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Chapter Author: Marcy Elkind Aurin

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Chapter Ten

Some Economic Effects of Residential Zoning in San Francisco

Marcy Elkind Avrin

INTRODUCTION

Zoning can be viewed as a political or legal constraint under which the urban property market must operate.

Two possible purposes exist for the adoption of a zoning ordinance by a city. The first is based on the acceptance of the notion that external diseconomies associated with land use exert important influences on urban property values. Zoning restrictions in this case are instituted in an effort to eliminate those external diseconomies which the construction of "undesirable" property features might impose upon other properties in any given zoning district. Zoning seeks to minimize total external effects by separating land uses. The restrictions increase the efficiency of the urban property market to the extent that they cause the price of a parcel of land to equal its true marginal product without causing the prices of "equal" parcels of land to differ. Thus, for a zoning ordinance to increase the efficiency of the local property market, it should remove any existing externalities without artificially constraining the supply of land in any given use.

The second purpose of zoning involves fiscal considerations. A municipality has the incentive to restrict the use of land for purposes that would impose the greatest burden on the fiscal budget. Zoning is a useful means of doing so. If it is successful, it serves to decrease the efficiency of the urban property market

Note: I thank Richard Muth and Michael Boskin of Stanford University for their helpful comments during the preparation of this study.

by causing the price of land in the overly restrictive uses to be higher than is efficient.

Effect on Property Value

The possible ways by which zoning may affect property value are shown in Figures 10-1 through 10-4. Figures 10-1 and 10-2 represent the case in which zoning causes a general increase in property value. This situation would occur if zoning increased the desirability of property by promoting neighborhood stability and limiting density. In Figure 10-1, no externality-related border effects exist. Before zoning, the unit price of a property in use X is P_x; and the unit price

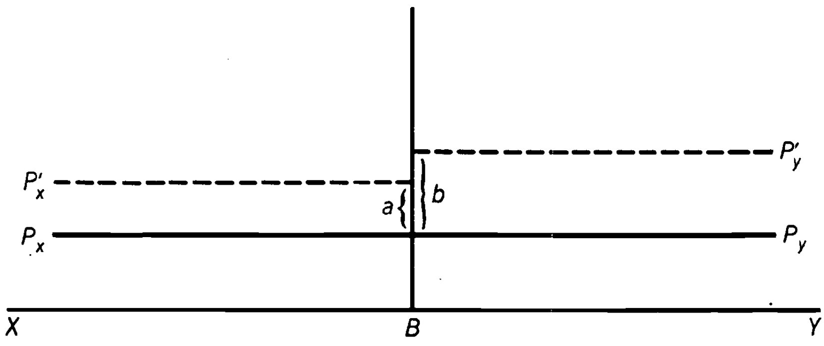

Figure 10-1.

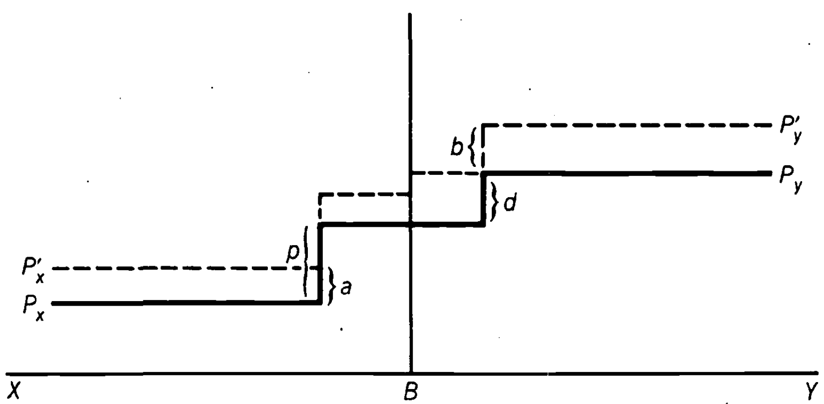

Figure 10-2.

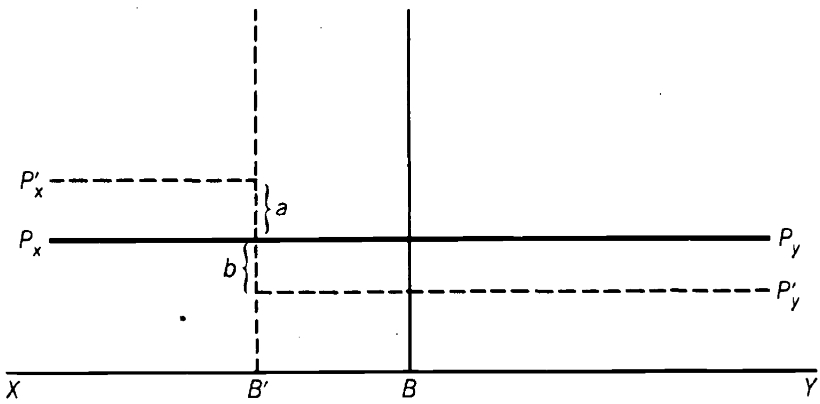

Figure 10-3.

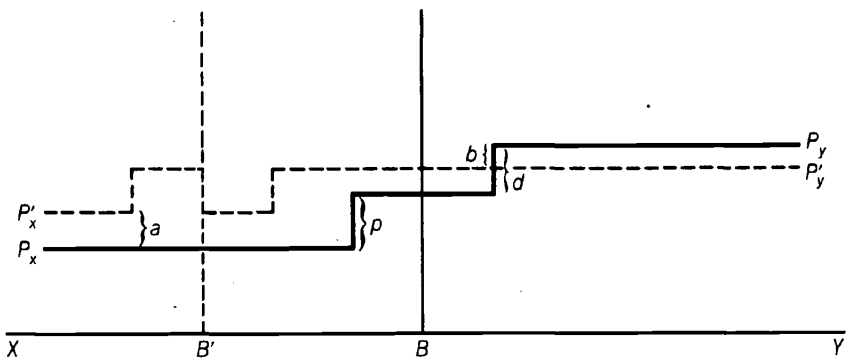

Figure 10-4.

of a property in use Y is P_y. After zoning, the combination of the stability and the limited density effect causes the price of X to increase by a to P'_x and the price of Y to increase by b to P'_y.

In Figure 10-2, border effects between X and Y types of properties exist and fragmented ownership of property is assumed. Before zoning, the price of interior X and Y properties are P_x and P_y, respectively. The price of a border X property is $P_x + p$ and that of a border Y property is $P_y - d$. Zoning increases the price of interior X and Y properties by a and b, respectively, to P'_x and P'_y, causing them to differ by an amount equal to $d + p + (b - a)$.

Figures 10-3 and 10-4 represent the case in which zoning affects value by allocating land among uses in a way that differs from the market allocation. Property designated for those uses but which is in restricted supply increases in price. The price of the other types of property declines.

In Figure 10-3, in which no border effect exists, moving the border from B to B' causes P_x to increase by a to P'_x and causes P_y to decrease by b to P'_y. The price differential between X and Y properties is, therefore, $a + b$.

Figure 10-4 shows that in a market with fragmented ownership in which border effects occur, the price effect of a zoning-caused reallocation of land is more complex. Depending on the relative magnitudes of a, b, p, and d, a general increase in the value of both X and Y properties could occur.

Complex Issue

Despite the possible detrimental effects on the urban property market, a zoning ordinance has been enacted in every major city in the United States except Houston. At first glance, it seems strange that the efficiency effects of such a widely used tool to control a market as important as that of urban property have received little scholarly inquiry.[1] There are several reasons for this situation. First, most of the scholars interested in the issue of zoning have focused their attention on the question of externalities: To what extent do nonconforming land uses create external economies or diseconomies in the market?[2] Those focusing on externalities have encountered great difficulty in developing an adequate research methodology with which to produce quantifiable answers. The market they are dealing with is so complex that it is difficult to design a study to isolate any external effects, which may be quite small in relation to the market as a whole.

Second, it is difficult to design a study of price effects in efficiency terms, using market price data and controlling for possible externalities, as long as the externalities issue itself is unresolved.

Finally, suitable data are unavailable. Property values are affected by so many variables that the potential data requirements of any conclusive study are enormous. These data requirements are difficult to meet because most of the available data on property values and characteristics are both inaccurate and confidential. Often, several sources must be consulted to obtain complete data on a given property.

In this study I attempt to determine whether zoning does in fact create inefficiencies in the urban residential property market. I attempt to determine whether zoning causes nonoptimal pricing by misallocating land among uses. In order to isolate this effect on price, I use both a time series and a cross-sectional approach. The time series analysis is based on repeat sales prices of given properties in each of four residential zoning categories in San Francisco. In the cross-sectional approach, zoning is included as a dummy variable in a regression which attempts to explain the variation in the sales price of individual properties. A major change in the residential zoning of San Francisco in 1960 allows both methods to be directly addressed to the zoning issue and makes it possible to avoid many of the complications encountered in previous studies.

