MIXED LAND USES, LAND-USE EXTERNALITIES, AND RESIDENTIAL PROPERTY VALUES: A REEVALUATION

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Abstract

Empirical evidence concerning the impact of neighborhood land-use externalities on residential property value is mixed. That is, no concensus has emerged in the literature as to whether locating non-residential land-use activities in residential neighborhoods can be expected to increase, decrease or leave unaltered surrounding property values. The purpose of this research was two-fold: 1) to construct a theoretical model of consumer behavior in which both the positive and negative effects of neighborhood land-use externalities are taken into account, and 2) to test this generalized model empirically, using hedonic pricing equations. The principal implication of the theoretical model is that the effect of non-residential activity on residential property values is a priori indeterminate, the outcome depending on the relative strength of the associated positive and negative external effects generated. The empirical test of the model was conducted for the city of Tucson, Arizona, where it is shown that over low ranges, increasing the amount of industrial, commercial, multifamily and public land-use activity in a neighborhood tended to increase surrounding residential property values. It is concluded that in locating future economic activity an optimal mix of land-use activities should be sought, not the regional separation of activities.

I. Introduction

The best known methods for controlling the use of private real property in the United States are zoning regulations. Today zoning statutes are a nearly ubiquitous phenomenon in urban America. Proponents of land-use planning and zoning argue that there exist external effects between various types of land uses in the urban property market. Since externalities cause inefficiency, they maintain, the government frequently intervenes in this market to protect property owners against the possible depression of property values.

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Despite the widespread practice of zoning in the United States, it is somewhat surprising that there exist only a few empirical studies designed to test for the existence and magnitude of neighborhood land-use externalities, and that the results of these studies are contradictory.[1] The evidence on the issue is mixed.

Given the conflicting results of previous research, this research attempts to accomplish a dual objective: (a) to expand the earlier methodology by constructing a theoretical model in which both the positive and negative effects of neighborhood land-use externalities are taken into account, and (b) to report some econometric results of an investigation directed toward the identification and empirical estimation of the effects of neighborhood land-use externalities on the value of single-family homes using the generalized theoretical model.

The remainder of the paper is organized as follows. First a brief description of the study area, the city of Tucson, Arizona, is presented. Next the estimation model, a hedonic-pricing equation, is discusssed. The formulation of the estimation model is based on the results derived in the theoretical model of consumer bidding behavior presented in Appendix A. An evaluation of the estimation results is presented in section IV, with the paper concluding with a discussion of policy implications for urban development.

II. Area Studied

The sample area under study consists of observations on 52 census tracts in the City of Tucson, Arizona, in 1970. For the purpose of this paper, a "neighborhood" is defined as a census tract. This definition is adopted because "tracts were generally designed to be relatively uniform with respect to population characteristics, economic status, and living conditions."[2]

The concept of neighborhood has been variously defined in the economic literature. For example, Stull's definition of what might constitute a neighboring land use was different from that found in previous studies.[3] In effect, Stull used the proportion of a whole community's land devoted to various nonsingle-family residential uses as the land-use environment variable, i.e., he defined the neighborhood of a home to be the entire community. Rueter on the other hand, defined neighborhood as either a 150-foot radius or a 300-foot radius from the home.[4] In other words, in Rueter's model, there was only a very small local neighborhood.

Neighborhood, in this study, is defined neither as a 150-foot radius (only about two houses away) nor as an entire city (80 square miles in the case of Tucson). The concept of neighborhood is seldom easily defined. However, the general consensus is that it should be homogeneous or uniform in some respect. For this reason, a census tract is probably the best candidate for an appropriate

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[1]See, for example, (4) and (13) who found no externalities in the urban property market; (14) who found negative effects of land-use externalities; and (11) who found net positive effects of proximity to commercial and industrial land uses.

[2](16, Appendix A, p. 1).

[3](14, p. 541).

[4](13, p. 321).

definition of neighborhood. It is therefore chosen as the unit of observation in this paper.

III. Estimation Model

The estimation model to be discussed is based on the theoretical model of consumer bidding behavior in an urban property market presented in Appendix A. The model of consumer bidding behavior extends previous specifications by explicitly incorporating both external costs and benefits of land-use externalities into the decision-making considerations of residents. That is, both the accessibility advantages and nuisance disadvantages of locating near non-residential land-use activities are weighed in residential choice decision-making.

As does much of the empirical literature concerning land-use externalities and urban property values, this paper adopts the hedonic price equation technique as developed by Griliches in 1961.[5] With this technique, housing is viewed as a bundle of many different items so that the general relationship between property value and various characteristics associated with the housing bundle can be formulated as follows:

$$MV = b_0 + \Sigma b_{1i}S_i + \Sigma b_{2i}A_i + \Sigma b_{3i}E_i + \Sigma b_4\gamma + \Sigma b_{5i}M_i + \Sigma b_{6i}L_i + e \quad (3.1)$$

where
- MV = market value of the property,
- S_i = a structural characteristics variable,
- A_i = an accessibility variable,
- E_i = a local public service variable,
- γ = the property tax rate,
- M_i = a variable representing "social" externalities (e.g., ethnic minorities in neighborhood),
- L_i = a neighborhood land-use variable,
- b_0 = a constant term,
- b_{ji} = a regression coefficient,
- e = a stochastic term.

The estimation model given by (3.1) is the empirical specification of equation (26) derived in Appendix A, with the expected relationship between the explanatory variables and the market value of the property given by (29) through (33).[6]

The hedonic pricing technique regresses the property's market value on a vector of neighborhood and property characteristics. The regression coefficients are interpreted as the implicit market prices of the various characteristics.[7] The conclusions derived from this equation are based on the magnitude and signs of the regression coefficients: a negative sign indicates that external

[5](5, p. 175).

[6]A linear specification was chosen for (3.1) although, as indicated by (26) in Appendix A, nonlinear relationships between property value and its characteristics would normally exist. After testing alternative regression specifications of the explanatory variables, the linear model gave the strongest statistical results.

[7]Essentially, the hedonic price method assumes that the market value of a house is a function of the "characteristics" of the house. For a theoretical discussion see (10), for empirical applications see (8) and (14).

diseconomies are anticipated and a positive sign denotes external economies.[8] The coefficients of the explanatory variables may have expected signs, but to exert a predictable influence on the property values they must also be significantly different from zero at some significance level. The t-ratios shall be used to perform this statistical test.

It is noted that the estimated coefficients of the regression equation are usually interpreted as implicit prices of the urban property's characteristics at a given point in time.[9] The hedonic prices obtained in this manner are not necessarily long-run equilibrium prices but rather a set of short-run market prices attached to various housing characteristics. The particular hedonic prices which are the result of a single urban property value study cannot be considered as invariant across time and space. Griliches noted that there is no reason to expect that the relationship between the overall price of the housing bundle and the level or quantity of various characteristics will remain constant.[10] That is, the estimated coefficients of the regression equation (presented in Table 5.1) cannot be applied directly to other urban areas without sufficient consideration of differences in land use and housing stocks.

