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HOUSING MARKET INFORMATION AND THE BENEFITS OF HOUSING PROGRAMS

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ABSTRACT

During the past fifteen years, there has been an outpouring of theoretical and empirical literature on "hedonic" methods for the evaluation of housing programs and public amenities. This paper provides a selective and non-technical review of these developments. The paper concludes that there is a much greater scope for utilizing these techniques in measuring consumers' willingness to pay for the benefits of government programs to improve housing or urban amenities.

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I. INTRODUCTION

Housing market transactions differ from many other purchases of consumer durables in their complexity and in the importance of the public sector in affecting consumption. A wide and diverse collection of commodities are bought and sold in a single tied sale. In return for a monthly contact rent, or the amount specified to purchase a dwelling in fee simple, the consumer obtains a variety of structural characteristics, including size and quality attributes. Notable among the size attributes are parcel and living areas, numbers of rooms, bathrooms, garages and the like. Notable among the quality aspects of dwellings are their insulation and thermal properties, the vintage of construction, and the general state of repair.

However important these physical and structural components may be, household consumption of a variety of other goods is determined jointly with housing. Included in these goods are physical, locational, and neighborhood attributes, the character and quality of the local environment, and the public and social services provided to dwellings and their residents. Many of these attributes are difficult to measure precisely. Few of them are produced or marketed competitively; many are not marketed at all in any direct way.

The technical character of these components of housing also varies substantially. Some are essentially private goods, publicly supplied (e.g., refuse collection). Some are public goods subject to congestion (e.g., local parks), and some are pure public goods (e.g., noise levels, and the aesthetics of neighborhoods).

These goods also differ from the structural and physical characteristics of housing in the importance of government and local planning agencies in their allocation. Many of these collective commodities are supplied consciously by the public sector or arise as the result of regulation or regulatory oversight (or the neglect of regulatory oversight) by public authorities.

To an economist, these collective attributes of housing services provide the principal rationale for government policy in the housing market. Absent these externalities, government housing policy would rest only upon the presumed "better tastes" of planners and public officials, their paternalistic motives, or the political ease of in-kind transfers.

The link between these attributes of residential life and the structure of housing prices suggests that housing market information can be used to "value" the diverse externalities in dense urban areas. This "valuation", in turn, implies that government decisions about increasing the supply of public goods or decreasing the supply of public bads can be informed by market based estimates of the potential benefits of such activities.

The existence of some relationship between local externalities and market prices has been recognized in the economics literature for almost two decades. (The first paper I have been able to locate which investigates the empirical relationship is by Ronald Ridker [1967]). The theoretical basis for such investigations, however, was sketched out more than three decades ago. (The first paper I have been able to locate is by Nobel laureate Jan Tinbergen in 1956).

Since these initial investigations in the 1950's and 1960's, there has been an outpouring of research on these issues of valuation, not only by economists

and planners but also by geographers, civil engineers, regional scientists and operations researchers. Despite these investigations and despite a number of high quality empirical analyses, there remains considerable controversy about just what is the appropriate theoretical framework for interpreting these relationships. Controversy abounds also in the appraisal of methodologies for estimating empirical relationships and for interpreting results as they relate to the benefits of any public program or government activity to improve housing amenities.

This paper provides a selective and non-technical review of these developments. In the following sections we sketch out and compare alternative strategies for the use of housing market information to estimate consumers' willingness to pay for public amenities. In addition, we compare the results of a wide variety of empirical studies which have attempted to estimate the benefits of the housing attributes provided collectively.[1] Finally, we speculate on factors which facilitate or retard the diffusion of these methodologies in the applied welfare economics actually practiced by government bureaus.

II. HOUSING PRICE INFORMATION

The point of departure for these investigations of consumers' willingness to pay for public goods is the analysis of price determination in the residen-

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[1] A more extensive review of studies which have been directed towards the demand for housing attributes has recently been published by Follain and Jimenez [1985]. Besides the difference in emphasis, at some points there is a difference in interpretation between my analysis and that provided by Follain and Jimenez. Despite the extensive bibliography in the Follain-Jimenez paper (some 67 papers are listed in the bibliography), the bibliography on page 20 of this paper notes some 33 additional research efforts devoted to valuing the externalities of housing. By any standard, the empirical work on these related topics has been prodigious.

tial market. The tied purchase (or rent) of the housing commodity implies that the purchase or rental price (P) observed in the market reflects the housing characteristics ($H=\{h_1, k_2,\ldots,h_I\}$) and public goods and externalities ($A=\{a_1,a_2,\ldots,a_J\}$) enjoyed by housing consumers.