The results are generally the same using either method, lending conviction to the conclusion that zoning in San Francisco creates inefficiencies in the urban residential property market by causing land to be allocated in a nonoptimal way among uses. I found no evidence that land use externalities exist.

DATA

The records of the San Francisco assessor's office on the sales of individual properties were used to obtain the price and year of "good" sales of a sample of properties between 1950 and 1973. A "good" sale is defined as one which reflects the true market value of the property.

Since time series were wanted, properties that were not sold at least twice during the period studied were excluded from the sample. Also excluded were properties that did not conform to the zoning ordinance or whose zoning had been changed since 1960. Finally, properties currently or previously located in redevelopment project areas, federally assisted code enforcement areas, or conservation areas were also excluded. Given the nature of these programs and their timing, they could cause price effects that would bias the results.

For the cross-sectional model, data on the various property characteristics included in the regression were obtained from the San Francisco assessor's office, the City Engineer, and the Census (1961). Appendix 10A contains a description of the sample in terms of these characteristics.

A property located on the same block or across the street from a less restrictive zone was defined to be in the neighborhood of that zone; information as to which properties were so located was obtained from detailed zoning block maps. The definition is based on the results of the few previous studies that have directly or indirectly dealt with the concept of neighborhood: Bailey (1966), Mieszkowski

(1972), Ridker and Henning (1967), Reuter (1974). The studies show that the concept as related to land use involves a relatively small area.

Zoning in San Francisco

The San Francisco data are particularly useful to a zoning study because of the unique situation which occurred in the history of residential zoning there. Until 1960 three types of zoning existed: commercial, industrial, and residential. Residential properties were divided into two districts. The First Residential district allowed only single-family, detached homes; the Second Residential district was unrestricted as to residential use. In 1960 a new zoning ordinance was adopted. The basis for its adoption was the belief that an increasing number of use-related external diseconomies were adversely affecting the value of certain properties in the Second Residential district. The purpose of the ordinance was to limit the spread of these externalities by restricting the density of any new development in individual areas. In doing so, it removed the threat supposedly felt by various property owners that new development would cause the quality of life in their neighborhoods to deteriorate. The new development owners feared involved the replacement of existing residences in their neighborhood with higher-density structures. This phenomenon was a common occurrence because by 1960 very little undeveloped land existed in the city.

From 1948 to 1958, the 1960 ordinance went through seven published drafts. In final form, it divided the Second Residential district into five new districts, their essential differences being in the restrictions on maximum density (San Francisco Department of City Planning 1972). The districts and their restrictions are as follows:

R1. one dwelling per lot or one dwelling per 3,000 square feet;
R2. one two-family dwelling per lot, or one dwelling per 3,000 square feet;
R3. one dwelling per 400 square feet;
R4. one dwelling per 200 square feet;
R5. one dwelling per 125 square feet.

Dissatisfaction with the R3 standard caused it to be changed in 1963 to 800 square feet per dwelling, because the 400-square-foot standard established in 1960 was not resulting in the type of neighborhood the planners had intended.

TIME SERIES ANALYSIS

The time series approach used allows any zoning-related change in the rate of increase of property value in each of the post-1960 zoning districts to be isolated. (The R5 district is not used because of the small number of properties zoned for that use.) Basically, it involves testing for any zoning-caused discontinuity in the trend of the price index, which is based on sales prices of properties in each group. These four separate yearly housing price indexes cover the years 1950-1973. Each index is based on observations of two sales prices of given properties whose zoning was changed from Second Residential to one of the post-1960 categories. If the zoning of a property does not change during the period between sales, the use of repeat sales data controls for the influence individual property characteristics have upon value. Thus, the price indexes are free from the effects of any externalities that were present at the time of both sales. In this regard, an externality is no different from any other property characteristic.

The indexes were constructed by using a regression method for combining price relatives. The method was chosen for several reasons. First, it was efficient because, in constructing the index number for a given year, information contained in future sales prices was used. Second, standard errors of the estimated index numbers could be computed, providing some basis on which to judge their reliability. Finally, the effects of certain property features on property values could be measured individually. In particular, the effect of zoning on properties located near less restrictive zones could be separated from the effect on those that were not.

The regression method is based on the following model developed by Bailey, Muth, Nourse (1963).

$$\text{Let: } R_{itt'} = (B_{t'}/B_t)\,U_{itt'} \text{ or} \qquad (10\text{-}1)$$

$$r_{itt'} = -b_t + b_{t'} + u_{itt'}$$

where $R_{itt'}$ is the ratio of the final sales price in period t' to the initial sales price in period t for the ith pair of transactions with initial and final sales in these two periods; B_t and $B_{t'}$ are the true but unknown indexes for period t and t' respectively, with $t = 0, 1, \ldots, T-1$, and $t' = 1, \ldots, T$; and the lower-case letters stand for the logarithms of the variables denoted by the corresponding capital letters. Assume that the residuals in log form, $u_{itt'}$, have zero means and identical variances, σ^2, and are uncorrelated with each other.

Estimation of the unknown B's is then treated as a regression problem. Let x_t take the value -1 if period t is the period of initial sale, $+1$ if t is the period of final sale, and 0 otherwise, for each pair of transactions. The index is normalized by letting $B_0 = 1$ or $b_0 = 0$. Using these conventions, Equation (10-1) becomes:

$$r_{itt'} = \sum_{j=1}^{T} b_j x_j + u_{itt'} \tag{10-2}$$

or, in matrix notation: $r = xb + u$. In each zoning category the price index for year j is thus the antilog of b_j.

This model is modified in order to determine whether the rate of increase of the price of a property is influenced by its location on the border of a less restrictive residential zone. A significantly different behavior of the price trend of border properties in response to the zoning would indicate that the phenomenon of residential "use" externalities may in fact exist. Zoning does not protect border properties from future land use externalities as it does interior properties.

In order to analyze the border effect, Equation (10-2) is modified as follows:

$$r_{itt'} = \sum_{j=1}^{T} b_j x_j + a \sum_{j=1}^{T} czx_j + u_{itt'} \tag{10-3}$$

where $z = 1$ for j greater than or equal to 10 (= year 1960) and zero otherwise, and $c = 1$ for a border property and zero otherwise. Then the equation becomes

$$r_{itt'} = \sum_{j=1}^{T} b_j x_j + ac \sum_{j=10}^{T} x_j + u_{itt'} \tag{10-4}$$

where the summation of x_j is the number of final sales made after the change less the number of initial sales.

The separate effect of the border characteristic on property values is measured by the antilog of a. Including this term in the price index model eliminates any border effect from the estimated index numbers. It essentially restricts the analysis of the indexes to "interior" properties.

The trend of the price indexes is shown in Figure 10-5.[3] The estimates of the price indexes and border-property coefficients are presented in Appendix 10A. The logarithm of each index number and the standard error of each logarithm provide evidence on the accuracy of the individual index numbers.

Positive coefficients of the border term indicate that zoning does not increase property value by stopping the spread of mixed land uses. If it did so, the border properties would be expected to have a lower price than the interior ones, given that the zoning does not legally prevent the former from being in the neighborhood of a more dense residential land use.

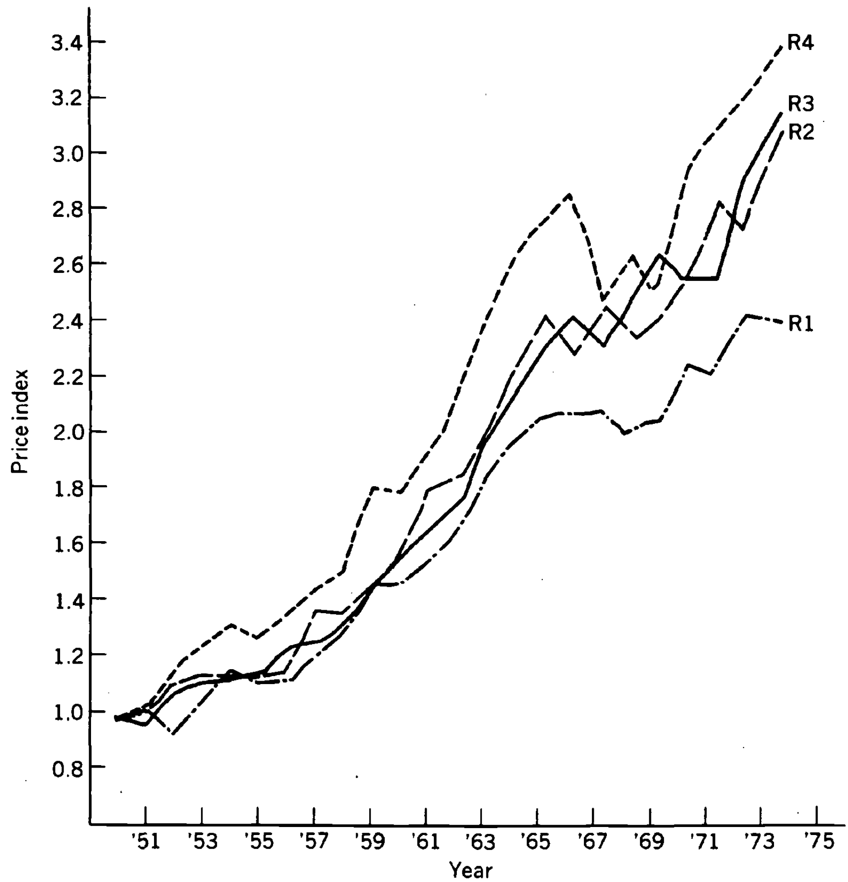

Figure 10-5. Price Trends.