IV. Description of Estimation Variables[11]

Property Value Variable

The response or dependent variable to be explained is the property value of single-family residences in Tucson, Arizona (1970). The variable selected to represent property value is the median value of owner-occupied single-family homes. Single-family homes on very large lots (10 acres or more) are excluded since their median value is unavailable and also because this category (ranch house/estate) makes up less than 4 percent of total single-family acreage. This variable is regressed on various independent variables describing the characteristics of the single-family housing bundle in the census tracts to determine which of these characteristics are of significance to home buyers.

Explanatory Variables

The bundle of housing characteristics expected to affect property values can be exhaustively classified in this study into five categories: (1) physical

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[8] Where this study differs from previous research is in the formulation that each land use generates both positive and negative externalities, thus the sign of the land use's coefficients can be positive, negative, or zero. The interested reader can see Appendix A for a mathematical specification of the model; in particular, relationships (29) through (33).

[9] These implicit prices are estimated in the form of the regression coefficients, e.g. $\partial MV/\partial S_{it}$ = hedonic price of the i^{th} component of the set of structural characteristics S, at time t.

[10] (6, p. 4).

[11] The discussion of each variable is generally brief. A detailed description of the variables used and their sources is presented in Appendix B.

characteristics, (2) accessibility characteristics, (3) public sector characteristics, (4) neighborhood environment characteristics, and (5) land-use characteristics. A description of the variables used in these five categories follows.

Physical characteristics. It is generally agreed that market value is higher for larger homes, ceteris paribus. But data on the size of houses (e.g., square feet of living area) are not available. The median number of rooms is used to capture this size effect. Additional information about the structures includes whether or not there is a basement. The houses must also have a significant remaining economic life expectancy to exert an influence on their price. The variable used to account for this effect is the age of the dwelling unit. In addition, the value of the houses depends on the existence (or nonexistence) of certain basic facilities. Thus an attempt is made to control for these effects by including a variable denoted as lack of plumbing facilities.

Accessibility characteristics. The present analysis deals with the City of Tucson proper. Within the city, there is no intrinsic economic value in distance or closeness to the Central Business Distruct (CBD). The CBD is important mainly as a surrogate for such attributes as convenience to shopping centers, convenience to work areas, etc. In Tucson, the CBD does not offer these conveniences to the population on a more concentrated basis than do other areas within the city.

Several previous studies have assumed that a significant amount of economic activities occurred in the CBD. Therefore, the road distance from the geographical center of a neighborhood to the CBD constituted an appropriate measure of accessibility in each neighborhood to sources of employment. The closer a neighborhood is to the CBD the higher its real property value ought to be. This measure of accessibility is deficient in the case of Tucson where its CBD employs only 5.7 percent of the labor force.[12] Therefore it was necessary to devise a new accessibility measure in this study. This measure is denoted distance and is the weighted sum of distances from the neighborhood to places of employment. It is assumed that, ceteris paribus, an increase in distance results in a decrease of the property's market value.

It is argued in this paper that the monocentric assumption of previous models is not an accurate description of modern cities. The present study achieves greater realism by generalizing this assumption to recognize that the urban area has numerous centers of economic activity to which access has value.[13]

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[12]Seventy-five percent of the labor force work in the remainder of Tucson and 19.3 percent of them work outside the city; for details see (16).

[13]A. T. King also acknowledged the importance of a measure of accessibility such as "distance." But he admitted that, for empirical work, this measure is very tedious to calculate when many places of employment are distinguished. King used instead a simple version which recognizes only two employment centers in his study of the New Haven SMSA, assuming that these two centers are a reasonable approximation of the more complete measure of employment potential, see (8). The present paper, on the contrary, recognizes employment centers in all 52 census tracts. This recognition involves a more complex calculation, but it constitutes a more appropriate measure of accessibility.

A second employment accessibility variable, denoted proximity, is also used in this study. It has been employed by Stull to calculate for each unit of observation the ratio of: $\frac{\text{total employment}}{\text{total number of owner-occupied single-family homes}}$.

The purpose of this variable is to account for the influence of proximity to local employment. The sign of this coefficient is expected to be positive. For example, 100 jobs in a particular census tract where there are many single-family homes would have a different effect on the median value of the property than would the same 100 jobs with fewer homes.

Public sector characteristics. To the extent that home buyers "shop" among different neighborhoods offering varying packages of tax and local public services and select as a residence those neighborhoods which offer a program of tax-public services combination best suited to their preferences, property tax and local public output are expected to exert some influences on urban property values. This is very much in the spirit of what has come to be known as the Tiebout Hypothesis. Tiebout has argued that households would choose a residential neighborhood on the basis of its packages of public services and taxes; this implies that households will compete for desirable locations and will bid urban property values up, capitalizing locational advantages.[14]

To account for these public sector effects two explanatory variables are used in this study: property tax rates (or an index representing excess tax burden) and a local public school quality index represented by a proxy variable--scores on Reading Achievement Tests. It can be assumed that property owners (especially those having children) make residential choices at least partly on the basis of this education quality criterion. This paper departs from several previous studies by not using total school expenditures to measure school quality. The use of budgetary input figures requires an assumption about input efficiencies (the doubling of expenditures provides twice as much education quality, for example). The measurement of a public service output by using input data is avoided when the test scores are adopted as a proxy to account for local public school quality.

On the tax side, one can expect that tax burdens may influence the market value of the property. In Tucson, property tax rates are greater in some areas than in others. Variations in taxes can affect the marketability of dwellings. Properties that are otherwise comparable to those not subject to special and heavier assessments can be expected to bring a lower sale price. To account for the effect of this burden, a variable denoted as "Excess Tax Burden" is included in the regression equation.[15]

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[14](15).