(1) $P = p(H,A)$

If the functional form for this relationship were linear, then the pricing of an observed housing and amenity package would be no different from the pricing of most other consumer goods. Marginal prices of all attributes would be constant and independent of the consumption of other aspects of the housing bundle. There is, however, ample reason to suspect that the housing price function is non-linear, since the costs of converting and reconfiguring existing dwellings are so large. With high conversion costs, it is entirely possible for a dwelling twice as large as another dwelling to rent for more or less than twice as much. High transformation costs sharply limit profitable arbitrage possibilities and can thereby insure that non-linear price schedules for housing attributes persist, even over a rather long run.

There is also good reason to believe that the prices of housing attributes are not independent of one another. For example, the unit price of increased quality probably depends upon the size and other amenities of a dwelling. Engineers, architects and quantity surveyors have postulated a variety of non-linear rules of thumb to estimate costs in new construction for dwellings with different sets of attributes. There is little reason to expect that the pricing structure of existing dwellings is less complex. In any case, the independence or separability of attribute prices is an empirical matter; the hypothesis of

a lack of joint pricing can always be tested in a straightforward way for any housing market.

Under these circumstances the marginal price ρ of any attribute of housing h_i or environmental amenity a_j can be defined as

$$(2)\quad \rho_{a_{jk}} = \partial p/\partial a_{jk} = g(H_k, A_k)$$

Note that the marginal price of the j th environmental amenity varies for each individual k, depending upon the entire vector of H and A chosen. Presumably competitive suppliers and demanders respond to these marginal prices, which represent the incremental cost of an additional unit of environmental amenity. It is important to note that if demanders are competitive, the marginal price represents the marginal rate of substitution of amenity for "other goods" (e.g., non-housing, non-amenity goods) regardless of the conditions underlying the supply of the amenity.

Since prices vary by individual, the demand curve for amenity a_j can be inferred from the empirical relationships

$$(3)\quad a_{jk} = D(\rho_{h_{ik}}, \rho_{a_{jk}}, p_x, y_k - P)$$

$$i = 1,2,\ldots,I$$

$$j = 1,2,\ldots,J$$

where p_x is the price of "other goods" (constant across individuals) and y_k is the income of individual k. Equation (3) represents the demand curve for

amenity a_i estimated from observations on individuals' housing and amenity consumption, marginal prices, housing expenditure and income.

If this demand curve were known with any confidence, it could inform a wide variety of practical decisions made by local governments, regional authorities and central governments. Believable empirical counterparts to equation (3) could provide estimates of the market valuation of reductions in pollution, of improved access to recreational facilities and the like. Such estimates could provide measures of the market valuation of public subsidy programs and urban renewal projects, of increases in public services and and could be used to evaluate a variety of housing related government investments.

Quite obviously, the quantification of market benefits relative to costs and the verification that these benefits exceed costs need not be viewed as necessary in order to undertake public projects to upgrade or improve housing externalities. One can also imagine quite easily circumstances in which public programs were proposed even though aggregate market benefits fell short of costs.

Nevertheless, it should be clear, even to those who are not particularly enamored of market allocations, that serious estimates of market based benefits would lead to better informed decisions about urban public projects.

III. THE WELFARE PROBLEM

A more formal statement of the consumer's problem is straightforward. Assume consumers have preferences over housing, amenities and other goods (x)

$$(4)\quad U_k = U(H_k, A_K, x_k).$$

The household's budget constraint is

$$(5)\quad y_k = p(H_k, A_k) + x_k,$$

where, $p_x=1$ is the numeraire.

