved to be of little use, as none of the observations in the sample were within reasonable walking distance of a park-ride station. Since the purpose of this variable was to account for any nuisance effects of residing near a park-ride station, inclusion of the PR variable would have produced misleading results. Consequently, the variable was dropped from the model.

The elimination of the PR dummy variable resulted in a decrease of the statistical significance of the above-surface dummy variable (SS). Closer examination of the two variables uncovered a partial correlation of 0.55, due principally to there being only two Metro stations in the sample which were at grade, one of which had a park-ride facility.

The central business district dummy variable (CBDDUM) was consistently insignificant at reasonable levels of confidence. In addition, the area defined as the CBD contained only a small number of single-family dwellings. As a result, this variable was also dropped from the model.

The preliminary investigations led to the final form of the linear additive model, with both the SS and PR variables dropped, as follows:[6]

$$\begin{aligned}
\text{DPRICE} = {} & 24{,}988 + \underset{(3.06)}{1212\ \text{DISTI}} - \underset{(2.09)}{876\ \text{YR}} - \underset{(5.03)}{6192\ \text{DISTM}} \\
& + \underset{(1.22)}{73.7\ \text{OWNER}} - \underset{(5.45)}{2023\ \text{HOUSE}} + \underset{(0.90)}{0.899\ \text{INCOME}} \\
& + \underset{(4.29)}{3.533\ \text{RDEN}} + \underset{(6.19)}{3.986\ \text{LOTA}} + \underset{(1.68)}{4492\ \text{ZDUM}} \\
& R^2 = 0.592
\end{aligned} \tag{6.1}$$

A number of models were also estimated using a variety of non-linear transformations of dependent and independent variables. From these tests, a mixed linear/log form was specified, using the functional form which implied the most plausible causal relationship. In some cases, goodness of fit (as measured by low standard errors in earlier equations) was used as a criterion to test specific hypotheses.

The final form of the mixed linear/log model is:[7]

$$\begin{aligned}
\text{DPRICE} = {} & -117{,}060 + \underset{(2.52)}{1001\ \text{DISTI}} - \underset{(2.93)}{4210\ \ln(1+\text{YR})} - \underset{(5.07)}{6104\ \text{DISTM}} \\
& + \underset{(2.47)}{4573\ \ln(1+\text{OWNER})} - \underset{(4.48)}{7512\ \ln(1+\text{HOUSE})} \\
& + \underset{(5.74)}{15{,}624\ \ln \text{INCOME}} + \underset{(4.96)}{4.57\ \text{RDEN}} + \underset{(6.52)}{4.139\ \text{LOTA}} \\
& + \underset{(0.87)}{2462\ \text{ZDUM}} \\
& R^2 = 0.601
\end{aligned} \tag{6.2}$$

A Box and Cox analysis was performed to estimate the best functional form of the dependent variable in the single-family dwelling model. These models were estimated

[6] Numbers in parentheses below coefficients are estimated t-statistics.

[7] All the independent variables which include possible zero values were translated by adding one in the logarithmic forms. All variables denoted by ln are natural logarithms.

by searching over values of λ including $-1, -0.5, 0.1, 0.3, 0.5, 0.7, 0.9, 1.0$ and 2.

The results imply an estimated value for λ of 0.5, indicating that the best functional form for the model is one between a pure linear ($\lambda = 1$) and pure log form ($\lambda = 0$). The estimated value of $\lambda = 0.5$ differed from both 0 and 1 at the 95% confidence level. Because of these results, a third functional form of the model, the Box and Cox form, was adopted for later use. The final Box and Cox model is summarised below:

$$\begin{aligned} \text{DPRICE} &= (0.003147{*}\text{REGREXP} + 1)^2 \\ \text{where REGREXP} &= \underset{(8.79)}{49{,}862} + \underset{(3.00)}{1077\ \text{DISTI}} - \underset{(2.14)}{814\ \text{YR}} - \underset{(5.18)}{5767\ \text{DISTM}} \\ &\quad + \underset{(1.72)}{93.8\ \text{OWNER}} - \underset{(6.20)}{2{,}084\ \text{HOUSE}} + \underset{(4.09)}{0.852\ \text{INCOME}} \\ &\quad + \underset{(4.44)}{3.313\ \text{RDEN}} + \underset{(4.37)}{2.58\ \text{LOTA}} + \underset{(1.94)}{5054\ \text{ZDUM}} \\ R^2 &= 0.603 \end{aligned} \tag{6.3}$$

b) Multi-family building models

Although many models of the values of multi-family buildings were estimated, a discussion of several of them suffices to give the reader insight into the results. Linear as well as inverse specifications for the "distance to station" varable were explored, but the predominantly logarithmic formulation consistently produced the most reasonable results.