[15]The possibility of bias from the simultaneous relationship between tax rates and house values was not considered serious for this sample because of the relatively low amount of variation in the tax variable. For this variable, the coefficient of variation measured:

$$\frac{\sigma(X)}{E(X)} = \frac{1.43}{15.71} = 9\%$$

Furthermore, the argument that house values and taxes should be regarded as simultaneously determined appears to be unimportant with respect to the present study. This follows from an institutional characteristic of an assessment practice in Tucson which tends to reduce the simultaneity between taxes and

Neighborhood Environment Characteristics. It is commonly suggested that environmental factors would be an important concern for property owners. However, no direct measure of this attribute is available. The selection of the independent variables to be used to control for neighborhood environment influences is largely dictated by the availability of data. It is hypothesized that there exists a relationship between the value of real property and various demographic, social, and economic features that characterize the environment in which the property is located. Variables selected in this category include such socio-economic characteristics of the environment as: ethnic composition, employment (or unemployment) status, proportion of poor families, percentages of housing units which are crowded, level of noise, and crime.[16]

Land-Use Characteristics. Estimation of real property values cannot adequately be made without data concerning government restrictions on urban land use. The Tucson zoning ordinance has created 24 zoning districts (or zones). In general, the city is divided into zones as follows: residential, commercial, and industrial land uses. Residential districts are divided into single-family and multiple-family districts. Comercial zones are divided into local business districts and general (and intensive) business districts. Similarly, industrial zones are divided into heavy and light industry districts. In addition there are two other categories of land use for which special districts are not always set up: public or institutional land and vacant land.

In each district, the ordinance limits the height, bulk, and uses of buildings and other structures, the use to which land may be put, and other matters. However, the city zoning ordinance has also made some provisions for the continuation of non-conforming uses, since to invalidate an existing non-residential use (e.g., a small commercial activity) in a residential area would be an unconstitutional deprivation of property.

The land-use and zoning data used by this study are obtained from the Department of Planning, City of Tucson. In their original form these data are broken down into 26 different land-use categories. They are aggregated appropriately in this paper to yield a set of 5 categories, corresponding to those listed in the Tucson Zoning Code. Since these categories constitute an exhaustive classification, all 5 types of land-use variables cannot be included in

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house values. Specifically, general reassessment of all houses in relation to market value occurred infrequently, thus holding the tax base constant regardless of changes in taxes which might be capitalized into market value. If houses were routinely reassessed after each sale, the simultaneity would be a more serious problem.

[16]It is found that there is a strong correlation between the (ethnic) minority variable and a number of independent variables representing various socio-economic characteristics of the neighborhood. The procedure adopted in this paper to resolve the problem of multicollinearity is to include one of these variables and to exclude the others. The "minority" variables has been chosen to be included in the equation. Since it is impossible to determine which of these variables is responsible for any estimated effects of neighborhood externalities in this case, the empirical estimates relating to "minority" must be interpreted as a proxy for an entire set of socio-economic characteristics of the neighborhood.

the regression equations.[17] The variable corresponding to the single-family category was dropped from the equations. The remaining four land-use variables are: multi-family land uses, commercial land uses, industrial land uses, and institutional (or public and semi-public) land uses.

In this study, two distinct sets of land-use data are used: the actual land-use variables (listed in the above paragraph) and the "zoning" variables.[18] Therefore, three zoning variables are also employed. They are proportions of land in the neighborhood zoned multi-family, commercial, and industrial. (Note again that the zoning ordinance does not set up special districts for public land uses.)

V. Estimation Results

The procedure was to regress the median value of single-family homes for 52 neighborhoods in Tucson on various combinations of the independent variables discussed in the previous section.[19] The estimation technique used was ordinary least squares. Table 5-1 presents the results of these estimations. This section will deal with two models separately. The first one concerns the analysis with samples based upon zoning data. The second model utilizes instead actual land-use data in its analysis of neighborhood external effects.

Zoning Model (Equations 1 and 2)

Equation 1 includes a conventional set of physical characteristics, accessibility characteristics, local public sector characteristics, and an

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[17]The land-use variables are proportions of neighborhood land contained in the various categories; if all 5 land-use variables were included in the regression equation, the X'X matrix would be singular.

[18]An actual land-use variable describes one of the following situations: residential single-family use, multiple-family use, commercial use, industrial use, public and semi-public use. A zoning variable describes the land-use situation as it has appeared on the city zoning map. This variable can be distinguished from a land-use variable by a simple example. Take the case of a R1 zoning district (which is a residential single-family zone) in Census Tract No. 4. Land uses found in this R1 district include not only the acreage devoted to single-family uses (24.31 acres) but also 2.44 acres of multiple-family uses, 19.00 acres of commercial uses, and 2.50 acres of public and semi-public uses. These nonsingle-family uses were allowed to exist by virtue of the non-conforming use provisions. This divergence between zoned land uses and actual land uses characterized much of the Tucson metropolitan area in 1970.

[19]The median value of owner-occupied dwelling units in single-unit structures used in this study is based on the homeowner's estimate of how much the property would sell for if it were for sale. This procedure would produce errors in the valuation of individual properties. However, there is evidence that these errors cancel out when the individual prices are aggregated into average values, see (9). These results also apply to the median values, presumably.

TABLE 5-1

ALTERNATIVE ESTIMATES OF A VALUATION EQUATION FOR SINGLE-FAMILY HOMES IN THE CITY OF TUCSON IN 1970: REGRESSION COEFFICIENTS (ABSOLUTE t-RATIOS IN PARENTHESES)

Equation Number[a]	1	2	3	4	5	6
Rooms	2588.3	2633.4	3296.2	3647.4	3639.2	3985.7
	(4.20)[b]	(4.04)[b]	(6.52)[b]	(6.16)[b]	(5.98)[b]	(6.41)[b]
Age	-2564.8	-2575.6	-1957.2	-2099.9	-2110.5	-3267.4
	(1.61)[c]	(1.57)[c]	(1.37)[c]	(1.52)[c]	(1.50)[c]	(2.07)[d]
Plumbing	-4504.5	-4501.9	-8259.1	-13794.0	-13855.0	-14693.0
	(0.31)	(0.30)	(0.63)	(0.98)	(0.97)	(1.11)
Basement	5967.9	4876.0	13184.0	12556.0	12321.0	10892.0
	(0.51)	(0.38)	(1.25)	(1.16)	(1.09)	(1.04)
Proximity	513.9	524.8	253.8	133.7	134.7	
	(3.03)[b]	(2.92)[b]	(1.53)[c]	(0.70)	(0.70)	
Schools	4402.7	4236.3	5548.4	5249.2	5186.3	4475.8
	(2.30)[d]	(2.03)[d]	(3.21)[b]	(3.10)[b]	(2.77)[b]	(2.66)[b]
Excestax	-5868.5	-5468.8	-7283.8	-6441.6	-6380.6	-5182.0
	(1.89)[d]	(1.48)[c]	(2.61)[b]	(2.33)[d]	(2.20)[d]	(1.88)[d]
Minority	-4187.6	-4280.6	-4376.6	-4079.5	-4140.5	-4412.1
	(2.83)[b]	(2.46)[b]	(3.42)[b]	(3.24)[b]	(2.82)[b]	(3.52)[b]
NSF1	-937.0					
	(0.67)					
MF		-660.7				
		(0.34)				
Commercial		-1174.6				
		(0.48)				
		-1382.0				
		(0.58)				
NSF2			6266.7			
			(3.41)[b]			
Mulfam				9436.4	9305.9	9516.9
				(2.63)[b]	(2.35)[d]	(2.70)[b]
Commerce				9901.5	10356.0	10322.0
				(2.56)[b]	(1.55)[c]	(3.17)[b]
Industry				4429.9	4386.2	4734.1
				(2.29)[d]	(2.17)[d]	(2.59)[b]
Public				9339.4	9322.3	9219.5
				(3.69)[b]	(3.63)[b]	(4.03)[b]
Commerces					-0.98	
					(0.08)	
Distance						-26.8
						(1.47)[c]
Constant	60.3	-73.7	-8580.5	-11148.6	-10972.8	-8552.4
Term	(0.01)	(0.01)	(1.61)[c]	(2.01)[d]	(1.83)[d]	(1.49)[c]