Discontinuity Model

The following model is tested for each zoning category to determine when the assumed discontinuity or switch in the trend of the price index occurred:

Let

$Index_t$ = property value index in year t
CPI = purchasing power of the dollar (Census 1973)
T = time trend
Z = shift in trend due to zoning

A = effect of the 1966 property reassessment
u = normally distributed random error terms which have zero means, variances of σ^2, and are uncorrelated with each other.

Then

$$Index_t/CPI_t = a_0 + a_1 T + a_2 Z_t + a_3 Z_t T_t + a_4 A_t + u_t \qquad (10\text{-}5)$$

where

$t = -9, -8, \ldots, 0, 1, \ldots, 13$
$T_t = t$
$Z_t = 0$ for t less than S (defined below); 1 otherwise
$A_t = 0$ for t less than 6; 1 otherwise.

The regression was calculated eleven times for each zoning category, with $S = -5, -4, \ldots, 0, 1, \ldots, 5$. The discontinuity occurs in year S for which the regression has the smallest sum of squared residuals.[4]

The housing price index numbers in each zoning category are normalized by the purchasing power of the dollar in order to remove the influence of the general rate of inflation on the determination of the switching point. If this were not done, the fact that prices are generally increasing at an increasing rate would tend to cause the most likely switching point to be biased toward a later year. This normalization has a disadvantage, however, in that it constrains the increase in the value of a property to be directly proportional to the purchasing power of the dollar.

A study of the sum of squared residuals resulting from this model shows that, given the assumption that a switch in conditions occurred, the most likely year of its occurrence was 1963 for properties in the R1, R3, and R4 zoning districts and 1965 for those in R2 (Table 10-1). It is understandable that 1963 was the most likely year of the switch in all but one of the zoning districts. Until then, the ordinance, though approved, was expected to undergo a major change of unknown extent. Also, changes in market conditions are signaled to sellers by a lag, through their own sampling experience and the buildup of observable changed conditions in other sales. The fact that the switch does not occur in the year of the adoption of the ordinance may be due to this lag.

After determining the most likely year of the switch for each of the four zoning categories, I examined the validity of the original assumption—that a switch does in fact occur. A reliable determina-

Table 10-1. Sums of Squared Residuals for Test of Discontinuity in Price Indexes

	R1	*R2*	*R3*	*R4*
Equation (10-6): no switch	.31066	.3478	.3516	.6090
Equation (10-5): switch model				
1955	.30906	.3384	.3502	.6070
1956	.3058	.3359	.3469	.6078
1957	.2870	.3143	.3440	.5929
1958	.2569	.3151	.3271	.5568
1959	.2086	.2650	.2813	.4664
1960	.1946	.2167	.2426	.4577
1961	.1452	.1567	.1991	.3619
1962	.0961	.1493	.1406	.2451
1963	.0583	.1150	.0816	.1791
1964	.0605	.0927	.0893	.2177
1965	.0707	.0812	.1148	.2513

Note: Equations are defined in the accompanying text.

tion of whether a switch in fact occurs is difficult. In order to make a determination, the following model, which represents the situation that no switch in conditions occurs, was estimated:

$$Index_t/CPI_t = a_0 + a_1 T_t + a_2 A_t + u_t \tag{10-6}$$

for $t = -9, -8, \ldots, 0, 1, \ldots, 13$.

If no switch occurs, the mean value of a_1 and a_2 will be different from 0. Ideally, an F test would be used to test the following: H_0 = no switch occurs; H_1 = a switch does occur. Let S_0 denote the sum of squares of deviations from the regression line estimated for the year of most likely switch (10-5) and S_1, the sum of squares of deviations from the regression line based on one situation (10-6). Then

$$(S_1 - S_0)/S_0 \times 17/2 \sim F_{2,17} \tag{10-7}$$

This is not a conclusive test, because the dividing point between the two situations is not given exogenously but is presumably a maximum likelihood estimate based on actual observations.[5] Hence the variance ratio would tend to be larger than if the value of S were given exogenously. If the critical values of the F distribution with 2 and 17 degrees of freedom are used, the procedure will result in the rejection of the null hypothesis more frequently than would otherwise be the case because the determination of S from the data reduces the number of degrees of freedom for the denominator of the variance ratio and increases the number for the numerator.

Despite the problems with this test, it does provide strong evidence that a zoning-related switch occurred. This is seen in the pattern of the likelihood ratios calculated using the sum of squared residuals (SSR) of the models for various switching points. A study of the SSRs of the models with switching points before 1960 shows that a switch was unlikely in those years in all zoning categories. A switch was, however, likely to occur in 1963 and in all following years. The likelihood of a switch occurring after 1960 increases as the switching point becomes more recent until 1963 for R1, R3, and R4 districts and 1965 for the R2 district.

Given that a switch in conditions occurred, it would be difficult to determine whether the entire amount of the switch was due to zoning. If the switch was only partially due to zoning, the interpretation of the effects of zoning would be more accurately made in terms of the relative change in value among categories. The extent to which the differences in levels and in their rates of change vary among zoning categories is, in any case, the valid measure of the inefficiency caused by zoning.

Results

The degree of discontinuity in the change in the level of prices in the various zoning districts is seen in Table 10-2. The coefficients of Z and ZT represent the disruption in the trend of prices for each of the four zoning districts, R1, R2, R3, and R4. The results are presented for a discontinuity in 1963. The way in which this effect is interpreted depends on a key assumption, namely, that no other factors which influence the general price level of all housing occurred at the time of the zoning change. If this assumption can be made, then the entire price level effect can be attributed to zoning. The results, in view of this assumption, show that the effect, represented by the coefficient of Z, increases with the maximum density permitted by the zoning ordinance. Increases of 42 percent, 43 percent, 47 percent, and 58 percent are noted in the R1, R2, R3, and R4 zoning districts, respectively. In 1950 dollars these increases amount to \$4,410, \$5,940, \$9,550, and \$11,500. If this first assumption cannot be made, then the zoning effect may only be discussed in terms of the relative price effect of zoning among zoning districts. In relative terms, the price of R4 properties jumped 11 percent more than R3 property prices, which in turn jumped 4

Table 10-2. Price Effect of Zoning, 1963

	Zone R1			Zone R2			Zone R3			Zone R4		
Variable[a]	*Coef.*	*SE*	*T*	*Coef.*	*SE*	*T*	*Coef.*	*SE*	*T*	*Coef.*	*SE*	*T*
Constant	1.239	.023	52.0	1.338	.033	40.7	1.294	.028	46.7	1.52	.041	37.0
ZT	−0.065	.010	−6.67	−0.052	.014	−3.80	−0.055	.012	−4.76	−0.074	.017	−4.28
Z	0.424	.053	8.02	0.434	.074	5.84	0.470	.063	7.50	0.586	.093	6.31
T	0.039	.005	8.12	0.047	.007	7.02	0.0413	.006	7.35	0.061	.008	7.34
A	0.011	.061	0.182	−0.042	.086	−0.49	0.064	.072	0.885	−0.129	.107	−1.20
R^2	0.9451			0.9430			0.9606			0.9389		
DW	1.89			1.79			1.70			1.89		

[a] *ZT* = rate effect; *Z* = price level effect; and *A* = reassessment effect.

percent more than R2 prices, which jumped 1 percent more than R1 prices.

In interpreting these changes, it is useful to recall some of the previous discussion. If zoning were imposed upon a prezoning market equilibrium with no border effects (Figure 10-1), it must affect prices in all zones by equal amounts if no divergence from optimality is to result. With a prezoning equilibrium under fragmented ownership and border effects (Figure 10-4), however, the results are different. By correcting the private market's overallocation of land to use X by shifting from B to B', the boundary separating X and Y use, the prices of all properties previously in X use could rise. Because of the positive boundary differential in X use, the rise in prices along the old boundary, B, will tend to be smaller than in the prezoning X interior area. Under the latter set of initial conditions, prices in both X and Y use might also increase because of the stabilizing effect zoning has on neighborhoods in general.

Since no border price effects were found in estimating the four zoning category price indexes, it is difficult to attribute the post-zoning price rise for all zoning categories to correction of market overallocation of land to denser uses. Rather, the price rise would have to be attributed to the stabilizing effects of zoning. The greater percent price increases for the denser zoning categories, however, are inconsistent with an optimal allocation of land among the different post-zoning categories. As argued above, optimal zoning would imply that prices would increase by equal amounts after zoning if the latter's only effect were to provide greater stability.

