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THE HEDONIC APPROACH: NO PANACEA FOR VALUING WATER QUALITY CHANGES

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"It is the nature of models in economics that their assumptions are to some extent unrealistic. The data are indadequate; variables are measured with error; and the definitions of empirical variables seldom correspond precisely to the theoretical constructs."

Freeman [1975, p. 155]

ABSTRACT

The hedonic approach has been advanced recently as an important tool for assessing the value of non-market environmental attributes. In its most usual form, the method involves an attempt econometrically to capture differential prices for homes attributable to variations in the environmental characteristic. This technique has been applied with success for a variety of attributes -- most notably the study of air pollution. However, the case studies reported here for water quality valuation were much less successful. We advance several reasons why the hedonic approach may be ill-suited to measuring the value of water quality.

INTRODUCTION

Reaching the goals for water pollution control established by Congress in 1972 and subsequent amendments has been estimated to cost \$167 billion in 1978 dollars (Anonymous). By 1980, \$26.6 billion of federal funds had been obligated for the program along with additional state, local, and private funds. Until recently, the political system has pretty much accepted both the goals and the expenditures required to reach them without much analysis of the relationship between these costs and the benefits of achieving the goals.

One reason for the neglect of the benefits side, of course, is the difficulty of measuring the demand for public goods. Indeed, such empirical measurement is arguably still in its infancy, the recent flurry of activity in this area notwithstanding. Recent attention has turned to two techniques: the hedonic (property value) and survey approaches, with the former the best known and most widely adopted (see Brookshire, et al. [1982]). The single attempt to value water quality improvements on a national basis followed this approach. Using changes in selling prices of residential property as a measure of the benefits of cleaner water, Dornbusch and Barrager estimated a national value of pollution abatement of \$1.3 billion. The study was subject to crippling methodoligical weaknesses (Willis, Foster, Sewall) which prompted this study. The later work of Epp and Al-Ani in Pennsylvania avoided many of these weaknesses; however, the untested pooling of data across communities leaves unanswered questions on the feasibility of the hedonic technique in establishing the value of water pollution abatement. A similar approach was taken by Witte, Sumka and Erekson in studying housing markets. While they estimated their hedonic price equation separately for four different cities, they constrained the demand and supply parameters to be identical across these cities. Concerns with this approach are expressed cogently in Brown and Rosen.

Our experience reported below was substantially less successful in detecting property value impacts of water pollution abatement. These negative findings are combined with some theoretical arguments in the final section to call into serious question the validity of estimates of water quality improvements based on the hedonic technique. But, first, we provide below the briefest of background on the competing hedonic and survey techniques.

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HEDONIC AND SURVEY APPROACHES

These techniques have been subject to intense theoretical scrutiny (and criticism) in the past several years; thus our cursory treatment here. Brookshire, et al. [1982] provide a comparison of these approaches.

Hedonic Approach: This approach, based on theoretical developments of the early 70's -- notably Rosen -- assumes that variation in housing values reflects variation in public good characteristics (like water quality) in addition to its structural, locational and other characteristics. Alternatively, variations in wages or salaries are sometimes used to reflect the benefits of environmental improvements -- see Bayless for an example applied to air quality changes. In principle, given the conditions necessary for identification, one should be able to estimate the demand for the environmental characteristic by: regressing house sales prices against all characteristics; using the estimated coefficients of the environmental characteristics and the actual values of the characteristic for the houses in the sample to compute implicit marginal prices for the characteristic; and, finally, regressing these implicit prices against the characteristics and other variables such as income. The technique has been used to value such public goods or bads as air pollution, climate, noise, and water pollution abatement.

Freeman offered an excellent survey of the theoretical underpinnings and criticisms of the approach. The criticisms roughly center on three areas: the underlying theory is seen as requiring unduly restrictive assumptions about such things as the utility function; assumptions of equilibrium in the housing market are considered so unrealistic as to bring the validity of any results into question; and a belief in general that observed associations between public goods characteristics could be more a matter of spurious correlation than a reflection of a true underlying relation. We emphasize several specific and rather obvious caveats -- viz., for water quality valuations the technique does not theoretically measure all benefits from pollution abatement but rather only those recognized by the actors in the riparian residential property market. Benefits that will not be captured by residential price studies include recreation, views, and general environmental improvement as seen from roads and bridges for non-riparian residents, option value of wildlife enhancement, slowed weathering of structures in contact with the stream water, and possible benefits to downstream municipalities and industries which pump water from the stream for use.

Survey Approach: The primary alternative currently is to ask individuals directly to reveal their willingness to pay for public goods. This approach has also been subjected to considerable criticism; centered in this instance on the possibility of strategic behavior in responding to these questions as well as those of the hypothetical nature of the questions serves to minimize strategic bias, although it reduces incentives to give accurate answers. Much of this is reported in Brookshire, et al. [1980], Bishop and Heberlein, and in Smith. Brookshire, et al. [1982] apply both techniques to the case of air quality in Los Angeles with an assuring degree of consistency of results.