Table 5-1 continued

Equation Number	1	2	3	4	5	6
R^2	0.83	0.83	0.86	0.88	0.88	0.89
Degree of Freedom (for t-tests)	42	40	42	39	38	39

[a]The dependent variable is the median value of owner-occupied dwelling units in single unit structures.

[b]Significant at the 0.01 level (one-tailed test).

[c]Significant at the 0.10 level (one-tailed test).

[d]Significant at the 0.05 level (one-tailed test).

additional variable describing the proportion of neighborhood land zoned nonsingle-family home uses (denoted NSF1). Equation 2 includes all of the variables in Equation 1, with the exception that NSF1 is decomposed into its three distinct components. This is done by subdividing the proportion of land zoned nonsingle-family into three general zoning categories: proportion of land zoned multiple-family (denoted MF); proportion of land zoned commercial (denoted COMMERCIAL); and proportion of land zoned industrial (denoted INDUSTRIAL). Each is then treated as a separate variable for estimation purposes.

Note first that the R^2 for these estimations (0.83) is fairly high for a cross-section study.[20]

Turning to the estimates themselves, observe that the variables have coefficients whose signs are as predicted in Appendix A. In both equations, the variables ROOMS, AGE, PROXIMITY, SCHOOLS, EXCESTAX, and MINORITY have coefficients which are significant (using a one-tailed test).[21]

The statistical test in this estimation could not demonstrate a causal relationship between CRIME or NOISE and urban property values. In various trial regression equations, the coefficient of NOISE is found to be negative and that of CRIME positive. Both variables are, however, completely insignificant. They are thus dropped from final regression equations as shown in Table 5-1.

One striking and interesting result is that none of the zoning variables in Equations 1 and 2 has a significant coefficient. Acreage zoned for various uses differed considerably from acreage actually employed in those uses for Tucson in 1970 (see Table 5-2).

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[20]In (4), R^2 for 10 equations varies from 0.24 to 0.79 (6 equations have $R^2 < 0.51$); in (13), R^2 for 12 equations varies from 0.56 to 0.80.

[21]One-tailed test was used because it is assumed that most of the coefficient signs in Table 5-1 were known *a priori*. Had two-tailed test been applied, the interpretation of the results shown in Table 5-1 would have been unaffected.

TABLE 5.2

ZONING AND LAND USE IN THE CITY OF TUCSON, ARIZONA IN 1970 (NONSINGLE-FAMILY USES).*

	Land Zoned by Categories in Acres (1)	Actual Land Use in Acres(2)	(2) as a % of (1)
Multiple-family	11,264	3,436	29.6
Commercial	4,593	2,721	59.3
Industrial	4,261	2,095	49.2
Total	20,478	8,252	40.3

*Source: City of Tucson, Department of Community Development, Land Use, Zoning and Census Data by Census Tract Number, 1973.

The insignificance of the zoning variables in equations (1) and (2) lends support to the contention that neighborhood land-use effects not perceived by the residents are ignored in their property valuation process. That is, when zoned acreage differs significantly from actual acreage due to overzoning, zoning land-use variables do not accurately reflect the land-use perceptions of neighborhood residents.

In both Equations 1 and 2, the coefficients of various zoning variables have a negative sign. This negative relationship may very well reflect the usual zoning board's behavior: that is, a tendency to allocate nonsingle-family land-use activities to census tracts with low residential property values to avoid political pressure.

Land-Use Model (Equations 3 through 6)

Various land-use variables have been included in Equations 3 through 6 (in lieu of zoning variables). Other variables remain unchanged.

Again, note that the R^2 for these estimations are fairly high (0.86 to 0.89).

All the variables (except PLUMBING, BASEMENT, PROXIMIY) have coefficients which are significant. The signs of the coefficients are as predicted.

The variable MINORITY has coefficient with negative sign and significant t-ratios. Since this variable is found to be highly correlated with some other independent variables describing various socio-economic characteristics of the neighborhood, such as the "percent of housing units which are crowded" (correlation coefficient r = 0.83), or the "percent of families with income below poverty level" (correlation coefficient r = 0.75), only MINORITY is included in the final regression.

Again, the variables CRIME and NOISE have completely insignificant coefficients. These two variables do not appear in the final Equations 1 through 6. Since the variation among census tracts in crime and noise levels was considerable, the insignificance of these variables suggests that both the incidence of personal and property crime and the level of neighborhood noise are minor considerations in the determination of residential property values. That is, other physical, accessibility, public sector, neighborhood environment and land-use characteristics of a residential site comprise the principal determinants of residential property values in the study area.

In Equation 6, the coefficients of the "squared commercial term" and "proximity" are not statistically significant, although they have the expected sign.[22] Also in Equation 6, PROXIMITY is replaced by a new accessibility variable denoted DISTANCE. The squared commercial term is dropped from the regression because of its poor performance. As a result of this technical refinement, the R^2 for estimations of Equation 6 slightly improved. All the coefficients have the expected signs as in previous equations. Again, except for PLUMBING and BASEMENT, all variables have significant coefficients. Observe that the coefficient of DISTANCE has a negative sign as predicted. In terms of t-ratios, this variable performs better than PROXIMITY which is simply the ratio of local employment to the number of single-family homes in a neighborhood. PROXIMITY is a proxy to measure the local accessibility characteristics. DISTANCE, on the contrary, is a measure of general accessibility, since it takes into account both: (a) the separation in space between one neighborhood and all others; and (b) a weighing factor representing the total employment situation of the entire city.

The land-use variables are now considered. Note that all of them have coefficients whose signs are positive and whose t-ratios are relatively high.

These land-use variables, it is recalled, are the proportion of neighborhood land devoted to uses other than single-family homes. It is argued that the effects of nonresidential sites on residential property values are a priori indeterminate. Residential property values may even rise with proximity to a commercial or industrial site. (See Appendix A).