Evidence of this stability effect supports the theory that participants in the urban property market do not have homogeneous tastes. Prices of property in all districts increase because buyers are secure in their knowledge of the future of the neighborhoods into which they are purchasing. Since zoning affects properties that border on more dense districts no differently than those which do not, buyers who do not mind being near denser uses purchase border properties and those who receive negative benefit from this type of location purchase interior ones. In both cases, buyers are willing to pay for the knowledge that their neighborhood will not change in a way contrary to their taste.

Not only is the pattern of price increases found inconsistent with optimal zoning, it is inconsistent with the hypothesis that zoning eliminates the threat of externalities. The magnitude of the price increase is positively related to density. A reverse order in the magnitude of the increase among zoning categories would be expected if zoning served to remove the threat of externalities from the property market. It could be argued that zoning would, for example, increase the value of R1 properties more than R3 ones because single-family dwellings are more threatened by dense uses than are apartments. Also, given this effect, zoning could potentially increase the value of R1 properties to a greater degree because a stable neighborhood may be more important to homeowners than to apartment dwellers.

Most important, though, is the kind of restriction imposed by the San Francisco zoning ordinance. Since the less restricted zones can be employed for any more restrictive use, the rezoning produced little change in the R4 areas, restricting only R5 developments. After the zoning, a developer who owned an R4 property could still choose among several types of structure, and select the one that commanded the most value. If, for example, he could make more money building a single-family home than an apartment, he was free to do so. The restrictions were greatest in the R1 areas, where any higher-density development was forbidden. The owner of an R1 property could not take advantage of the market in the same way as an R4 owner. Therefore, if prevention of adverse future externalities were the only factor at work, the price effect of zoning would have been highest in the R1 areas and lowest in those zoned R4, rather than the reverse, which is in fact observed.

Prices might increase with allowable density not only because owners of high-density property could take advantage of the market, but also because of actual demand conditions for housing in the city. Demand for high-density structures is increasing faster than the demand for other types of dwellings. Thus, given that zoning is imposed largely according to the 1960 land use pattern, it is likely to allocate too little land to the denser uses and too much to the others. The shift in demand is seen in the rise in the proportion of all dwelling units that were in apartment buildings—from 28 percent in 1950 to 76 percent in 1960 (San Francisco Department of City Planning 1967). The shift is also noted in Table 10-2, where the coefficient of the time trend T is much smaller for R1 properties than for those in R4, indicating an aggregate change in demand away from single-family homes.

Table 10-2 also shows that the effect of the zoning change on the real rate of change of prices was negative in all zoning districts. The decrease in the rate was 7.4 percent in the R4 district, 6.5 percent in R1, 5.5 percent in R3, and 5.2 percent in R2. In relative terms, the rate of change of prices of R4 properties switches 0.9 percent more than those of R1 properties, which in turn switch 0.3 percent more than those of properties zoned R2. Both the absolute rate effects and these differentials are quite small in comparison with the differential zoning-caused shift in the real price level among districts.[6]

The rate effects in general are somewhat puzzling in that they are negative in sign. A positive effect was expected for R2, R3, and R4 because zoning, by allocating properties to nonoptimal uses, could potentially cause the supply of a given type of dwelling to meet a given demand at a higher price than would be dictated in the unconstrained market. For example, zoning may designate uses in such a way that the properties most likely to be converted to a given use in the free market are not zoned for that use. In doing so, zoning forces more expensive conversions, making the supply curve of dwellings of these types more price-inelastic. This situation occurs, for example, when a property which is a prime candidate for conversion to an apartment house is zoned for a single-family home.[7] Zoning does not cause conversions to R1 type of properties to be more costly, since it does not in any way limit the number of properties which can be converted to single-family homes.

Only the following ex-post explanation can be given for the negative effect. Home buyers and developers may have overestimated the positive impact zoning would have on the city. This overestimation would cause the initial price effect of the zoning ordinance to be too high. The decrease in the rate of increase of property values after the zoning would, therefore, serve to correct for this effect.

CROSS-SECTIONAL ANALYSIS

The economic effects of zoning were also studied by including the zoning category as a dummy variable in a regression which attempts to explain the variation in the sales price of individual properties. The unique zoning situation in San Francisco makes it possible to determine what the price of residential land would be in an "unzoned" equilibrium and, therefore, to measure the zoning-caused distortion.

Before 1960 all Second Residential properties were essentially "unzoned residential" in that they were unrestricted as to residential use. Depending on demand, a high-rise building or a single-family dwelling could be built on any of the properties. The value of each property was, therefore, determined by the property characteristics and supply and demand conditions in the entire residential property market. In an equilibrium situation, the variation in property value among Second Residential properties was due to the various property and neighborhood characteristics and was unaffected by residential zoning. After 1960, the variation in property value among these same properties was also influenced by the new zoning ordinance. The value of Second Residential properties before 1960 can, therefore, be used as a base from which to measure the actual amount of distortion, if any, caused by zoning. Property values of the Second Residential properties before the zoning change can be considered to be the values of "unzoned" residential properties. Given a pre-1960 property market equilibrium and no border effects, any difference in value between pre-1960 and post-1960 sales not related to time and to the various other property and neighborhood characteristics can be considered to be a distortion due to zoning.

The regression is a reduced form of the supply and demand equation for housing. It is postulated that the value of a house is an additive function of its lot, neighborhood, and structural characteristics. Value is expressed in constant 1950 dollars because the observations are sales of structures over a twenty-year period. Since a cross-sectional analysis implies an equilibrium market at any point in time, a deflator must be used in order to adjust for shifts in aggregate levels of demand over the years. An example of such a condition is a change in the average level of income of the general population. Thus:

$$P_i = a_0 + a_1 S_i + a_2 L_i + a_3 N_i + u_i \tag{10-8}$$

where S_i, L_i, and N_i are vectors of characteristics of the ith structure, lot, and neighborhood, respectively, and a_1, a_2, and a_3 are vectors of unknown coefficients.

Dependent Variable

Given the purpose of the study, a dependent variable must be used which allows for an accurate estimate of the significance of the zoning dummies. Since the effect of zoning, along with most other property characteristics, is proportional to the total finished area of the improvement, and since previous studies have shown that the variance of the disturbance is related to the total finished area (Brown, n.d.), the dependent variable used is real sales price per square foot of total finished area. The use of this variable eliminates the problem of heteroscedasticity, which would bias the estimated variances of the estimated coefficients.

Real sales price per square foot of total finished area is also used to estimate the effect of various factors on property values in each zoning district separately. Comparing the correlations among districts is helpful in providing evidence as to the characteristics with which zoning interacts to create value. However, other than the externality interaction, the results of the main analyses in this study do not decompose this effect into its various components. By comparing the effects of the various characteristics among districts, questions such as the following can be answered: Is the relative price effect of zoning on a property with and without a view greater for an R4 zoning classification than for an R1 designation? This would be the case if a view is more important to the value of properties in the R4 district than in the R1 district, for example.

In order to produce results somewhat comparable to those of the time series analysis, the logarithm of the real sales price is also used as a dependent variable in an estimating equation.

Independent Variables

The combined sales prices of land and improvements were studied in order to determine whether zoning causes the value of equal parcels of land to differ among zoning categories. The price of the land is a function of the price of the improvement which is in turn a function of the supply and demand for that type of dwelling. In order to discover the extent to which zoning causes the prices of equal parcels of land to differ among zoning categories, the effect of the improvement on price must be removed. Therefore, six characteristics of the improvements are included in the regression: number of floors (*FLOOR*), number of rooms (*RMS*), number of units (*UNITS*), total finished area (*TFA*), basement (*BSMNT*), and age at time of sale (*SLAGE*). Furthermore, all characteristics of the lot and its surroundings whose effect on price could be falsely attributed to the zoning effect must be included in order to obtain unbiased results. The variables which must be accounted for meet two criteria: they influence property values and they occur to different extents in each of the various zoning categories.[8] Eight of these types of variables have been included. The descriptions in Appendix 10A show that they occur to different extents in each of the various zoning categories.

Assumptions were made as to the proper forms of the independent variables. The logarithmic form was used for distance to the CBD, total finished area, lot frontage, and lot depth. It is hypothesized that they affect price per square foot of total finished area in a way that increases with their magnitude, but at a decreasing rate. The results of using other forms of these variables show that their form does not affect the conclusions about the effect of zoning.

Because of the limited purpose of this study, independent variables representing various quality-quantity relationships were not included in the equations. Zoning is believed to interact with total finished area. The interaction term, however, drops out when price per square foot of total finished area is used as the dependent variable.

Results

The estimates of the hedonic indexes are presented in Table 10-3. Since the time series results indicate that 1963 was the year of greatest zoning impact, estimates are also presented using 1963 as the year of the zoning change. The differences between these results and those for 1960 are not significant.