The signs on most of the coefficients of the first model (which employed most of the variables defined in Table 4) were reasonable, but indicated numerically very small and statistically very unreliable estimates for several coefficients, especially the qualitative, dummy variables. The theoretical doubtfulness of these dummy variables led to a more restricted form:

$$\begin{aligned} &\ln(\text{DPRICE}) = \\ &\underset{(-3.15)}{-0.492} - \underset{(-3.88)}{0.187\ln(\text{DIST})} - \underset{(-2.15)}{0.111\ln(\text{YR}+1)} + \underset{(0.011)}{0.137\ln(\text{DISTM})} \\ &- \underset{(-4.15)}{0.206\ln(\text{OWNER}+1)} - \underset{(-3.68)}{0.0043(\text{NWHITE})} + \underset{(3.68)}{0.084\ln(\text{HOUSE}+1)} \\ &+ \underset{(6.01)}{0.829\ln(\text{INCOME})} - \underset{(-1.24)}{0.022\ln(\text{RDEN})} + \underset{(2.54)}{0.144\ln(\text{PDEN})} \\ &+ \underset{(3.60)}{1.233(\text{CBDDUM})} + \underset{(2.43)}{0.142\ln(\text{LOTA})} + \underset{(9.20)}{0.615(\text{DUDUM})} + \underset{(11.24)}{0.500\ln(\text{NBDU})} \\ &R^2 = 0.616 \end{aligned} \tag{6.4}$$

In this functional form, the park ride dummy (PR), employment density (EDEN), the zoning classification dummy (ZDUM) and proximity to station dummy (PXDUM) were omitted. Total employment density was omitted, largely because it represents the same causal factor as retail density. While the t-statistic for the coefficient for retail density in this model was lower than the previous ones, the reliability of the coefficient of RDEN (as indicated by the smallness of its standard error) is actually greater.

To test the validity of using the deflated transaction prices of the parcels as the dependent variable, a model using the logarithm of assessed total value of a parcel (TOTV) was also estimated. The model, with a somewhat reduced set of variables as compared with equation (6.4), is as follows:[8]

$$
\begin{aligned}
\ln(\text{TOTV}) = {} & \underset{(9.15)}{4.72} - \underset{(-0.51)}{0.02 \ln(\text{DIST})} - \underset{(-0.21)}{0.008\,(\text{YR}+1)} - \underset{(-2.33)}{0.3\,(\text{PR})} + \underset{(1.57)}{0.05\,(\text{DISTM})} \\
& - \underset{(-3.38)}{0.14 \ln(\text{OWNER}+1)} - \underset{(-7.65)}{0.001\,(\text{NWHITE})} - \underset{(-0.83)}{0.001 \ln(\text{HOUSE}+1)} \\
& + \underset{(3.61)}{0.08 \ln(\text{EDEN})} - \underset{(-2.50)}{0.09 \ln(\text{PDEN})} + \underset{(25.01)}{0.96\,(\text{DUDUM})} + \underset{(39.89)}{0.84 \ln(\text{NBDU})}
\end{aligned}
\tag{6.5}
$$

$$R^2 = 0.794$$

The results seemed to underscore the factors which assessors probably included in their judgements. One of the most striking aspects of the model based on assessed rather than transaction value is that the coefficient of the logarithm of the distance to the nearest station in the two models differs by a factor of more than 9. In equation 6.4, the estimated coefficient for the log of distance is –0.19 (with a standard error of 0.049), while in the equation using assessed value the corresponding coefficient is only –0.02 (with a standard error of 0.04). Similarly, the absolute value of the coefficient of the number of years before the station is to open is far less in the assessed model than in the transaction value model (–0.11 as compared to –0.008).