The present study of externalities from nonresidential land uses has taken account of both the advantages and disadvantages of proximity to them. As shown in the theoretical model, an a priori specification of the sign of the nonresidential variables' coefficients is impracticable. Only empirical tests can determine the direction and magnitude of each of these nonresidential land-use effects. It turns out that these neighborhood external effects are positive. This does not imply that there are no external diseconomies from the nonresidential site (e.g., noise, traffic, etc.), only that they are more than offset by the advantages of proximity. What Equation 4, for example, says is that converting 10 percent of a neighborhood's land from single-family homes to another land-use (say, commercial activity) would raise median home values in that neighborhood by around $990, ceteris paribus. The important implication of this equation is

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[22] A "Squared commercial" term has been introduced into Equation 5 because it was suspected that the relationship between commercial activity and residential property value might be nonlinear. This squared term is expected to have a negative sign because the increase in scale and intensity of commercial activity beyond some acceptable level is expected to depress property values.

that neighborhood effects are significant and that, over the ranges studied in this paper, there is a net beneficial impact of nonresidential land uses on home values. This evidence would lend some credence to arguments favoring mixed land use. The conventional belief, according to which homeowners prefer neighborhoods whose land is exclusively occupied by single-family homes, seems to have no firm empirical foundation in the context of land use in Tucson.

These results are directly contrary to the conclusions of Crecine et al., Rueter, and Stull (among others). Crecine et al. argued that there is a strong possibility that, in Pittsburgh, "the urban property market is not characterized by great interdependence and that externalities do not abound in that market."[23] Rueter repeated Crecine et al.'s study and found that the external effects expected by the municipal land-use control did not actually materialize. Therefore, he concluded that "there is much more independence in urban property markets than the zoning ordinance anticipates."[24] Stull, on the contrary, found that zoning does affect property values in the Boston metropolitan area. His conclusion is that "households were fairly sensitive to the land use environments....Homes in communities with large amounts of multiple-family, commercial, industrial or vacant land sold at a discount, other things equal."[25] In other words, Stull not only identified the existence of nonresidential land-use externalities but also found that these externalities unambiguously caused negative effects on single-family home values.

The results given in Table 5-1 of this paper did not corroborate the above findings. In fact, whether one considers Equation 3 which contains a single nonresidential land-use variable (denoted NSF2) or Equations 4 through 6 where this variable is decomposed into its various components (multiple-family, commercial, industrial, public), the external effects of nonsingle-family land uses—after both the advantages and disadvantages of proximity have been taken into account—are found to be positive. In the study area of Tucson, propinquity to nonresidential sites is valuable and residential property values even increase with proximity to them.

Further Discussion of Mixed Land Uses in Tucson

The findings discussed above should not be interpreted as evidence that any random mixing of land uses can be expected to increase surrounding residential property values. Mixed land uses in Tucson in 1970 were characterized by a distinct distributional pattern and limitations on the amount of nonresidential land-use activity permitted in residential areas.

First, it should be emphasized that the statement concerning the positive relationship between nonsingle-family land uses and residential property values existed over low ranges of nonresidential activity. For the categories of land use under discussion, observations were bunched between zero and 10, 12, 20, or 21 percent (see Table 5.3). Therefore, the conclusion that an increase of non-single-family land use tends to raise residential property values is particularly

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[23](4, pp. 93-94).

[24](13, p. 334).

[25](14, p. 551).

appropriate over "low" ranges of these land uses, and less applicable to high ranges. There is a need in future studies to analyze the relationship between land uses and property values at high ranges of various nonsingle-family land uses.

TABLE 5-3

RANGE OF VARIOUS LAND-USE PARAMETERS

Land-use category	Range in which at least 75% of the total observations occur	
Multi-family	0 < % MF	≤ 20%
Commerce	0 < % COMMERCE	≤ 12%
Industry	0 < % INDUSTRY	≤ 10%
Public	0 < % PUBLIC	≤ 21%

Note: MF means Multi-family

Any statistical inference drawn from the findings of this study should take into account these range limits. For example, the range of multi-family land uses, as shown in Table 5-3, is between zero and 20 percent. The results presented in Table 5-1, together with the range qualifications, can now be understood in the following way: property value tends to vary directly with multi-family land use when this land use is within the range of zero and 20 percent of the neighborhood's total area. Similarly, home value tends to increase with commercial, industrial, and public land uses, when their range is respectively between zero and 12 percent, 10 percent, and 21 percent. Beyond these specified ranges, the number of observations is so small that it is not appropriate to make any significant inference about the relationship between property value and various categories of land use.[26]

The second point to be emphasized is that the pattern of metropolitan development in the Tucson area may be accurately described as homogeneous; that is, with a few exceptions, low density residential land uses and commercial uses are spread fairly evenly across the urbanized area. Since 1960, development has followed a neighborhood unit concept whereby new subdivisions at the edges of the urban area were arranged to form square-mile neighborhoods. These neighborhoods were characterized by a core of single-family residential activity

[26] In the study area, the actual proportion of nonsingle-family land uses varies as follows:

-multi-family:	1.7% to 47.4%
-commercial:	0.% to 69.5%
-industrial:	0% to 95.9%
-public:	0% to 57.7%.

surrounded by multifamily, commercial, and light industrial land uses. Moreover, while commercial activities varied from neighborhood shopping centers to heavy commercial activities (i.e., activities having characteristics between commercial and industrial uses), industrial land uses were restricted to light industrial activities only (e.g., light manufacturing and research and development). Within this context, the estimates presented in Table 5.1 provide evidence that the diseconomies generated by nonresidential land uses being proximate to single-family residential uses were more than offset by accessibility benefits.

Summary of Findings

It is worth noting that almost without exception the results of Table 5-1 are in conformance with those derived mathematically in Appendix A, especially those given by relationships (29) through (33).

The major findings are now recapitulated:

- General accessibility should be measured using "DISTANCE"; local accessibility measured by "PROXIMITY" is largely captured by land-use variables. "DISTANCE" is appropriate for comparing relatively small neighborhoods like census tracts; "PROXIMITY" is relevant for large areas like suburbs.
- The tax capitalization hypothesis is given additional support with new evidence in this study that tax levels had a significant negative impact on property values.
- School quality is an important determinant of home values. (Parents' income and education can be significant predictors of student outcomes. To the extent that this is true, income can be correlated with property value, via the effect of school quality.)
- The incidence of personal and property crime and the level of neighborhood traffic noise were found not to be significant determinants of residential property values.
- Zoning variables are inferior to actual land-use variables in the sense that the latter possesses statistically significant coefficient while the former does not: homeowners are more concerned with existing land-use mix than with probable future land-use configurations.
- Over the ranges studied in this research, increase of nonsingle-family land uses in a census tract tends to raise the value of homes.