The magnitude of the price effect of zoning is indicated by the deviation between the price per square foot of total finished area in each of the various zoning districts and the price per square foot of unzoned land. The results show these differences to be $2.40 for R1 properties, $3.20 for R2 properties, $3.60 for R3 properties, and $4.40 for R4 properties. These results are expressed in 1950 prices. Since the mean sales price is $11.90 per square foot, the figures indicate that the zoning effect is considerable.

This model, given that the error terms are homoscedastic, also provides evidence concerning the significance of the other independent variables in explaining the variation in property value. Of the variables tested, number of floors, basement, corner location, and view all added significantly to value. Lot frontage and lot depth added significantly to property value per square foot of total finished area in a way which increased with magnitude at a decreasing rate. Property age at time of sale, total finished area, and distance to the CBD all detracted from value per square foot of total finished area in a way which increased with magnitude at a decreasing rate. The effect of the percent nonwhite on the block is inversely proportional to magnitude. The coefficients of *COMX* and *RESX* are positive, indicating that the value of properties that border on commercial or denser residential districts is not adversely affected compared with interior properties in a given district.

The results of the semilogarithmic model show that the real prices of properties zoned R1 are 21 percent higher than those which are unzoned. The prices of properties zoned R2, R3, and R4 are 32 percent, 36 percent, and 44 percent higher, respectively. These estimates are significant at the 0.005 level.

Table 10-4 presents the results of the linear model estimated for each zoning district separately. They show that zoning interacts with certain property characteristics to create value. This means that the change in value which zoning causes is directly dependent on the characteristics of the properties in the various districts. Any charac-

Table 10-3. Cross-sectional Results

Independent Variables[a]	Dependent Variable: Price per Sq. Ft. of Total Finished Area (thous. dollars) 1960 Coef.	1960 SE	1963 Coef.	1963 SE	Log (price) 1960 Coef.	Log (price) 1960 SE
Z1	.0024	.0006	.0023	.0005	0.2101	.0474
Z2	.0032	.0006	.0033	.0006	0.3178	.0477
Z3	.0036	.0006	.0035	.0006	0.3641	.0465
Z4	.0044	.0006	.0042	.0006	0.4371	.0468
RESX	.0006	.0003	.0004	.0003*	0.0395	.0264*
COMX	.0000	.0000	.0002	.0004*	0.0032	.0303*
YR	.0001	.0000	.0001	.0000	0.0121	.0030
FLOOR	.0010	.0004	.0008	.0004	0.0647	.0306
BSMNT	.0009	.0003	.0007	.0003	0.0756	.0232
RMS	.0000*	.0000*	.0000	.0000*	0.0021	.0054*
UNITS	.0000*	.0000*	.0001	.0002*	0.0167	.0131*
CORN	.0011	.0005	.0012	.0005	0.1181	.0420
GRADE	.0000*	.0002	.0002	.8809*	−0.0080	.0188*
VIEW	.0012	.0004	.0013	.0004	0.0898	.0346
SLAGE	−.0000	.0000	−.0000	.0000	−0.0077	.0006
LFTA	−.0070	.0006	−.0068	.0006	0.4408	.0460
IRREG	−.0005*	.0008	−.0004	−.5118*	−0.0536	.0643*
LDIST	−.0023	.0006	−.0025	.0006	−0.0905	.0472
*NW*60	−.0000	.0000	−.0001	.0000	−0.0056	.0007
LFRONT	.0034	.0007	.0035	.0007	0.2462	.0580
LDEPTH	.0015	.0005	.0015	.0005	0.0813	.0416
Constant	.0515	.0045	.0505	.0045	−1.2118	.3662
R^2	.5489		.5472		0.7312	
No. of observations	727		727		727	

*Not significant at .05 level of confidence.

[a]Variables: *Z*1, *Z*2, *Z*3, *Z*4 = *R*1, *R*2, *R*3, *R*4 zoning districts, respectively. *RESX* = residential border; *COMX* = commercial border; *YR* = year of sale; *FLOOR* = number of floors; *BSMNT* = basement; *RMS* = number of rooms; *UNITS* = number of units; *CORN* = corner; *GRADE* = grade; *SLAGE* = log of age at time of sale; *LTFA* = log of total finished area; *IRREG* = irregular lot; *LDIST* = log of distance to the CBD; *NW*60 = percent of nonwhites on block in 1960; *LFRONT* = log of lot frontage; *LDEPTH* = log of lot depth. The terms *COMX* and *RESX* indicate whether a given property borders on a commercial district or on a higher density residential district. I included them in order to restrict the analysis to properties which are interior to a given zoning district.

Table 10-4. Cross-sectional Results by Zoning District

Independent Variables[a]	Dependent Variable: Price per Square Foot of Total Finished Area (thous. dollars)							
	R1		*R2*		*R3*		*R4*	
	Coef.	*SE*	*Coef.*	*SE*	*Coef.*	*SE*	*Coef.*	*SE*
RESX	–.0003	.0005	.0018	.0009	.0012	.0011	.0009	.0015
COMX	.0018	.0008	–.0003	.0013	–.0007	.0009	.0000	.0011
YR	–.0000	.0000	.0001	.0001	.0002	.0001	.0002	.0001
FLOOR	.0007	.0009	.0006	.0009	.0019	.0012	.0016	.0010
BSMNT	.0004	.0004	.0022	.0009	.0024	.0009	.0007	.0010
RMS	.0002	.0002	.0009	.0003	.0002	.0002	.0002	.0001
UNITS	–.0017	.0012	–.0008	.0009	.0006	.0004	–.0000	.0004
CORN	.0004	.0008	.0004	.0017	.0013	.0014	.0015	.0015
GRADE	.0003	.0003	.0000	.0006	.0004	.0008	.0002	.0009
VIEW	.0014	.0008	–.0002	.0012	–.0007	.0010	.0034	.0014
SLAGE	–.0000	.0000	–.0000	.0000	–.0001	.0000	–.0001	.0000
LFTA	–.0055	.0008	–.0128	.0020	–.0106	.0018	–.0110	.0016
IRREG	.0005	.0010	.0025	.0027	b	b	–.0022	.0020
LDIST	–.0007	.0010	–.0026	.0026	–.0015	.0014	–.0084	.0024
NW60	–.0000	.0000	–.0001	.0000	–.0000	.0000	–.0000	.0000
LFRONT	.0053	.0013	.0073	.0026	.0004	.0027	.0057	.0017
LDEPTH	.0019	.0011	.0053	.0014	.0009	.0016	.0040	.0013
Constant	.0312	.0075	.0597	.0213	.0910	.0156	.0819	.0114
R^2	.4764		.5363		.5944		.5689	
No. of observations	204		103		117		139	

[a]For identification of variables, see Table 10-3, footnote a.

[b]No such lots in sample.

teristic whose coefficients differ among districts interacts with zoning to create value. Several interesting results may be noted. First, *VIEW* adds \$3.50 per square foot to the value of an R4 property but does not significantly affect the value of properties in the other districts. Second, the age of a building detracts more from the value of R4 and R3 properties than from those zoned R2 and R1. Third, distance to the CBD appears to have an important influence on R4 properties only. Finally, lot frontage has a significant effect on all properties except those in the R3 district and is greatest for those zoned R2. Lot depth is also most important in R2 properties; a one-foot increase in depth causes the value of an R2 lot to increase approximately $2.30 more per square foot of finished area than an R4 lot.

CONCLUSION

In this study a strong case is made for the proposition that residential zoning in San Francisco affects values in the urban residential property market to different degrees which are determined by the zoning classification. The results of both the time series and cross-sectional studies indicate that, by providing stable neighborhoods and by limiting the growth of the city in general, zoning affects the demand for residential property, causing the value of all properties to increase. Its effect on the relative supply of properties among uses causes differential levels of increase in property values in the various zoning districts. The magnitude of the effect increases with allowed density; the value of R4 properties, on which high-rise buildings are permitted, is affected most. This finding is inconsistent with optimality in the property market.

The results of the cross-sectional estimation for each of the zoning districts separately shows that zoning interacts with certain property characteristics to create value. The evidence shows that the change in value which zoning causes is directly dependent on the characteristics of the properties in each district.

No evidence is provided that boundary externalities exist in the urban residential property market. The indication is that zoning does not cause the value of properties near zones of commercial or denser residential use either to decrease or to increase less than that of interior properties in a given district. Furthermore, the pattern of price increases found among zoning categories is inconsistent with the hypothesis that zoning eliminates the threat of externalities. These findings indicate that land use externalities do not exist, but the point is not conclusively proved.

APPENDIX 10A

Table 10A-1. Characteristics of Sample Properties

	R1	*R2*	*R3*	*R4*
Average 1950 sales price (000 dollars)	11.7	13.8	20.3	19.8
Average total finished area in square feet (*TFA*)	1261	1888	2812	4123
Average lot frontage in feet (*FRONT*)	26.8	27.0	27.4	30.1

Table 10A-1 (cont.)

