Comments on Chapters Nine and Ten

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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.

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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:

$$ {}_JQ_t^D = {}_JQ_t^S + {}_IQ_0 - {}_IQ_t \qquad (10B\text{-}9) $$

and

$$ {}_KQ_t^D = {}_KQ_t^S + \mu_I Q_t \qquad (10B\text{-}10) $$

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_JQ_t/d_IQ_t, d_KQ_t/d_IQ_t, d_KP_t/d_IQ_t, and d_JP_t/d_IQ_t, which can be used to construct the measures specified in (10B-1) through (10B-4) above:

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

$$ H_{t_0} = {}_KP_{t_0} - {}_JP_{T_0} = H_{t_0} + \left(\frac{d_KP_t}{d_IQ_t} - \frac{d_JP_t}{d_IQ_t} \right) {}_IQ_t $$

and

$$ TS = {}_KP_{T_0} - {}_JP_{t_0} = {}_KP_{t_0} + \frac{d_KP_t}{d_IQ_t}\, {}_IQ_t - {}_JP_{t_0} $$

$$ = H_{t_0} + \frac{d_KP_t}{d_IQ_t}\, {}_IQ_t $$

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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