VI. Implications for Public Policy

The results of any single empirical investigation should not be overgeneralized. The estimates presented here reflect relationships existing in Tucson, Arizona, in 1970. Thus, deriving policy implications for other cities in later years must be done cautiously. However, having stated this caveat, the empirical findings of this research do suggest that, over low ranges, mixing land uses in residential neighborhoods need not lead to a depression of residential property values.[27]

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[27] Readers interested in mixed land use and urban development can read, for example, (12), (17), (18), and (7, Chap. 11), among others.

Locating industrial or commercial economic activities near single-family residences generates both external costs and benefits. Efficient use of limited land resources requires that nonresidential activities be increased in a neighborhood up to the point where the associated marginal benefits equal marginal costs. Although it is entirely conceivable that costs could exceed benefits for any positive level of nonresidential activity sited in residential areas, the results of this investigation do not support this contention. That is, residential property values increased in areas studied as the amount of industrial, commercial and multi-family residential activity rose in a census tract. The efficiency implications of these findings is clear: in locating future economic activity in rapidly growing areas, an optimal mix of land-use activities should be sought, not the regional separation of activities.

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APPENDIX A

A MATHEMATICAL MODEL OF CONSUMER BIDDING BEHAVIOR IN AN URBAN PROPERTY MARKET

It is assumed that, in buying a single-family home, the household not only wants proximity to employment and shopping but also a wide variety of housing attributes, such as the structural characteristics of the unit, the local public services, the neighborhood quality, inter alia. These notions can be formalized by writing the household's utility function in the following way:

$$U = U(H, X) \tag{1}$$

where H = a vector of housing consumption characteristics,
X = a vector of non-housing commodities.

The H vector consists of several subvectors and can be written as follows:

$$H = (L, S, A, E) \tag{2}$$

where L is surrounding land use mix characteristics associated with housing bundle (nonsingle-family land uses),
S is structural or physical characteristics associated with housing bundle,
A is accessibility characteristics associated with housing bundle,
E is public sector characteristics associated with housing bundle.

Each land use included in the L subvector is assumed to have a dual function:

- desirable function, since it provides accessibility to employment, shopping convenience, etc...
- undesirable function, because of the amount of noise, pollution traffic, etc. which it generates.

In mathematical terms, the subvector L can be written as follows:

$$L = (L_{11}, L_{12}, L_{21}, L_{22}, \ldots, L_{N1}, L_{N2}) \tag{3}$$

where L_{i1} = desirable characteristic of land use i
L_{i2} = undesirable characteristic of land use i,
for $i = 1, \ldots, N$.

It is assumed that L_{i1} would raise the household's utility, while L_{i2} would lower it, or:

$$\partial U/\partial L_{i1} > 0 \quad (4)$$

$$\partial U/\partial L_{i2} < 0 \quad (5)$$

Those land uses which raise utility generate positive externalities while those which lower it generate negative externalities. Under these definitions, each land use generates both positive and negative externalities. That is, $L_{i1} = L_{i1}(L_i)$ and $L_{i2} = L_{i2}(L_i)$ and $L_{i1}/ L_i \; 0$ and $L_{i2}/ L_i \; 0$. The net effect of each land use depends on which externality has a relatively stronger influence.

By substitution of (2) into (1), the utility function becomes:

$$U = U(L, S, A, E, X) \quad (6)$$

It is convenient to enumerate the various sets of arguments in the utility function (6) as follows:

1. L (land uses)
2. S (Structural characteristics)
3. A (accessibility)
4. E (public services)
5. X (non-housing commodities)

The partial derivative of U with respect to a particular argument will be noted u_i^j. The j refers to a set of arguments and i to a specific element of that set. Thus, u_i^2 is the partial derivative of the utility function with respect to a small change in the argument corresponding to the second enumerated set, i.e., the structural characteristics of the housing unit.

It is assumed that the signs of the u_i^j are as follows:

$$u_i^1 \gtrless 0 \quad (7)$$

$$u_i^2 > 0 \quad (8)$$

$$u_i^3 > 0 \quad (9)$$

$$u_i^4 > 0 \quad (10)$$

$$u_i^5 > 0 \quad (11)$$

The sign of the total differential of U with respect to L_i, as noted earlier, is indeterminate a priori because the positive external effects may outweight the negative external effects, or vice versa. The signs of u_i^2, u_i^3, u_i^4, and u_i^5 are positive because it is assumed that all the relevant variables are defined so that increases in them increase the household's well-being.

The household's choice is subject to its budget constraint which can be written as follows:

$$Y = \Sigma P_i X_i + R + T + g(A, L, X) \quad (12)$$

where
Y = annual income,
P_i = price of non-housing commodity i,
X_i = quantity of non-housing commodity i,
R = annual housing payment,

T = annual property tax payment,
g = the transportation cost function,
A = accessibility to work, shopping, etc.

It should be pointed out that A is defined here as accessibility to employment, shopping, recreation, etc., outside of census tract which is the unit of observation in this study. Accessibility inside census tract is captured by L_{i1}. Thus, the household's annual income is exhausted by payments for non-housing commodities, for housing, for property tax, and for commuting costs (assuming that there are no savings and no other taxes than property tax).

Let V represent the market value of the housing unit and assume further that:

$$R = \alpha V$$
$$T = \gamma V$$

where α is a credit parameter and γ is the property tax rate. Substitution of the above into (12) yields:

$$Y = \Sigma P_i X_i + (\alpha + \gamma)V + g(A, L, X) \quad (13)$$

Obviously, the more accessible the site, the smaller is the commuting cost. The sign of $\partial g/\partial A$ is therefore negative:

$$\partial g/\partial A < 0 \quad (14)$$

Also, the more commodities a household consumes, the more trips it makes, the higher is the transportation cost, or:

$$\partial g/\partial X_i > \quad (15)$$

Since L_{i1} describes the amount of land in the neighborhood having "desirable" characteristics, it is reasonable to assume that:

$$\partial g/\partial L_{i1} < 0 \quad (16)$$

In words, this means that if the land in the neighborhood is more desirable and convenient (e.g., more varieties of commodities in a shopping center), the household would make fewer trips to the stores, hence the lower transportation cost. By a contrario reasoning it can be assumed that:

$$\partial g/\partial L_{i2} \geq 0 \quad (17)$$

Now, suppose that a single-family home is up for sale and the quetion is the following: what is the maximum value a consumer will bid for that particular house? Unless one specifies in advance a given level of utility of the household, the answer is indeterminate.[1] An arbitrary utilitylevel $U = \overline{U}$ is selected in this analysis. Equation (13) can be rearranged as follows:

$$V = \{1/(\alpha+\gamma)\} \; \{Y - \Sigma P_i X_i - g(\cdot)\} \quad (18)$$

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[1](1, p. 59). The present analysis draws heavily from (1), Chapter 4.