Average lot depth in feet (*DEPTH*)	95.0	100.4	97.9	98.4
Average number of floors (*FLOOR*)	1.1	1.6	1.9	2.3
Average number of units (*UNITS*)	1.1	1.5	2.4	4.1
Average age (*AGE*)	39.4	57.9	62.5	66.5
Average percent nonwhite on the block in 1960 (*NW60*)	10.3	5.9	14.0	15.5
Number of properties with a view	14	23	28	26
Percent of properties with a view (*VIEW*)	5.4	18.1	19.3	13.0
Number of corner properties	47	29	38	54
Percent of properties with corner location (*CORN*)	8.3	5.9	7.9	11.8
Average peak-hour auto travel time to CBD in 1969 in minutes (*DIST*)	17.9	16.9	13.9	11.9
Percent of properties which border on commercial zone (*COMX*)	3.4	8.5	23.0	23.8
Percent of properties which border on zones of higher (denser) residential use (*RESX*)	28.5	40.1	17.3	10.0

Table 10A-2. Price Index of *R*1 and *R*2 Properties (figures in parentheses are standard errors of logs)

	R1 Properties			*R2 Properties*		
Year	*Index*	*Ln Index*	*N*[a]	*Index*	*Ln Index*	*N*[a]
1950	1.000	0.000	42	1.000	0.000	30
1951	1.030	0.0296 (−0.0425)	32	1.028	0.0279 (0.0651)	28
1952	0.9574	−0.0434 (0.0448)	29	1.122	0.1153 (0.0612)	32
1953	1.073	0.0706 (0.0378)	51	1.150	0.1400 (0.0598)	33
1954	1.174	0.1606 (0.0372)	52	1.161	0.1497 (0.0626)	27
1955	1.136	0.1281 (0.0355)	61	1.153	0.1430 (0.0565)	41
1956	1.140	0.1312 (0.0415)	36	1.162	0.1504 (0.0574)	44
1957	1.234	0.2107 (0.0392)	48	1.381	0.3231 (0.0578)	35
1958	1.310	0.2702 (0.0401)	43	1.359	0.3072 (0.0530)	58
1959	1.486	0.3962 (0.0364)	69	1.494	0.4015 (0.0598)	43

Table 10A-2 (cont.)

	R1 Properties			*R2 Properties*		
Year	*Index*	*Ln Index*	N^a	*Index*	*Ln Index*	N^a
1960	1.496	0.4029 (0.0385)	52	1.604	0.4727 (0.0608)	43
1961	1.586	0.4614 (0.0388)	52	1.817	0.5974 (0.0605)	49
1962	1.697	0.5293 (0.0386)	60	1.877	0.6302 (0.0591)	58
1963	1.879	0.6308 (0.0364)	83	2.015	0.7007 (0.0591)	57
1964	1.996	0.6912 (0.0377)	67	2.263	0.8170 (0.0562)	90
1965	2.082	0.7335 (0.0388)	61	2.422	0.8850 (0.0598)	53
1966	2.099	0.7418 (0.0450)	29	2.298	0.8324 (0.0667)	31
1967	2.095	0.7396 (0.0422)	42	2.452	0.8970 (0.0714)	25
1968	2.016	0.7011 (0.0430)	37	2.360	0.8591 (0.0659)	36
1969	2.058	0.7222 (0.0415)	40	2.435	0.8901 (0.0680)	29
1970	2.256	0.8139 (0.0453)	29	2.610	0.9598 (0.0693)	29
1971	2.214	0.7952 (0.0400)	52	2.840	1.046 (0.0634)	44
1972	2.420	0.8841 (0.0397)	57	2.729	1.005 (0.0654)	38
1973	2.404	0.8775 (0.0401)	47	3.089	1.128 (0.0641)	39
Border	1.08	0.0767 (0.0298)	–	0.9600	−0.0413 (0.0443)	–
Total			585			496
R^2			.4512			.2446
DW			1.842			1.859

[a]Number of initial and final sales.

Table 10A-3. Price Indexes of *R*3 and *R*4 Properties (figures in parentheses are standard errors of logs)

	R3 Properties			*R4 Properties*		
Year	*Index*	*Ln Index*	*N*[a]	*Index*	*Ln Index*	*N*[a]
1950	1.000	0.000	32	1.000	0.000	31
1951	0.9974	−0.0025 (0.0564)	29	1.025	0.0251 (0.0688)	28
1952	1.095	0.0907 (0.0537)	32	1.160	0.1485 (0.0587)	37
1953	1.132	0.1240 (0.0464)	52	1.281	0.2475 (0.0664)	37
1954	1.144	0.1349 (0.0501)	41	1.310	0.2702 (0.0643)	33
1955	1.161	0.1493 (0.0505)	32	1.286	0.2516 (0.0650)	35
1956	1.255	0.2269 (0.0492)	37	1.363	0.3096 (0.0635)	38
1957	1.299	0.2615 (0.0537)	34	1.459	0.3777 (0.0643)	46
1958	1.342	0.2942 (0.0481)	50	1.519	0.4182 (0.0616)	53
1959	1.481	0.3930 (0.0475)	62	1.826	0.6024 (0.0655)	44
1960	1.589	0.4634 (0.0477)	62	1.812	0.5948 (0.0684)	39
1961	1.667	0.5166 (0.0492)	58	1.935	0.6600 (0.0618)	60
1962	1.781	0.5772 (0.0484)	66	2.162	0.7712 (0.0612)	64
1963	2.023	0.7048 (0.0486)	65	2.478	0.9074 (0.0616)	66
1964	2.189	0.7836 (0.0480)	67	2.633	0.9681 (0.0677)	42
1965	2.325	0.8436 (0.0496)	57	2.754	1.013 (0.0643)	52
1966	2.426	0.8865 (0.0519)	44	2.855	1.049 (0.0768)	22
1967	2.323	0.8430 (0.0520)	44	2.455	0.8984 (0.0834)	18
1968	2.489	0.9121 (0.0557)	29	2.630	0.9668 (0.0720)	31
1969	2.645	0.9726 (0.0564)	31	2.493	0.9135 (0.0714)	29

Table 10A-3 (cont.)

	R3 Properties			R4 Properties		
Year	*Index*	*Ln Index*	N^a	*Index*	*Ln Index*	N^a
1970	2.571	0.9443 (0.0625)	21	2.941	1.079 (0.0735)	24
1971	2.545	0.9342 (0.0555)	28	3.121	1.138 (0.0724)	27
1972	2.915	1.070 (0.0488)	57	3.199	1.163 (0.0699)	35
1973	3.107	1.134 (0.0590)	26	3.374	1.216 (0.0710)	33
Border	1.06	0.0594 (0.0436)	–	1.01	0.0075 (0.0825)	–
Total			525			462
R^2			.4408			.2461
DW			1.824			1.813

[a]Number of initial and final sales.

NOTES TO CHAPTER TEN

1. Recent work on the subject has been done by Siegan (1972), Plosser (1972), and Sagalyn and Sternlieb (1973).

2. The major works in this area are by Crecine, Davis, Jackson (1967), Rueter (1974), Mieszkowski (1972), and Bailey (1966).

3. The erratic behavior around the year 1966 has a logical explanation in that a major reassessment of all residential property in San Francisco occurred in that year. This reassessment was mandated by California Assembly Bill 80, passed in July 1966, which required each county assessor to assess all taxable property at 25 percent of his estimate of the full cash value. A study of the capitalization of this reassessment indicates that it began in January 1966 (Smith 1971).

4. The likelihood that a discontinuity occurs in year S is inversely proportional to the sum of squared residuals in the regression for year S is seen in the following: The logarithm of the maximum likelihood for a given value of T is: $L(S) = T \log \sqrt{2} - T \log \hat{\sigma} - (T/2)$, where T = total number of observations (Quandt 1958).

5. Quandt (1960) suggests that the difficulty could be avoided by not using a maximum likelihood estimate for S but instead, arbitrarily deciding upon S such that $S = T/2$ if T is even and $S = (T+1)/2$ or $(T-1)/2$ if T is odd (where T is the total number of observations). Although this procedure eliminates one difficulty, it creates another in that either of the situations is likely to be contaminated with observations from the other. This will impair the power of the test.

6. The coefficient of the assessment term is not significant, perhaps because the model is not formulated properly to estimate a true value for the capitalization of the increased tax. The effect of any factor which would cause demand to increase in the years after the assessment or which would cause property values to increase for any other reason is included in this coefficient.

7. The fact that most apartments in the city are built on sites which were formerly occupied by single-family homes indicates that this elasticity effect may have occurred (San Francisco Department of City Planning 1967). Some of the properties zoned R1 may have been the least costly sites for R2 and R3 properties. In prohibiting such conversion, the zoning ordinance could easily have caused the supply of R2 and R3 types of structures to become more price-inelastic.