Apparently, assessors tend to understate significantly the effect of transit systems on the value of multi-family structures. They appear to use criteria which are more closely linked to "easy to observe" factors such as the number of dwelling units (NBDU). Furthermore, the goodness-of-fit for the assessed value model (as measured by the value of R^2) is much greater than that obtained in any of the models based on transaction prices. This would indicate that market prices are subject to a wide range of influences that assessors in Washington may understate or totally ignore.

As with the single-family dwelling model, a series of Box and Cox analyses of transformations was performed. For the model in equation 6.4, the estimate of λ in the transformed dependent variable was 0.05, indicating a functional form very close to logarithmic. Statistically, this value of λ was not different from 0 at reasonable confidence levels. It was therefore concluded that the logarithmic form in equation 6.4 was a suitable transformation.

The final Box and Cox estimates are given below.[9]

$$\frac{(\text{DPRICE})^{0.05} - 1}{0.05\,(gm(\text{DPRICE}))^{-.95}} =$$

[8] This model was estimated at an earlier stage in the model development process; time and budget did not allow for re-estimation using the specification in equation 6.4. All the models using assessed value produced similar results, and the conclusions below would not be likely to change if the model were re-estimated.

[9] This model can be put in the same general form as equation 6.3 by noting that the geometric mean of the deflated housing price in the multi-family building sample is \$35,138.

$$
\begin{aligned}
&-98364 - 6464 \ln(\text{DIST}) - 3914 \ln(\text{YR} + 1) + 4556 \ln(\text{DISTM}) \\
&\quad (-1.79) \qquad (-3.82) \qquad\qquad (-2.16) \qquad\qquad (1.89) \\
&-7271 \ln(\text{OWNER} + 1) - 149\,(\text{NWHITE}) + 2877 \ln(\text{HOUSE} + 1) \\
&\qquad (-4.15) \qquad\qquad (-3.65) \qquad\qquad (3.57) \\
&+ 29265 \ln(\text{INCOME}) - 658 \ln(\text{RDEN}) + 4910 \ln(\text{PDEN}) \\
&\qquad (6.03) \qquad\qquad (-1.08) \qquad\qquad (2.46) \\
&+ 44953\,(\text{CBDDUM}) + 4859 \ln(\text{LOTA}) + 21775\,(\text{DUDUM}) \\
&\qquad (3.73) \qquad\qquad (2.36) \qquad\qquad (9.26) \\
&+ 18445 \ln(\text{NBDU}) \\
&\qquad (11.79) \\
&\qquad\qquad\qquad R^2 = 0.62
\end{aligned}
\tag{6.6}
$$

c) Retail establishment models

The process of model development for retail establishments was nearly identical to that for single and multi-family buildings. An initial set of exploratory specifications was used to limit the scope of the later development process. These initial models included all the independent variables, and suggested that:

(1) Because only 10% of the observations were near park-ride stations, it would be impossible to obtain a reliable estimate of the coefficient of PR (park-ride station dummy variable).
(2) The coefficients for percentage of substandard dwellings (HOUSE) and percentage non-white (NWHITE) consistently had both very small magnitudes and high standard errors.
(3) The empirical results from the log-log models were generally superior to alternative functional forms.

In the second stage, models were developed in a log-log form in which most of the variables had coefficients significantly different from zero at the 95% level of confidence.

The most reasonable of these models is as follows:[10]

$$
\begin{aligned}
\ln(\text{DPRICE}) = {} & 6.51 - 0.54 \ln(\text{DIST}) - 0.55 \ln(\text{YR} + 1) - 0.45\,\text{SS} \\
& (5.70) \qquad (-1.50) \qquad\qquad (5.26) \qquad\qquad (-2.22) \\
& + 0.38 \ln(1 + \text{RENTER}) - 0.07 \ln(\text{INCOME}) + 0.02 \ln(\text{DISTM}) \\
& \qquad (1.95) \qquad\qquad (-1.24) \qquad\qquad (0.65) \\
& + 0.56 \ln(\text{LOTA}) + 0.26 \ln(\text{FLAREA}) + 0.05 \ln(\text{RDEN}) \\
& \qquad (6.07) \qquad\qquad (3.43) \qquad\qquad (1.71) \\
& - 0.80\,\text{PRE} - 0.30 \ln(\text{PDEN}) \\
& \quad (-3.67) \qquad (-4.68) \\
& \qquad\qquad R^2 = 0.506
\end{aligned}
\tag{6.7}
$$

---

[10] In these models, the percentage of nearby households renting their dwellings (RENTER) was used instead of the percentage owner-occupied. Note that RENTER + OWNER $\neq$ 1, since some units were vacant when the census was taken.