To determine the maximum bid for a piece of property is to maximize (18) subject to the constraint:

$$\bar{U} = U\,(L, S, A, E, X) \tag{19}$$

The above problem can be expressed in a Lagrangian form:

$$\mathcal{L} = \{1/(\alpha+\gamma)\}\{Y - \Sigma P_i X_i - g(\cdot)\} - \lambda\{\bar{U} - U(\cdot)\} \tag{20}$$

where λ is a Lagrangian multiplier. The piece of property in question being fixed, the following variables are parametric to the bidder's decision: γ, A, L, S and E. When the property is varied, they vary. The remaining parameters are not associated with the property: Y, α, P, $\bar{U}$. The decision variables under the control of the bidder are the X_i's. Differentiating (20) with respect to X_i and λ and setting these partial derivatives equal to zero yield the following first-order conditions:

$$\partial\mathcal{L}/\partial X_i = \{1/(\alpha+\gamma)\}\{-P_i - (\partial g/\partial X_i)\} + \lambda u_i^5 = 0 \tag{21}$$

$$\partial\mathcal{L}/\partial\lambda = \bar{U} - U(\cdot) = 0 \tag{22}$$

Equation (21) can be rewritten to obtain the value for λ:

$$\lambda = \{P_i + (\partial g/\partial g/\partial K_i)\}/\{(\alpha+\gamma)\, u_i^5\} \tag{23}$$

The numerator is positive by (15) and because P_i is positive. The denominator is also positive by (11) and because $(\alpha + \gamma)$ is positive. Therefore, λ is positive.

$$\lambda > 0 \tag{24}$$

Repeating the calculation for X_j and dividing the results into (23) yields:

$$(P_i + (\partial g/\partial X_i)\}/\{P_j + (\partial g/\partial X_j)\} = u_i^5/u_j^5 \tag{25}$$

This is the usual utility maximization condition from consumer theory which requires that the marginal rate of substitution between any two commodities be equal to their price ratio. Note that the term on the left includes both price (P_i and P_j) and the transportation costs ($\partial g/\partial X_i$ and $\partial g/\partial X_j$) required to purchase the last unit of the good.

If the maximum bid is denoted by B, then for every consumer there will be a B associated with each property on which he bids. B would be obtained by substituting the equilibrium values of the X_i's into (18). Recall that the following parameters are associated with the property: γ, A, L, S and E. If one or more of these parameters changed, B would change. The relationship between B and these parameters can be written as follows:[2]

$$B = B\,(\gamma, A, L, S, E, \bar{U}) \tag{26}$$

The signs of the partial derivatives of B can be obtained by using the Envelope Theorem which, in this context, states that:

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[2]Those parameters not associated with the property are not included in (26).

$$\partial B/\partial \beta = \partial \mathcal{L}/\partial \beta \tag{27}$$

where $\mathcal{L}$ is the Lagrangian function defined in (20) and β is any variable parametric to the bidding process.

Application of (27) yields:

$$\partial B/\partial \bar{U} = \partial \mathcal{L}/\partial \bar{U} = -\lambda < 0 \tag{28}$$

The above result indicates that an increase in the given level of utility of the consumer causes B to fall, other parameters held constant.

Other interesting results are also obtained by applying (27):

$$\partial B/\partial A_i = \partial \mathcal{L}/\partial A_i = \frac{1}{\alpha + \gamma}\left(-\frac{\partial g}{\partial A_i}\right) + \lambda u_i^3 > 0 \tag{29}$$

using (9), (14), and (24).

$$\frac{\partial B}{\partial S_i} = \frac{\partial \mathcal{L}}{\partial S_i} = \lambda u_i^2 > 0 \tag{30}$$

using (8) and (24).

$$\frac{\partial B}{\partial \gamma} = \frac{\partial \mathcal{L}}{\partial \gamma} = -\left(\frac{1}{\alpha + \gamma}\right)^2 \{Y - \Sigma P_i X_i - g(\cdot)\} < 0 \tag{31}$$

using (13).

$$\frac{\partial B}{\partial E_i} = \frac{\partial \mathcal{L}}{\partial E_i} = \lambda u_i^4 > 0 \tag{32}$$

using (10) and (24).

$$\frac{\partial B}{\partial L_i} = \frac{\partial \mathcal{L}}{\partial L_i} = \left(\frac{1}{\alpha + \gamma}\right)\left(-\frac{\partial g}{\partial L_{i1}} - \frac{\partial g}{\partial L_{i2}}\right) + \lambda\left(\frac{\partial U}{\partial L_{i1}} + \frac{\partial U}{\partial L_{i2}}\right) \gtreqless 0 \tag{33}$$

using (4), (5), (16), (17) and (24).

In words, (29) shows that the more accessible the site to employment, shopping and recreation, the higher will be the bid. The positive sign of (30) means that the maximum bid a household will make on a particular piece of property varies directly with the structural qualities of the property itself. The property tax rate varies inversely with the maximum bid, since (31) is negative. The quality of local public services has a positive relationship with the household's maximum bid, because (32) is positive. Finally, (33) indicates that land uses *a priori* have an indeterminate effect on the maximum bid, because of the simultaneous and opposing forces of positive and negative externalities due to the "desirable" and "undesirable" characteristics of each land use in the neighborhood.[3]

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[3]The theoretical model discussed in this Appendix can easily be extended to include additional explanatory variables. For example, if one also wants to study the effects of racial composition on property values, one has to repeat the above analytical procedure by doing the following steps:

—include in the utility function U an argument denoted M;

APPENDIX B

DEPENDENT AND INDEPENDENT VARIABLES

Description, Notation and Sources of Data

MEDIAN VALUE OF OWNER-OCCUPIED SINGLE-FAMILY HOMES (Notation: VALUE)—This is taken directly from the U.S. Bureau of Census, 1970 U.S. Census of Population and Housing, Census Tracts, Tucson, Arizona, SMSA (hereinafter cited as 1970 Housing Census), Table H-1.

MEDIAN NUMBER OF ROOMS (Notation: ROOMS)—The basic source is the 1970 Housing Census (Table H-1). The Census provides a series for the median number of rooms in all year-round housing units.

PROPORTION OF OLD HOUSING UNITS (Notation: AGE)—The 1970 Housing Census (Table H-2) provides the distribution of all year-round housing units among six age-of-construction categories for each census tract (1939 or earlier, 1940 to 1949, 1950 to 1959, 1960 to 1964, 1965 to 1968, and 1969 to 1970). In this study, housing units are divided, for convenience, into two groups: new and old. Dwelling units built in 1959 or earlier are considered "old." The number of old houses divided by the total number of housing units gives the proportion of old housing units in the neighborhood.