8. Since the study deals with a very specific issue, the number of variables which must be included in the analysis is reduced. In the study, I attempt to determine how much of the variation in property value is due to the zoning misallocation of land among uses through zoning. Because of this, the effects of all the determinants of demand on price are included in the measure of the zoning effect. A general shortage of all land is measured by the constant. A differential shortage of land among zones means that zoning is misallocating supply and, therefore, the measure of this shortage is part of the zoning effect.

Also, it is not necessary to include the effect of certain property characteristics which are randomly distributed among zoning categories but which interact differently with the different categories to affect price. The purpose of this study is to determine the total effect of zoning, including the effect of all interactions of which it is composed.

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Comments on Chapters Nine and Ten

Eugene Smolensky

I am a discussant in an anomalous position, since I (along with Ingram) selected the studies by Nelson and Avrin as the best in our competition. They were the best of a good lot and I must and will say what they contribute. I will also offer some criticisms, but, of course, since I obviously think highly of them, those criticisms will be far from stinging.

It has been maintained that zoning is not required for the efficient allocation of land among alternative uses and that in practice the purpose of zoning is to allocate land inefficiently so as to maximize the narrow benefit-cost calculus of the city's initial residents. Proof of the former proposition lies mostly in the polemical descriptions of Houston by Siegan.[1] Proof of the second proposition has been the findings that zoning conversions in particular cities have resulted in large changes in land values. Both sorts of evidence have serious deficiencies, and it is therefore important to have this evidence by Avrin, confirming one of the propositions and rejecting the other. Needless to say, however, Avrin's study will not, indeed cannot be, the last word on the subject.

I am particularly concerned with what might be labeled the counterfactual to Avrin's time series analysis, which is, I think, that in an unconstrained market, over a decade or so, prices of land in different uses would rise proportionately. This is an assertion not only that the market is in equilibrium at the outset, as she notes, but in equilibrium over the whole of the period. Now we know that over decades, using Census data, density gradients not only rose and fell at their intercepts, but that their slopes changed, even before zoning was finally sanctioned by the Supreme Court in 1926. The increasing and then decreasing slopes of density gradients, which theory suggests must follow from shifting rent gradients, suggest the obvious: that a whole lot of factors including the high cost of demolition will retard equilibrium in housing markets over long periods. Failure to standardize for these factors raises questions about both of Avrin's conclusions, especially since her cross-sectional data suggest that the zoning categories are correlated with density and, hence, with rent gradients (peak-hour auto travel time to the CBD rises monotonically from R4 to R1). A plausible question, for example, is: Did anticipations of BART (Bay Area Rapid Transit) have the effect of stretching out the city while increasing densities at nearly every distance, with the growth in R1 occurring at the extensive margin where conversion would be cheapest?

Now of course Avrin can say she only claimed the zoning was nonoptimal and not that markets could do better, but that would be a copout, I think.

I turn now to Nelson's study. To John Kain's credit, in two instances he has gone beyond the usual issue in the literature on discrimination in housing (do blacks pay more?) to important subsidiary hypotheses. One, the issue here, is whether discrimination against blacks, particularly nonprice discrimination, adversely affects employment and the nominal wages of blacks relative to whites. Kain's approach was empirical, and Nelson's theoretical supplement is both welcome and required. What is most surprising to me about Nelson's study is how little she can adduce from her bold simplifications.

On the basis of her model, Nelson cannot say anything definitive about either unemployment or nominal wages. She can show that real wages will be lower for blacks in her model, but I suspect that even this result is not very robust. Application of her model to the data will have to deal with the fact that black housing, while more concentrated near the CBD than white housing, nevertheless generally moves out toward and into the suburbs in a broadly triangular wedge. The powerful simplification of the Muthian circular city which underlies much of the work of Mills and his students is I think a poor abstraction for studying both race and income distribution. It may nevertheless be possible to save the Kain hypothesis, reformulated in real terms as Nelson has cleverly transformed it, by appeal to the higher transport costs confronting blacks because of segregation and because of the radial nature of the public transport net (a fact indeed relied upon by Kain), but even here I wonder if the Kain conjecture would survive the demand-side adjustments hinted at by Nelson at the end of her study.

In short, whether Nelson intended to do so or not, Kain's judgment that segregation in housing leads to higher unemployment and lower nominal wages has been seriously undermined.

NOTE TO COMMENTS ON CHAPTERS NINE AND TEN

1. Bernard Siegan, *Land Use Without Zoning* (Lexington, Mass.: Heath, 1972).

Comments on Chapters Nine and Ten

Stephen P. Coelen and
William J. Carroll

Many of the contributors to this volume suggest in their studies that exogenous environmental change in the economic system finds its way into the housing market. Measurement of the impact of that change on the housing market provides useful information on the nature of the change; and, in particular cases, this information may be all that we have for evaluation of alternative public policies. The majority of the studies deal with the need to develop general equilibrium models for interpretation and measurement of the property value reaction (the terms "property" and "housing" are used synonymously). This ability is required if we are to discern from the morass of all the conflicting effects of simultaneous determinants of property values the rather minute effect of a single incremental change. Only then can cross-sectional modeling (which has the data simplicity of dealing with only a single point in time) be satisfactory. Most of the studies dealing with general equilibrium do, in fact, utilize the cross-sectional methodology as a basis for empirical technique.

Avrin's study is different from the others' since she also uses time series data to measure the effects of an environmental change—the extension of zoning in San Francisco. This dual use of time series and cross section is potentially valuable because the techniques yield seemingly similar information but use different data sets, so that the robustness of estimation is improved.

Note: We are indebted to the Army Corps of Engineers under contract DACW31-75-C-0018 for funding the research underlying these comments.

However, in using the techniques, concern should then be given to the compatibility and interpretation of the estimates.

Because we are inclined to discount the absolute effects of zoning that Avrin calculates, owing to her heroic assumption that no macro factors influenced the general price level of all housing contemporaneously with the impact of the zoning, consider her time-series-based conclusions on the relative effects of zoning: that the price of R4 properties jumped 11 percent more than that of R3; R3 properties, 4 percent more than R2; and R2, 1 percent more than R1. Conflicting with this is information from the logarithmic form of Avrin's cross-sectional results: "... the real prices of properties zoned R1 are 21 percent higher than those which are unzoned" and that "the prices of properties zoned R2, R3, and R4 are 32 percent, 36 percent, and 44 percent higher, respectively."

Let the unzoned property values be R0 and the values of properties in zoned areas be R1, R2, R3, and R4. Avrin's cross-sectional results imply that R1 = 1.21 R0; R2 = 1.32 R0; R3 = 1.36 R0; R4 = 1.44 R0. From this we can conclude that R4 = 1.0588 R3; R3 = 1.0303 R2; R2 = 1.0909 R1, which is at variance with the time series results. The time series and cross-sectional models present the following relative price changes:

	Time Series	*Cross Section*
R4:R3	11%	5.88%
R3:R2	4	3.03
R2:R1	1	9.09

The margin of estimation variance provided by the standard errors associated with the two techniques is not large enough to explain such discrepancies. This leads us to a general evaluation and interpretation of the relationship between such time series and cross-sectional measures.

Envision a tripartite city in which one part is not currently zoned and has never been zoned, one part has been zoned for a long time, and one part was previously unzoned but has recently been zoned. Assume a single zoning classification, and denote the never-zoned area as J, the always-zoned area as K, and the recently zoned area as I. The latter has experienced a change in environmental conditions of the type outlined at the beginning of Avrin's study. The time period t_0 is unambiguously before and T_0 unambiguously after anticipation of and adjustment to the zoning of area I. In other words, t_0 can be taken as the last period of long-run equilibrium before the zoning and T_0, as the first period of long-run equilibrium after zoning. While zoned and unzoned properties are highly substitutable, consider them to be in different markets, since Avrin concludes that zoned properties may be viewed quite differently; i.e., buyers of such property "... are secure in their knowledge of the future of the neighborhoods into which they are purchasing." Properties in area *I* are assumed initially (t_0) to make up part of the market of homogeneous properties lacking zoning. This market also includes all the properties in area *J*. As area *I* becomes zoned, properties in *I* move from the unzoned market (i.e., the *J* market) and by period T_0 are homogeneous units in the *K* market. Assuming reasonable competition in the *J* and *K* markets, housing prices in these markets (denoted by subscripts) are equalized in the respective periods so that

$$ {}_IP_{t_0} = {}_JP_{t_0} \text{ and } {}_IP_{T_0} = {}_KP_{T_0} \tag{10B-1} $$

These prices indicate a measure of the total hedonic value of attributes associated with respective property types. In this simple case an equilibrium adjustment is assumed in markets for products that differ only by the flow of benefits associated with zoning. Hence, two hedonic values (H) can be calculated for such benefits in equilibrium periods t_0 and T_0:

$$ H_{t_0} = {}_KP_{t_0} - {}_JP_{t_0} = {}_KP_{t_0} - {}_IP_{t_0} \tag{10B-2} $$

and

$$ H_{T_0} = {}_KP_{T_0} - {}_JP_{T_0} = {}_IP_{T_0} - {}_JP_{T_0} \tag{10B-3} $$

The ambiguity inherent in the existence of two measures arises because the hedonic, cross-sectional measures can be constructed at many points in time.