In the next stage of model development, RENTER, SS, RDEN, EDEN, INCOME, DISTM and CBDDUM were included singly and in combination with each other. In addition we tested four new variables, ratios of the employment and of density data for properties both inside and outside the CBD. Finally, the log of the difference between lot area and floor area was introduced as a proxy for available parking lot space. Then, in cases where floor area was greater than lot area, a dummy variable, HIGHRISE, was included as a proxy for the existence of multiple stories in the structure.

The ratio of retail employment density to population density (RDEN/PDEN) was intended to be a measure of the supply of retail stores per person. This variable was segmented into two variables corresponding to CBD and non-CBD parcels (denoted below as R/PCBD and R/PNCBD for within and outside the CBD, respectively). Two alternative effects were possible: (1) a competitive effect (the higher the ratio, the higher the number of retail employees per person and the lower the transaction price of the retail property), and (2) an agglomerative effect (the higher the employees per capita in the area, the more business is generated and the higher is the transaction price of retail property).

As the CBD dummy, employment density and distance to Metro Centre variables were used in various combinations, the coefficients of RDEN/PDEN in the CBD were consistently positive and ranged from 0.24 to 0.73, with very low standard errors. These results seemed to point to the agglomeration effect which one expects to occur in the CBD. The corresponding non-CBD coefficients were all positive, but smaller in value than their CBD counterparts by about a factor of ten. The inclusion of employment density and distance by transit to Metro Centre had very large effects on the values and significance of the non-CBD effect; the values dropped dramatically and, as a result, the coefficient became almost totally insignificant.

The ratio of non-retail employment density to retail employment density, (EDEN-RDEN)/RDEN, is a measure of the number of employees not involved in retail sales who may generate retail business during working days, particularly during lunch hours; it provides some indication of the number of potential shoppers who might find a retail establishment located nearby. Additionally, it is a measure of the competitive supply of retail establishments in the area. As with the ratio of retail employees to population, this variable was allowed to have a different coefficient within and outside the CBD, denoted as QCBD and QNCBD respectively. Again, there were two alternative effects which might have been explained by the regression: (1) the variables might have positive coefficients, signifying that the higher the number of potential shoppers, the higher the transaction price of the retail property; and (2) the variables might have negative coefficients, signifying that there were agglomeration benefits of locating among a large number of non-retail establishments.

Within the CBD, the coefficient of the ratio (EDEN—RDEN)/PDEN was consistently positive and ranged in value from 0.21 to 1.00. The non-CBD variables, like the non-CBD ratio RDEN/PDEN, had coefficients which were all considerably lower in absolute value, and in many cases negative. Again, employment density and distance to Metro Centre had insignificant coefficients. While the negative signs were suggestive of significant agglomeration effects, the high standard errors cast doubt on their reliability.

A third variable, the difference between lot area and floor area (denoted as

PKLOT), was used as a proxy for availability of parking space. In many observations lot area was found to be less than floor area, indicating that the retail store had more than one storey. In such cases, PKLOT was assigned a value of zero and the effect of a multi-storeyed structure on the dependent variable was picked up by a dummy variable. HIGHRISE, defined as 1 when PKLOT was zero. Since lot area is simply a linear combination of floor area and parking area, it was dropped from subsequent models.

The final model estimated using these new variables is as follows:

$$\begin{aligned}
\ln(\text{DPRICE}) = {} & \underset{(-0.38)}{-0.544} - \underset{(-2.01)}{0.678}\ln(\text{DIST}) - \underset{(-1.87)}{0.200}\ln(\text{YR}+1) \\
& + \underset{(4.52)}{0.675}\ln(\text{INCOME}) + \underset{(4.19)}{0.153}\ln(1+\text{PKLOT}) \\
& + \underset{(8.35)}{0.562}\ln(\text{FLAREA}) - \underset{(-1.57)}{0.328}\,\text{PRE} + \underset{(5.33)}{0.399}\ln(\text{R/PCBD}+1) \\
& + \underset{(2.78)}{0.107}\ln(\text{R/PNCBD}+1) + \underset{(4.75)}{0.342}\ln(\text{QCBD}+1) \\
& + \underset{(1.78)}{0.092}\ln(\text{QNCBD}+1) + \underset{(2.07)}{0.533}\,\text{HIGHRISE}
\end{aligned} \tag{6.8}$$

$$R^2 = 0.559$$

Equation 6.8 was used in a Box and Cox analysis of the transformation of DPRICE. The estimated value of λ was 0.1, which was significantly different from zero at the 95% but not at the 99% confidence level. The simpler, logarithmic form implied by $\lambda = 0$ was therefore adopted.