Maximizing (4) subject to (5) yields

$$(6a)\quad \frac{\partial u/\partial h_{ik}}{\partial u/\partial x_k} = \partial p/\partial a_{ik} = \rho_{h_{ik}} \qquad i=1,2,\ldots,I$$

$$(6b)\quad \frac{\partial u/\partial a_{jk}}{\partial u/\partial x_k} = \partial p/\partial a_{jk} = \rho_{a_{jk}} \qquad j=1,2,\ldots,J$$

Equation (6b) is the compensated (Hicksian) demand for amenity j -- the amount paid for an additional unit of a_j, holding the level of well-being constant.[2]

Since each consumer chooses one dwelling, the constant level of well being is for consumer k:

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[2] Implicit in this statement of the problem and in all the empirical analyses derived from it is an assumption that there is sufficient variation in each amenity so that the p function is continuous with continuous first and second derivatives. (See Harrison and Rubinfeld [1978] for a discussion). The analysis also assumes that the housing market is "open" in the sense that a change in amenity will induce immigration sufficient to keep utility levels exogeneous. (See Quigley [1986] for an investigation of more complicated models in which housing markets are "closed"). The analysis also assumes that the market is in temporary equilibrium and, in particular, that the sizes of residential sites are not variable. (See Scotchmer [1985] for a discussion).

(7) $U^{o}_{k} = U(H_k, A_k, y_k - p[H_k, A_k])$,

and the amount the consumer would be willing to pay for other amounts of the housing-amenity package W_k is the solution to

(8) $U_k^{o} = U(H_k, A_k, y_k - W_k)$.

The willingness-to-pay for individual k depends upon his income and utility level and varies with the housing-amenity package.

(9) $W_k = W(U^{o}, y_k, H_k, A_k)$
$= W(p[H_k, A_k], y_k, H_k, A_k)$

Two properties about the consumer's willingness to pay are observed from market data. First at the equilibrium chosen by the consumer, the value of the willingness to pay function must equal the value of the hedonic function (W=P). Second, for each consumer, the partial derivative of the willingness to pay function must equal the partial derivative of the hedonic function ($\partial W/\partial a_i = \partial p/\partial a_i$). Each observation on the choice of a housing-amenity package reveals a household's willingness to pay for amenity level a_i and the household's marginal willingness to pay for an additional unit of a_i.

The competitive supplier's problem is analogous. Let C_k be the unit cost function for firm k

(4') $C_k = c(H_k, A_k, Z_k)$

where Z_k are production function parameters for that firm and A_k is produced privately.

The firm maximizes unit profit π

$$(5') \quad \pi = p(H_k, A_k) - c(H_k, A_k, Z_k),$$

yielding first order conditions of the form

$$(6a') \quad \partial c/\partial h_{ik} = \partial p/\partial_{h_{ik}} = \rho_{h_{ik}} \qquad i=1,2,\ldots,I$$
$$(6b') \quad \partial c/\partial a_{jk} = \partial p/\partial_{a_{jk}} = \rho_{a_{jk}} \qquad j=1,2,\ldots,J$$

Let Ω_k be a function specifying the unit prices at which unit profits are constant for firm k

$$(7') \quad \Omega_k = \omega(H, A, \Pi_k, Z_k) = \Pi^o{}_k - c(H, A, Z_k)$$

Again, market data provide two pieces of information about these iso profit offer functions. At each supplier's equilibrium, the value of the offer function must equal the value of the hedonic function (Ω=p) and the derivative of the cost function must equal the derivatives of the hedonic function ($\partial\Omega/\partial a_i = \partial p/\partial a_i$).

Each observation on the housing amenity package reveals a supplier's willingness to offer a private amenity level a_i for sale and the supplier's marginal willingness to supply an additional unit of a_i.

IV. EMPIRICAL APPROACHES

Since these theoretical notions have been advanced and especially since the influential work of Rosen [1974], there has been an explosion of applications and empirical attempts to evaluate consumers' willingness to pay for amenities. Many of these are only loosely related to the foregoing theoretical treatment and many make implicit assumptions about the equilibrium process. This section reviews some of this work.