EMPIRICAL EXPERIENCE

Two studies of the valuation of water quality changes via impact of such shifts on house prices are reported below. The descriptions are deliberately kept brief in order to reserve space for developing implications in the subsequent section. The studies are reported fully in Willis, Foster and Sewall.

Western Massachusetts: The contiguous towns of Great Barrington and Stockbridge were initially selected for study. The sample consisted of residential properties which: were single family dwellings, were located within 1500 feet of the Housatonic River, contained five acres or less, and were sold between January 1962 and June 1980. Data were gathered on structural and locational characteristics for 47 households in Stockbridge and 34 in Great Barrington, and on water quality. Information on sales transactions and some property characteristics was secured from the offices of the town assessors. The remaining information was obtained by a survey administered to property owners. This on-site questionnaire also elicited perceptions of water quality and questioned owners on willingness-to-pay for water quality improvements.

Coinciding with the completion of water pollution control facilities on the Housatonic River, water quality in this area improved by about 1975 from a level in violation of water quality standards to a rating level of Class C (suitable for recreational boating and as a habitat for wildlife and fish, but not for swimming). About half of the householders noticed a change in water quality, while the rest perceived no improvement.

Several model specifications were examined, with negligible differences in results. (One version, for example, assumed that water quality improved in steps during the period rather than viewing the changes as taking place in 1975 only.) Therefore, we offer only one for illustration:

$$(1)\quad P_i = \beta_1 + \sum_{j=2}^{19} \beta_j X_{ji} + \beta_{20} X_{20,i} + \beta_{21} X_{21,i} + \beta_{22} X_{22,i} + u_i$$

where P_i is purchase price of the i^{th} residential property deflated to 1967 terms by the Home Purchase Index component of the Consumer Price Index, X_{2i} through $X_{19,i}$ are various location and property characteristics, X_{20} is a dummy variable assigned a value of unity if the property was purchased in 1975 or after, X_{21} is distance from the river in feet, X_{22} is X_{20} times X_{21}, u_i is the usual stochastic error term and β_j are the unknown parameters. The interpretation of β_{20} is the change in property value due to the improvement in water quality; its expected sign is positive. The parameter β_{21} is the change in property value resulting from a one foot increase in distance from the river during the pre-1975 period. Its expected sign is ambiguous and depends upon whether the river quality is perceived as attractive or repulsive. The interpretation of β_{22} is as the differential change in property value due to distance from the river after the water quality changes relative to before; its sign should be negative, reflecting the expectation that property values will decrease more (or increase less) with distance after the water quality changes. Partial results of Classical Least Squares estimation are provided in Table 1.

Four of the variables not reported here were statistically significant at the 90% level or better (lot size, home size in square feet, index of house condition, number of bathrooms), and of the anticipated sign. Unfortunately, the three variables of interst in Table 1 were not, and the positive sign on $\hat{\beta}_{22}$ is certainly counter-intuitive.

In a situation like this, of course, multicollinearity is always suspected. Accordingly a number of alternative procedures, including variable deletion and principal components regression, were employed, without improving the results. Indeed, the relative insensitivity of the remaining coefficients to selected deletions of variables is supportive of the suggestions of Butler that coefficient bias of even a severely restricted specification are rather limited.

Table 1: CLS Regression Results*

Application	$\hat{\beta}_{20}$	$\hat{\beta}_{21}$	$\hat{\beta}_{22}$	R^2
Western Massachusetts	2777.0 (2619.8)	0.508 (3.195)	3.370 (4.321)	0.783
Montpelier	-10283.7 (5436.9)	-4.189 (3.730)	14.227 (8.368)	0.684

* Standard errors are in parentheses.

For comparison, in responding to willingness-to-pay questions, 63% of the householders indicated a willingness-to-pay a positive amount for increased water quality and 16% would pay over $50 -- the highest figure quoted was $100. This, even though most claimed the condition of the Housatonic did not influence their decision to buy.

To be sure, the lack of positive results for this case study does not invalidate the hedonic technique for valuing water quality. It may well be, for example, that it is simply not suitable for the case of changes from dreadful to better, but still fairly inferior, water quality levels. See Epp and Al-Ani on this point. Thus, it was decided to repeat the experiment in an area with a higher quality river.

Montpelier, Vermont: The Winooski River flows through Montpelier and was selected for follow-up study for several reasons. Initial conversations with area residents revealed a consensus that the river quality had been improved markedly since sewage treatment was initiated in 1969. Further, some residents spoke of fishing and swimming in the river, activities which were quite unsafe before the installation of sewage treatment. Finally local realtors questioned indicated that housing price inflation for this community has been approximately the same as that for the national average. In the absence of specific local house inflation indices, this correspondence lends a measure of credibility to the use of the national housing component of the CPI for deflating prices to a common base.

The analysis of the type reported in the previous section was repeated for Montpelier, with a sample of 40 households. To be very brief, the results (Table 1) were quite similar. The value of R^2 was a bit lower (0.684), similar structural characteristics variables were statistically significant (house age, lot size, number of bathrooms), and the water quality variable (assigned a value of 1 if purchased after 1969) was accompanied by a negative estimated effect, significant at the .10 but not the .05 level.