PROPORTION OWNER-OCCUPIED DWELLING UNITS LACKING SOME OR ALL PLUMBING FACILITIES (Notation: PLUMBING)—This is taken directly from the 1970 Housing Census (Table H-1).

PERCENTAGEL OF SINGLE-FAMILY HOMES WITH BASEMENT (Notation: BASEMENT)—The 1970 Housing Census (Table H-2) provides the number of single-family homes with basement. This number divided by the total number of single-family homes gives the percentage of single-family homes with basement.

--assume $u_i^M \gtreqless 0$, because the presence of this type of neighbors (i.e., ethnic minorities) and their characteristics may decrease, increase, or leave neutral one's level of utility;

—argument M also appears in the Lagrangian function, via the utility function;

—finally, M is included in the maximum bid function B and the partial derivative of B with respect to M_i is $\partial B/\partial M_i = \partial \mathcal{L}/\partial M_i = \lambda u_i^M \gtreqless 0$, which means that the effect of the presence of ethnic minorities in a neighborhood on property values is *a priori* indeterminate.

ROAD DISTANCE TO PLACE OF WORK (NOTATION: DISTANCE)—This series is obtained by measuring the road distance from the geographical center of each and every census tract to the center of all other tracts of Tucson, using the Map of Tucson and Vicinity Census Tracts, 1970 Housing Census. This measure, denoted d_{ij} (where i = origin and j = destination), is then weighted by the ratio $\frac{e_j}{E}$, where E is total employment in the city and e_j is local employment for tract j. It is

$$A_i = \sum_{j=1}^{52} d_{ij} \left(\frac{e_j}{E} \right), \; i = 1, \ldots, 52.$$

Employment figures are taken from <u>Employment Survey by Traffic Analysis Zone</u>, Tucson Area Transportation Planning Agency, 1973, hereinafter cited as TATPA Survey.

PROXIMITY TO LOCAL EMPLOYMENT (notation: PROXIMITY)—This is the ratio of local employment to the number of single-family homes. The denominator of this ratio is taken from the 1970 Housing Census. The numerator, total local employment, is given by TATPA Survey.

PROPERTY TAX RATE (Notation: TAXRATE)*—Property tax rates are obtained from the Pima County, Arizona, 1969-1970 Annual Report and 1970-1971 Adopted Budget, Schedule 38, page 53. Additional information (e.g., improvement district tax rate) are provided by Pima County Assessor's Office and Property Management Department.

EXCESS TAX BURDEN (Notation: EXCESTAX)—Same source of data as above. Using the formula $\left(EXCESTAX = 1 + \frac{T_i - T_1}{T_1}\right)$, the excess tax burden is computed for each census tract. This is an index ranging from 1.000 to 1.502. T_i is the tax rate in tract i and T_1 is the lowest tax rate.

READING ACHIEVEMENT TEST (Notation: SCHOOLS)—Scores on reading achievement tests are used as a proxy variable in the absence of a direct measure of the local school quality. Note that the first reading scores in the State of Arizona and Tucson were given in January 1971. These test scores are obtained from the Office of the Pima County School Superintendent.

PERCENT OF NEGRO IN NEIGHBORHOOD'S POPULATION (Notation: BLACK)*—This is taken directly from the 1970 Housing Census (Table P-1).

PERCENT OF PERSONS OF SPANISH LANGUAGE OR SURNAME (Notation: HISPA)*—This is taken from the 1970 Housing Census (Table P-7).

PERCENT OF ETHNIC MINORITY IN NEIGHBORHOOD (Notation: MINORITY) —This is simply the arithmetic sum of BLACK and HISPA.

PERCENT OF OCCUPIED HOUSING UNITS WHICH ARE CROWDED (More than 1.01 Persons Per Room) (Notation: CROWDING)*—This is taken from the 1970 Housing Census (Table H-1).

PERCENT OF CIVILIAN LABOR FORCE UNEMPLOYED (Notation: UNEMPLOYED)*—This is taken from the 1970 Housing Census (Table P-3).

PERCENT OF FAMILIES WITH INCOME BELOW POVERTY LEVEL (Notation: POORS)*—This is taken directly from the 1970 Housing Census (Table P-4).

CRIME AGAINST PERSONS (Notation: CRIMEPERS)*—This is taken from the Monthly Crime Statistics, Department of Police, City of Tucson. Data are available for the period August-December 1972. It is expressed as a rate per 1,000 population.

CRIME AGAINST PROPERTY (Notation: CRIMEPROP)*—Same source of data as above. This type of crime is expressed as a rate per 100 residential single-family homes.

AUTOMOBILE TRAFFIC NOISE (Notation: AUTONOISE)*—Data for this variable are taken from V. B. Conley and M. R. Bottaccini, Daytime Noise Environment in Tucson, Arizona, EES Report No. 40, College of Engineering, University of Arizona, July 1973.

AIRCRAFT NOISE (Notation: AIRNOISE)*—Same source of data as above.

PROPORTION OF LAND IN THE NEIGHBORHOOD DEVOTED TO MULTIPLE-FAMILY USES (Notation: MULFAM if actual land use; and MF if zoning)—The source of all the land use variables used in this study is the City of Tucson, Department of Community Development, Land Use, Zoning, and Census Data by Census Tract, Spring 1973. This report, published in 1973, describes the 1971 land use situation. The assumption made in this study is that the city land use patterns changed very little between 1970 and 1971. The denominator of the proportion multiple-family variables (and of all the following land use variables) is the total land area of the census tract net of washes and medians. The numerator is the acreage of land devoted to multiple-family uses—defined to include land zoned R2, R3, R4, R5, MHP, PR.

PROPORTION OF LAND IN THE NEIGHBORHOOD DEVOTED TO COMMERCIAL USES (Notation: COMMERCE if actual land use; COMMCIAL if zoning)—Commercial uses as defined in this study, include the following land uses: B1, B2, B2A, B2H, B3, RV. Note that "commercial squared" term (denoted COMMERCESQ) is included in Equation 5.

PROPORTION OF LAND IN THE NEIGHBORHOOD DEVOTED TO INDUSTRIAL USES (Notation: INDUSTRY if actual land use; INDTRIAL if zoning)—This category includes land zoned P-I, I1, I2.

PROPORTION OF LAND IN THE NEIGHBORHOOD DEVOTED TO PUBLIC AND SEMI-PUBLIC USES (Notation: PUBLIC)—This category includes land devoted to religious, medical, cultural activities (churches, hospitals, museums); schools; universities, public buildings.

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*Dropped from the final regression equations.