A. Early Studies

The earliest empirical applications of this framework for the evaluation of amenities were in analyses of air pollution (Ridker [1967], Ridker and Henning [1967]) and residential "blight" (Kain and Quigley [1970a, 1970b]). In these applications, regression models of the form of (1) were estimated using the average rents and housing values by census tract in a city or using samples of individual rental and owner-occupied dwellings. At the individual level, the willingness to pay Δ for an improvement in amenity a_1 from a_1^* to a_1^{**} was measured by the hedonic relation directly as

$$(10)\quad \Delta = p(H,\{a_1^*,a_2,\ldots,a_J\})-p(H,\{a_1^{**},a_2,\ldots,a_J\}) \quad .$$

The market benefit to improved neighborhood air quality from a_1^* to a_1^{**} was computed as the sum of these quantities across the dwellings in the neighborhood.

As the analysis in the previous section indicates, this procedure is in general incorrect, and will overestimate consumers' willingness to pay for amenities. In fact, there is only one special case in which the procedure in

(10) would yield accurate measurements of the benefits, namely if all households within the market were identical. In this special case, the hedonic function (1) and the willingness to pay function (9) would coincide, and (10) would provide an exact measure of benefits of some program to each housing consumer.

The most charitable interpretation of these early studies is that they could be used to identify correctly each household's willingness to pay for a marginal improvement in amenity (see Freeman [1974] or Small [1975] for details).

Despite these serious shortcomings, the flawed procedure outlined in (10) has been used in a variety of recent papers to estimate households' willingness to pay for public beaches, access, aircraft noise, etc. (These recent studies are noted by Follain and Jimenez [1985]).

B. Simultaneous Estimation

The original paper explicating the relationship between bid and offer functions and the price relationship (Rosen [1974]) includes an explicit recommendation for the econometric estimation of bid and offer functions: namely to estimate (1), differentiate it, and use the marginal prices to estimate equations 6a, 6b, 6a' and 6b' simultaneously. The suggestion is the estimation of

$$\begin{aligned} \rho_\lambda &= W\,(H,A,y,V_\lambda) \\ \rho_\lambda &= \omega\,(H,A,Z_\lambda) \end{aligned} \qquad \lambda=1,2,\ldots,I+J \tag{11}$$

where ρ is an estimate of the marginal price obtained from (1) and (2), and V_λ and Z_λ are the identifying taste or cost parameters. Subject to this "garden variety" identification problem (in Rosen's terminology), estimation of 2(I+J)

simultaneous equations will yield parameters of the compensated demand and offer functions.

There are apparently only two papers which have implemented this strategy using housing market information and which have presented simultaneous estimates of supply and demand parameters. Witte *et al* [1979] present a six equation system estimating bid and offer curves for dwelling quality, dwelling size, and lot size, conditional upon prior estimation of the hedonic price function. Nelson [1978] presents estimates of a two equation system measuring the compensated demand and the supply of air quality. The latter study is directly intended to provide estimates of the willingness to pay for environmental improvement. Three related issues arise in the estimation of the system described in (11).

The first involves the garden variety identification problem and the legitimacy of including some taste variables in the household bid for one or the other components of housing. It is quite difficult to specify the set of variables which identify the separate components of housing, say dwelling unit quality and neighborhood amenities.

The second derives from the prior estimation of the price relationship and the computation of its derivative. Since the dependent variable is computed from the H and A vectors via the regression, the only new information that arises from the computation of ρ is attributable to its non-linear functional

form. For at least some functional forms, Brown and Rosen [1982] have shown that the system is unidentified.[3]

The third important issue is also inherent in the underlying methodology of the Rosen proposal. A comparison of W, the derivative of W in equation (11) with the equation for willingness to pay W, i.e., equation (9), indicates that it is misspecified. The marginal bid W for any amenity depends upon the consumption of housing (H) and amenity (A) attributes as well as "other goods". The latter term is income minus housing expenditures, y-P, not simply income, y. Thus as explicated by Epple [1984] in a very careful paper, estimation of (11) by simultaneous equation methods will yield inconsistent parameters of the willingness to pay function, at least if willingness to pay is defined as the compensating Hicksian variation.