Only two individuals indicated that location near the river had any impact on their decision to buy, and only one indicated intentions to use the Winooski for recreation at the time of purchasing their home. Quite simply, there are superior water recreation areas nearby.

IMPLICATIONS

Of course one cannot generalize on the basis of two futile attempts to measure impacts of water quality changes on residential property prices. And the hedonic technique has been applied with success for a range of other environmental characteristics, including air and noise pollution. Further, for the case of air pollution, Brookshire, et al. [1982] found remarkable consistency between estimates based on survey and hedonic techniques. Indeed their theoretical result that the survey estimates should be bounded below by zero and above by the hedonic estimate of the value of the environmental characteristic was confirmed empirically, with the survey results in quite close agreement with hedonic findings.

However, the Brookshire application was tailor-made for success. First, the experiment took place in Los Angeles, where individuals are well aware of air quality differentials, where there are rather sharp pollution gradients across the region, and where public concern over air pollution is strong. It seems unlikely that there are close substitutes on a daily basis for the ambient air environment; and, most importantly, the fluid housing market of the late 1970's in Los Angeles tended to minimize the disequilibrium arguments. That is, the rapidly escalating house prices made it feasible to move often, despite the existence of real estate commissions and moving expenses.

Our impression is that the conditions for estimating value of water quality are seldom so favorable. First, a major ingredient of the value of a river to a nearby household is access to recreation. If there are close substitutes within the region, hedonic estimation becomes undependable. A second problem is one of perceptions. Our two studies revealed that the sample households have only vague notions of river water quality -- certainly nothing rivaling the sophistication of most households in the South Coast Air Basin in Los Angeles, wherein radio and television news programs and newspapers report the air quality index daily for various valleys in the basin. And air quality is pervasive and subject to constant perception, in contrast with water quality which is generally of concern only on those occasions when the river is used.

as fluid and with as wide a range of house models as in Los Angeles during that period. It seems difficult, therefore, to minimize the likelihood of chronic house market disequilibrium due to the typically fairly substantial transaction costs. To this we add a reviewer's observation that in addition to home purchasers' criteria for selecting a home to buy, we should not discount the method by which offer price is generally set -- viz., realtors visit, count bathrooms, etc., but seldom check water quality in the river nearby.

Finally, if the other problems weren't enough, we suspect that given the multiplicity of objectives that bear on the choice of a home to purchase, it stretches the imagination to believe that preferences for water quality characteristics are accurately reflected in the decision alongside all other arguments of the utility function. Limits to the information processing ability of the human mind have been discussed elsewhere in the JOURNAL (Willis and Perlack). Miller provided an early and an entertaining synthesis of the literature on this point. He begins, "My problem is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data, and has assaulted me from the pages of our most public journals. This number assumes a variety of disguises, being sometimes a little larger and sometimes a little smaller than usual, but never changing so much as to be unrecognizable. The persistence with which this number plagues me is far more than a random accident." Of course, this magical number is seven. He cites: 7 point rating scale; 7 categories for absolute judgment; 7 objects in the span of attention; 7 digits in span of immediate memory; 7 days of week; 7 notes of musical scale; 7 primary colors; 7 deadly sins; 7 digits of telephone numbers, among other "coincidences." He concludes that people are less accurate if they must judge more than one attribute simultaneously -- as they add attributes, they decrease the accuracy of the evaluation of any one. Similar conclusions have been reached in subsequent work. For example, Scott and Wright used regression analysis to compare buyers' decisions with self-reported weights for product evaluation. Increasing attributes to six led to instability in the weighting process.

Simply put, then, given the multiplicity of pressing criteria used in selecting a home, a characteristic with a relatively minor valuation by the individual may not even be considered in the ultimate decision on which house to purchase. Alongside the other considerations, including the transaction costs of making a change, it seems unlikely that the valuation of water quality differentials of less than one hundred dollars would be reflected in the sales price of a home.

It may be well to state explicitly that our conclusion is not that cleaner water, on the case study rivers or elsewhere, is without value. Our simple point is that for most applications the reasons given make it unrealistic to expect that such valuations are accurately reflected in home purchase decisions. The results of our empirical applications lend support to this conclusion, but are not essential to it.

Freeman sandwiches the introductory quote with "...one's assessment of the hedonic technique seems to depend upon which end of the telescope one looks through in examining the theory, the assumptions, and the data. The theory is logical and consistent, but it involves a substantial simplification and abstraction from a complex reality. The assumptions are never completely realized in practice. But this is a dubious test of the validity of an empirical model.... But all of these criticisms can be raised against virtually any empirical work on economics. The hedonic technique for estimating benefits seems to pass the appropriate tests about as well, or as poorly, as any empirical technique for estimating such things as demand functions, production functions, consumption functions, and so forth."

For some applications of air pollution and noise, perhaps. But the points made above leave us with a healthy dose of skepticism in the case of water quality.

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