7. SUMMARY AND EVALUATION OF RESULTS

For the multi-family building and retail establishment models, it was possible to select one functional form as a final model. These results correspond to equations 6.4 and 6.8 of the preceding sections in this paper. For single-family dwellings, no one model was clearly superior; so three functional forms, equations 6.1, 6.2, and 6.3, were used in later analyses.

The results of the models indicate that:

(1) In all cases, the distance of a parcel to the nearest Metro station was a statistically significant determinant of the transaction price of an urban parcel. In all the final models, increasing distance to the station was associated with lower property values; moreover, the effect of distance seems to decline quite rapidly.

(2) Table 5 summarises the estimated elasticity of deflated transaction price with respect to distance to the nearest Metro station. As this table indicates, the effect of the Metro system has been far more pronounced in the retail property sector than in either of the residential property markets. Indeed, the elasticity in the retail sector is (at least intuitively) very high, and perhaps should be taken as an upper bound.

(3) The effect of the opening date of a particular Metro station on property values is substantial. Table 6 summarises the elasticities implied by the model results. The

TABLE 5

Elasticities of Price with Respect to Distance to Station

	Single-Family			*Multi-Family*	*Retail*
Equation No.	6.1	6.2	6.3	6.4	6.8
Elasticity of price with respect to distance	−0.13[a]	−0.11[a]	−0.06[a]	−0.19	−0.68
Standard error of elasticity estimate	0.042	0.044	[b]	0.0049	0.337

[a] Elasticity evaluated at average of dependent and independent variables.
[b] The standard errors of the estimated elasticity in the Box and Cox models are not available, because they depend on the variance-covariance matrix of all the coefficient estimates. They can be approximated in a separate computational step; this was not performed for reasons of time and budget.

TABLE 6

Elasticities of Price With Respect to Years to Completion

	Single-Family			*Multi-Family*	*Retail*
Equation No.	6.1	6.2	6.3	6.4	6.8
Elasticity of price with respect to number of years to completion	−0.11[a]	−0.11[a]	−0.05[a]	−0.09[a]	−0.15[a]
Standard error of elasticity estimate	0.050	0.038	[b]	0.040	0.080

[a] See footnotes to Table 5.

effect of the number of years to completion appears to be much more uniform over the markets than in the case of transit access. However, the effect is still greatest in the retail property market.

(4) The effects of the other Metro-related variables, such as whether the nearest transit station is above ground, whether it is a parking facility, and a dummy variable indicating extreme proximity to a station, are not certain. None of these variables was included in the final models; careful analysis indicated that in many cases the data were insufficient to obtain reliable estimates of these coefficients.

(5) Many of the other factors which were hypothesised to affect property values (both parcel-related and demographic variables) appear to have a strong influence on both the residential sectors. Included in the demographic set are income, employment densities and the quality of the housing stock; included in the parcel-related variables are the distance to Metro Centre and lot area. The racial composition of the neighbourhood and a CBD dummy variable were only significant in the multi-family model, and a zoning compatibility indicator appeared to influence the single-family market.

(6) The availability of parking positively influences retail property values, though, as one might expect, the marginal effect of an added unit of floor space exceeds the

effect of an equal amount of parking space. The elasticities for parking area and floor area are 0.153 and 0.562 respectively.

(7) There appear to be strong agglomerative effects on retail property values in the CBD, as indicated by a large positive coefficient on the number of retail employees per person; these effects are much less in non-CBD areas. The estimated elasticities are 0.399 and 0.107 for inside and outside the CBD respectively.

(8) The density of non-retail employees per retail employee increases values of retail properties significantly, but more so within the CBD then outside it. The elasticities of values of retail properties with respect to the number of non-retail per retail employee are 0.342 within the CBD and 0.092 outside.