These complications quite naturally suggest one approach to estimating the bid and offer curves which does not depend upon prior estimation of the hedonic price function or upon the differentiability of that function. As noted in a paper by Son [1986], the bid and offer relations could be inferred from

$$\begin{aligned} P &= W(H,A,y-P,V) \\ P &= \Omega(H,A,Z) \end{aligned} \tag{12}$$

subject to

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[3] For example, suppose the hedonic function is quadratic, as assumed by Witte *et al*. Then its derivative will be linear in the elements of H and A, and this will not permit estimation of (11) as a linear equation system.

$$\frac{\partial W}{\partial h_i} = \partial\Omega/\partial h_i \qquad i=1,2,\ldots,I$$

$$\frac{\partial W}{\partial a_j} = \partial\Omega/\partial h_j \qquad j=1,2,\ldots,J$$

The two equation system in (12) could be estimated, consistently at least, subject to the coefficient restrictions noted by, standard simultaneous equation methods.[4]

C. Fixed Supply Approaches

As noted in the introduction, a great many of the amenities which are important components of housing choice are not supplied competitively. For most of these components of housing, it may be quite sensible to view their supply as fixed according to some distribution within a housing market and as exogeneous to any individual housing supplier or consumer. This assumption greatly simplifies the theoretical structure which must be imposed in order to evaluate consumers' willingness to pay for amenities, and may provide an adequate description of housing supplier behavior, at least when the public sector is the supplier.

Harrison and Rubinfeld [1978] use this simplified structure to estimate the willingness to pay for clean air. Papers by McDougal [1976] and Linneman [1980] use similar techniques to estimate consumers' willingness to pay for the ser-

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[4] Again, this is subject to the caveat noted by Brown and Rosen [1982]. The system is certainly not identifiable for any arbitrary functional forms for W and Ω.

vices provided to dwellings by local government. The structure of these analyses is exemplified by the Harrison-Rubinfeld analysis of air pollution.

The authors estimate equation (1) from a sample of dwelling units, their characteristics, their sale prices, and the level of local air quality. They then postulate an inverse demand function of the form of equation (3), relating the level of air quality experienced by an individual household to its income and to the marginal price of air quality faced by that household. This equation is estimated by ordinary least squares on the assumption that air quality is inelastically suppled to each dwelling in the sample, and the authors include income (rather than income minus expenditures) in the model.

As noted above, the inclusion of y rather than y-P in the demand curve means that it cannot be interpreted as the compensated demand curve for air quality unless the marginal utility of money is constant. Also, as pointed out by Epple [1984], the assumption that supply is inelastic at each point is quite strong. If either condition -- variable marginal utility of money or the supply assumption -- is not met, then the simple estimation strategy is inadequate.

Some of these objections are overcome if the form of utility function is specified directly. In that case, for a specific functional form the inverse of equation (3), i.e.,

$$(3') \quad p_{a_j} = MRS_{a_j,y-P} \qquad j=1,2,\ldots,J$$

can be estimated by an instrumental procedure. For at least several rather general utility functions (see Quigley [1982]), this procedure can be used to

estimate the willingness to pay for amenities in a consistent manner. For example if the utility function is of the generalized CES form

$$(13)\quad U = [\Sigma\alpha_i h_i^{\beta_i} + \Sigma\alpha_j a_j^{\beta_j} + x^{\varepsilon}]^{\psi}$$

then (3') reduces to

$$(3'')\quad p_{a_j} = (\alpha_j\beta_j/\varepsilon)\ a_j^{\beta_j-1}[y-P]^{1-\varepsilon}$$

and the parameters are clearly estimable. The estimation of consumer demand under these conditions insures that the empirical results do satisfy the logical postulates of consumer choice. In contrast, the less well specified demand relationship in question (3) need not satisfy this "integrability condition." Note, however, that the estimation of equation (3') does depend upon the non-linearity of the market price function to achieve identification.

This approach is clearly related to the bid rent analyses undertaken by Wheaton [1977]. For example if (13) is the form of the utility function, then

$$(14)\quad y-P = (U^{o^{1/\phi}} - \Sigma\alpha_i h_i^{\beta_i} - \Sigma\alpha_j a_j^{\beta_j})^{1/\varepsilon},$$

which is, in principle, estimable, at least for samples of households with identical incomes or tastes. The Wheaton analysis is thus analogous to the proposal by Son [1986] under the assumption of a fixed supply of amenity.