The time series (TS) measurement of the effect of zoning on properties in area *I* is defined as

$$ TS = {}_IP_{T_0} - {}_IP_{t_0} = {}_KP_{T_0} - {}_JP_{t_0} \tag{10B-4} $$

No ambiguity exists in this definition.

When the relationships developed in (10B-1) through (10B-4) are used, it is clear that the measures may not be identical. Adding and subtracting equal quantities on the right-hand side of (10B-4), we obtain

$$TS = {}_K P_{T_0} - ({}_J P_{T_0} - {}_J P_{T_0}) - {}_J P_{t_0} + ({}_K P_{t_0} - {}_K P_{t_0})$$

and substituting from Equations (10B-2) and (10B-3):

$$TS = H_{T_0} + {}_J P_{T_0} + H_{t_0} - {}_K P_{t_0}$$

hence $TS = H_{T_0}$ if and only if $H_{t_0} = {}_K P_{t_0} - {}_J P_{T_0}$. This can occur only if there is no price reaction in the unzoned area arising from the zoning of area I (i.e., ${}_J P_{T_0} = {}_J P_{t_0}$). Similarly, $TS = H_{t_0}$ if and only if $H_{T_0} = {}_K P_{T_0}$ which would require no reaction of the K properties to the zoning of area I, so that ${}_K P_{t_0} = {}_K P_{T_0}$.

For any sizable zoning program impact the conditions ${}_K P_{t_0} = {}_K P_{T_0}$ and ${}_J P_{t_0} = {}_J P_{T_0}$ would not be expected to hold because of the market reactions of transferring I-area properties out of the J market and into the K market.

These notions may be extended into a structural model capable of empirical estimation. The demand relations are written as functions of all relevant commodity prices:

$${}_J Q_t^D = f_J({}_J P_t, {}_K P_t, {}_X P_0) \tag{10B-5}$$

and

$${}_K Q_t^D = f_K({}_K P_t, {}_J P_t, {}_X P_0) \tag{10B-6}$$

where ${}_K Q_t^D$ and ${}_J Q_t^D$ are the demand quantities in the zoned and unzoned markets respectively and ${}_X P_0$ is the price of some composite good. The long-run supply curves are written simply as functions of the prices in respective housing markets and an exogenous price of building materials:

$${}_J Q_t^S + {}_I Q_0 - {}_I Q_t = g_J({}_J P_t, {}_y P_0) \tag{10B-7}$$

$${}_K Q_t^S + \mu_I Q_t = g_K({}_K P_t, {}_y P_0) \tag{10B-8}$$

where ${}_K Q_t^S$ and ${}_J Q_t^S$ are the quantities of properties in the K and J areas supplied to the K and J markets respectively; ${}_I Q_0$ is the initial fixed quantity of property in area I supplied to the J market; ${}_I Q_t$ represents the additional properties in the K market which had each been subdivided, on average, into μ_I properties from the original ${}_I Q_0$

properties, and ${}_yP_0$ is the price of a composite building supply good. Subdivision by a factor such as μ is usually the consequence of zoning change. The short-run supply functions need not be defined to locate the initial and final (postzoning) equilibriums, since these are meant as long-run equilibriums. However, the short-run functions are used implicitly, for example, by the inclusion of the terms $(-{}_IQ_t)$ and $(+\mu_I Q_t)$ in Equations (10B-7) and (10B-8), respectively. The model is completed by adding the equilibrium equations:

$$ {}_JQ_t^D = {}_JQ_t^S + {}_IQ_0 - {}_IQ_t \tag{10B-9} $$

and

$$ {}_KQ_t^D = {}_KQ_t^S + \mu_I Q_t \tag{10B-10} $$

Application of the model prior to any of the given set of properties in area I before implementation of zoning is carried out by simply assuming ${}_IQ_t = 0$. With the introduction of zoning in area I, ${}_IQ_t$ is greater than zero, entering exogenously into the simultaneous equation system, (10B-5) through (10B-10), to reflect the number of properties coming under zoning specifications.

From such a model it is easy, at least conceptually, to derive the reduced forms for the endogenous variables ${}_JQ_t = {}_JQ_t^S + {}_IQ_0 - {}_IQ_t - {}_JQ_t^D$, ${}_KQ_t = {}_KQ_t^S + \mu_I Q_t = {}_KQ_t^D$, ${}_KP_t$, and ${}_JP_t$. The reduced forms then yield the important derivatives, $d_J Q_t/d_I Q_t$, $d_K Q_t/d_I Q_t$, $d_K P_t/d_I Q_t$, and $d_J P_t/d_I Q_t$, which can be used to construct the measures specified in (10B-1) through (10B-4) above:

$$ H_{t_0} = {}_KP_{t_0} - {}_JP_{t_0} $$

$$ H_{t_0} = {}_KP_{t_0} - {}_JP_{T_0} = H_{t_0} + \left(\frac{d_K P_t}{d_I Q_t} - \frac{d_J P_t}{d_I Q_t} \right) {}_IQ_t $$

and

$$ TS = {}_KP_{T_0} - {}_JP_{t_0} = {}_KP_{t_0} + \frac{d_K P_t}{d_I Q_t} {}_IQ_t - {}_JP_{t_0} $$

$$ = H_{t_0} + \frac{d_K P_t}{d_I Q_t} {}_IQ_t $$

The preceding has demonstrated the conceptual differences both between cross-sectional and time series estimates and between intertemporal cross-sectional estimates. In the framework of implementing a simultaneous equation methodology (Equations (10B-5) to (10B-10)), there is no a priori expectation about possible interrelationships except on a case-by-case basis, where the forces operating in affected markets may be evaluated to yield expectations about such relationships.

In this note we have focused on the difference in time series and cross-sectional methods and their associated empirical estimates, including the difference in the cross-sectional measures that can be obtained from different temporal applications of the hedonic method. We are left with the problem of interpreting these various measures and of knowing which to select to provide the right kind of information. The solution can be developed from the old debate found in the papers of Ridker and Henning (1967), Freeman (1971), and Edel (1971) over Ridker and Henning's erroneous generalization that their cross-sectional regression coefficient for pollution (on housing values) multiplied by the number of affected properties gives an expected response to pollution abatement in the housing market. These arguments suggest that cross-sectional work is partial equilibrium modeling and cannot be used to obtain general equilibrium results of the market reaction to more than a marginal change of some environmental variable—in Avrin's case, zoning.

There are really two kinds of environmental change that are troublesome—changing the environment more than marginally at a single observation (property, census tract, etc.) and changing the environment marginally but at more than one marginal observation. It is a solution of the second difficulty that is sought by the majority of contributors to this volume, with their concentration on general equilibrium models of residential location. Edel's comment (1971, pp. 10-11), too, suggesting that Ridker and Henning's erroneous calculations provide accurate welfare information, is applicable to the second problem. From that debate, without proof, we offer the following suggestions:

1. For the case of a marginal change in the environment at a marginal observation, the cross-sectional measure correctly states both the appropriate welfare standard of willingness to pay for the environmental change as it is capitalized into the land (property) market and the actual land value reaction that would be observed to result from the change.

2. For the case of a marginal change in the environment, at more properties than just the marginal property, as would be the case for zoning under certain conditions, the cross-sectional results correctly states the average willingness to pay but is unlikely to forecast

accurately the actual land value change. This is related to open city-closed city models of Polinsky and Shavel (1975) and the suggestions of Edel (1971).

3. For the case of a more than marginal change in the environment confined to a marginal property, the cross-sectional result is likely to measure correctly neither the land value reaction nor the welfare change because of less than perfectly elastic demands for most environmental commodities. However, joint use of cross-sectional measures taken before and after the environmental change may give information that averaged together approximates the average marginal willingness to pay over the relevant range of environmental conditions. This average multiplied by the number of units of change may approximate the changes in property market values.

4. For nonmarginal changes both of observations (properties) and of environmental conditions, or in Avrin's case, a set of institutional constraints throughout a market area, the cross-sectional measures are likely only to approximate the welfare measures and not the actual market changes, and then only by multiplying the average of the two temporal cross-sectional results by the number of units affected by the change in environmental conditions.

While the cross-sectional measures under all four conditions yield very useful information, it is clear that they fall short most when asked to give full information in cases of simultaneous changes at many properties. It is then that they fail to give information on expected actual market changes. It is especially in these cases that time series measures are most powerful. The time series method directly evaluates the impact of actual environmental changes already implemented in the economic world and therefore the method compares pre- and postevent prices to determine the market reaction. The shortcoming of the time series approach as a method is its ability to accomplish only this result, failing (except in the case of marginal changes) to measure any welfare standards.

Our conclusion is to urge much greater care in the application of the methods of time series and cross-sectional analysis to housing market data. The measures will always bear some relation to each other but need not convey the same information. Without the application of both, full information on environmental impacts will not be recovered.

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