8. CONCLUSIONS

As stated in Section 1, the concept of public "taxing away" or otherwise sharing some of the benefits of investment in urban transit is based on a number of fundamental assumptions. The most significant of these is that such benefits are capitalised in the real estate market. This study has provided some tentative empirical support for the thesis that real estate property shifts do indeed occur in areas near transit stations. However, it leaves entirely open other questions about the economic efficiency and equity associated with alternative "value capture" policies. For example, if value is "captured" from owners near to a facility, should value also be returned to owners distant from the same facility who perhaps suffer relative losses?

It is clear that the decision on whether or not a value capture programme will be implemented in conjunction with mass transit investments is largely political. Issues of equity among various groups (particularly land owners and the public at large), as well as the need for increased revenue to offset the escalating costs of transit construction and operation, are likely to be dominant. Nevertheless, research of the type described in this article can help to pinpoint either areas of maximal potential or the combination of transit-related, parcel-specific and demographic features which lead to the greatest increase in values.

For example, as indicated at the end of Section 7, values of retail properties appear to be much more sensitive to proximity to transit stations. The relatively high elasticity of retail property value with respect to the distance to the nearest Metro station suggests that retail areas are better suited for any form of value capture policy (ranging from direct taxation to joint private/public sector development of retail floor space).

Although the study has broken new ground in several respects, there have also been a number of issues raised, both explicitly and implicitly, which were left unresolved. Some of the most critical of these are as follows:

(1) It is still necessary to examine transaction prices in Washington, D.C., for the period after Metro was opened. There is no certainty that the kind of anticipatory reaction found before the opening will have continued. Even around stations which will not open for a number of years (if at all), the anticipatory reaction may be different, simply because Metro is a reality for other neighbourhoods. Future research might monitor the development of the value of properties. This evidence would

provide the only clear picture of how urban property values near transit stations evolve through the planning, constructing, and operating phases.

(2) To the extent that the real estate market in Washington, D.C., is unique, it would also be useful to conduct research parallel to our effort in other cities which expect extensive investments in mass transit. Properties in cities with real estate markets which are less active than Washington's would probably show far slower rates of change, and might have smaller transit-related effects.

(3) In conjunction with (2), it is important to consider the variations in impact on real estate markets of different types of transit systems. That is, does the presence of a light rail system or a system of exclusive bus lanes have substantially different impact on the values of urban properties from that of a heavy rail system as in Washington, D.C.? The answer to such questions would prove invaluable in the evaluation of alternative transit system designs.

(4) It is apparent that virtually any large capital investment can have an impact on the real estate market. Consequently, the impact of transit in conjunction with other large investments should be examined. Housing developments, commercial and retail space, recreational areas, and parking facilities have all been developed on or near transit stops. This kind of "joint development" is surely a means to promote an increase in values. Unfortunately, it is not at all clear how much effect these facilities have and to what extent transit-related effects interact with these investments to induce value shifts.

(5) The study has been restricted to changes in property value; in reality, transport systems may also alter patterns of property and land use. The empirical evidence suggests, for example, that values will rise faster for retail than for residential property. This would imply strong economic incentives for some conversion of land use near transit stations, which may affect specific segments of the housing market. Some examination of whether or not this is indeed occurring is clearly warranted.

(6) In conjunction with (4) and (5), the effect of alternative land use controls (either individually or as a set) in different types of station areas needs to be detailed. In this vein, the authors of the Environmental Impact Statement conducted on the Metro system concluded that Metro "alone cannot be expected to successfully implement the region's wedges and corridors policy and local development objectives. In addition to land use regulations designed to promote more intensive, well planned development around Metro stations, there is a need for re-evaluation of zoning regulations and property tax policies in terms of their ability to limit or control development" (p. 275). As Knight and Trygg (1977) have pointed out, "Rapid transit can have substantial growth-focusing impacts, but only if other supporting factors are present."

(7) The effect of transit investment on vacant parcels was beyond the scope of the study. The basic methodology, however, is applicable to such parcels, and would provide significant insights into the effects of a transit system in relatively underdeveloped areas.

(8) Finally, as Metro expands, it will become more important to extend the focus of this empirical work to suburban portions of the metropolitan area.

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