V. PRACTICAL IMPLEMENTATION

As the foregoing discussion indicates, there has been a remarkable development during the past two decades in methodologies for estimating the market

benefits of a broad variety of the housing-related amenities enjoyed in urban areas. This explosion of methodological research and empirical analysis has been fueled by advances in social scientific theory and statical methodology, and by declines in the real costs of computation.

The economics and planning literature provides a rich set of substantive examples, not only of consumers' willingness to pay for environmental improvement, including clean air and a quiet milieu, but also for increased public safety, better schools, neighborhood quality, parks and recreational opportunities. It is not yet so clear, however, that these techniques have been used by planners and analysts in their evaluations of alternative policies for improving the housing and residential conditions of urban life. Definitive evidence on this is difficult to obtain, but I am aware of relatively few cases in which empirical analyses based upon these recent developments have been decisive, or even influential.

From one perspective, of course, this may be expected. The path from theoretical advance in economics to routine application has always been long, even when the theoretical advances could be shown to be privately profitable (e.g., linear programming). In cases where the profit is purely social, that is, measured in terms of a better balance between government expenditures and citizen preferences, the incentives for diffusion are certainly weaker.

This is not to imply that the data underlying conclusions about willingness to pay for externalities in the housing market has not been scrutinized professionally. On the contrary, it appears that these data and methodologies have been analyzed and picked over by other professionals to a rather remarkable extent. For example, the housing market data gathered and analyzed by Kain and

Quigley [1970a, 1970b, 1975] have been reanalyzed, using more general models, by Galster [1977, 1979] and by Yinger [1978]. The housing market data gathered and analyzed by Harrison and Rubinfeld [1978] has been reexamined using more general statistical models in a recent monograph (Belsley, *et al* [1980]). This body of data and the problems of market valuation and willingness to pay has also been used quite recently to illustrate more powerful statistical optimization procedures, for example the alternating conditional expectation (ACE) model (see Brieman and Friedman [1985]).

These extensive investigations have not been undertaken, however, to evaluate the benefits of any real public program or to analyze the choices facing any public decision maker. Rather, they have been purely scientific and methodological investigations -- by mathematical statisticians, planners, economists and engineers -- whose purpose is to create better analytical tools.

These techniques are not widely diffused among practitioners and analysts. The abstraction of the willingness-to-pay argument may be too great, especially when the alternative in many instances is a physical damage function. Urban air quality is a good example. Statistical analyses relating morbidity or lost productivity to pollution (e.g., Lave and Seskin [1970], Mendelsohn and Orcutt [1979]) are easily motivated and readily interpreted, even though they are based upon extremely strong assumptions and even though the estimates appear to be quite fragile (see Atkinson, Crocker, and Murdock [1985]). In contrast, the behavioral assumptions imbedded in the willingness-to-pay measures reviewed here are susceptible to caricature (e.g., the assumption of purposeful behavior can be castigated as a requirement for "perfect" information in "perfect" markets, etc.).

The distinction between damage-based and willingness-to-pay based benefit measures would not be important if estimates derived from such approaches were similar. The are not. Theory predicts that benefits calculated as willingness-to-pay would be larger than damage-based benefits; empirical evidence suggests that they are larger by a factor of ten (Gerking and Schultze [1981]).

Rigorous benefit cost analyses are sometimes discounted because they quantify the obvious fact that the rich are better prepared to pay for almost anything than the poor. Indeed for most of the housing amenities discussed in this paper the consumer demand estimates suggest an income elastic demand. In these cases, however, the practical implication of willingness to pay is somewhat different. The results of these analyses suggest that improved housing amenities could be provided to urban residents and financed by progressive taxes and that this would be a pareto improvement.

There are precious few cases in which the analyst or planner evaluating public choices can simultaneously apply relatively innovative methodological techniques, conduct rigorous and hard-nosed dollar-based measurement of intangible benefits, and be on the side of the angels when it comes to distributional considerations.

I think we should spread the word.

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