Ann Reg Sci (1992) 26:171–176

The Annals of
Regional Science

Measuring the economic value of water quality

The case of lakeshore land*

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Received September 1989 / Accepted November, 1991

Abstract. The valuation of water quality has proved difficult for economists using hedonic methods. This study, by employing a sample of lakes and considering only land values, is able to overcome many methodological and empirical problems inherent in previous studies. One objective measure of water quality, secchi disc reading, is found to be significant for various alternative specifications of the hedonic model. As explained, however, the results suggest that economic value may be attached to a perceived, rather than actual, measure of water quality. This raises fundamental questions as to how economists and natural scientists can work together to formulate public policy regarding water quality.

I. Introduction

While the importance of environmental quality has been asserted by those in many disciplines, measuring its economic value has proved a difficult task for economists. Most previous studies attempt, as will this one, to measure the property value of water quality using a hedonic approach. However, other methods have been tried. For example, a recent case in Minnesota regarding acid rain resulted in testimony using both the survey and travel cost methods. One side used a travel cost approach to argue that acid rain damage to a few remote lakes would not significantly change recreational usage. The opposition used a survey to show that non-users place a high value on the existence of these lakes without acid rain

* An earlier version of this paper was presented at the annual meetings of the Western Regional Science Association. This research was supported, in part, by grants from the Minnesota Legislative Committee on Minnesota Resources and the University of Minnesota Computer Center. The cooperation of the Minnesota Department of Natural Resources in supplying data is gratefully acknowledged as is the able research assistance of Wade Oman through the Undergraduate Research Opportunities Program. Comments provided by J. Knetsch and W. Sinclair on an earlier draft are gratefully acknowledged. Nonetheless, the author remains solely responsible for the opinions and conclusions expressed in this paper.

damage. Given the undeveloped nature of these lakes and their remoteness, the hedonic approach would not have been able to directly value the effects of acid rain. Indirectly, however, the results to be presented, which show transparency (secchi disc) increases property value, would actually indicate acid rain raises values. This paradoxical conclusion, which may reflect the difference between perceived and actual water quality, would follow from the fact that acid rain, by killing off algae, gives lakes a clear blue water appearance.

The hedonic approach, which is generally traced to Rosen [7], may be seen as involving a two-stage estimation process. First, prices are regressed on attributes and the estimated coefficients are interpreted as the marginal implicit prices of the attributes. A second, and more controversial, step is to estimate the demand for the attribute based on the first stage results. This study, as have most, will be confined to estimation of a first-stage hedonic equation for property values.

Before discussing the hedonic studies of water quality, it should be noted that, in general, there have been far fewer of these than for air quality and that the air quality studies have been more successful, both theoretically and empirically. One difference between water and air quality valuation, as reflected in property prices, is that attempts have been made (e.g. Brown and Pollakowski [1] and Knetsch [5]) to determine the value of water (shoreland) independent of considering the issue of water quality. For this type of estimation a general sample of properties is used and the value of water is introduced with a binary variable (on/off water) or an access measure (distance to water). On the other hand, the value of water quality can be best estimated using a sample of waterfront properties.

Sample selection requires that sufficient variation in water quality be present in order to allow for valuation using the hedonic approach. Previous studies have tried to achieve this by observing changes in water quality (over time) for the same location (body of water) or by sampling a cross-section of water bodies with variations in water quality. Either approach has its problems and creates the need to control for differences in time or in location. It may be argued that controlling for these differences is made even more difficult if the hedonic price equation is also required to value housing attributes in addition to land attributes since such housing attributes may be correlated with temporal and/or locational variations.

The few efforts to measure the property value of water quality have led to rather inconclusive, and questionable, results. Willis et al. [8] review the studies and find most to have a methodological flaw or insignificant statistical results. Likewise, their own effort, which they argue overcomes methodological weaknesses of earlier studies, leads to the conclusion, statistically, that water quality is insignificant. The earliest study, by David [2], used a cross-section of Wisconsin lakes and a subjective measure of water quality (poor, moderate or good). Nonetheless, the water quality variable was found to explain property values though she did not interpret the result in terms of benefits or derive a demand function for water quality.

Probably the most ambitious effort to value water quality was a study by Dornbusch and Barrager [3] which estimated a national value for pollution abatement of $ 1.3 billion. The study was based on property value changes due to water pollution control in various U.S. locations. Changes in value, between 1960 and 1970, were estimated on the basis of increases in excess of inflation as measured by the consumer price index. If housing inflation exceeded general inflation this was attributed to pollution control by their methodology. A clever, though dubious, way of controlling for temporal variation was to assume no changes in housing attributes during the decade.

Rich [6] tried to avoid introducing changes in housing and locational attributes by assuming the assessed values could act as a proxy. However, the high correlation between assessed value, used as an independent variable, and sales price led to water quality being insignificant. His sample was based on individual houses on a river sold between 1957 and 1975 with water quality change being introduced as a binary variable after clean-up of the river occurred.

Epp and Al-Ani [4] studied properties on streams and rivers and after considering various measures of water quality (acidity, nitrate, phosphate, etc.) used a measure of acidity, pH. Data were collected from 1969 to 1976 though they concentrated on cross-section comparisons of clean and polluted streams and rivers. The results did find water quality significant though the use of different communities raises some questions of cross-sectional variation. Also, the use of house sale data required that the equations specify housing attributes.

The final study to be considered is by Willis et al. [8] who, as noted, criticize all of the previous studies. Their own effort was based on sales of houses on two rivers in New England between 1962 and 1980. As with previous studies, the use of house prices required the specification of housing attributes, which provide most of the explanatory power. Water quality is introduced with a binary variable, as did Rich [6], indicating if the home was purchased after river cleanup. While they do adjust prices for housing inflation, the binary variable could still be correlated with a trend. In any case, the empirical results are viewed as futile by the authors.

The present study differs from previous work in several ways. It will use lakes, whereas most have used rivers, and it will use components of water quality, whereas most have used subjective or binary (clean-up/no clean-up) measures. Perhaps most unique is that values of land, rather than houses, are used for the dependent variable. This allows alternative specifications (per front foot or per lot) to be used and, more importantly, it means that housing attributes do not have to be specified in the model. In previous studies, they provide most of the explanation and if they are correlated with water quality (e.g. bigger, better houses are built on high water quality sites) it may diminish the explanatory power of the water quality variables.

Maybe the most questionable part of most studies cited is their use of data over a several year period. While prices are adjusted in most studies for inflation, there still remains a question of whether some trend might not be present. Since water quality is usually rising over the period it can easily be correlated with missing variables and thus achieve significance. While cross-section estimation solves this problem, it raises the question of whether there are community differences. Some cross-section studies introduce community attributes but the differences may still not be captured. This paper uses lakes which are all in unincorporated areas in Northern Minnesota and so community differences are minimal. Also, the properties on the land are seasonal and so the owners have less sense of community than do owners of properties in the previous studies. Finally, while the lakes do vary somewhat in terms of accessibility, this proved to be insignificant statistically.

II. Estimation results

The basis of the data to be used is an appraisal done by the Minnesota Department of Natural Resources of leased lots on 53 lakes in the state. Market appraisal procedures were used to determine the market value of the land, for each lot, so that the lots might be sold per a legislation decision. That is, the lots were compared to the sale of other lots in the same market and adjustments wrere made for terrain, accessibility, structures, etc. However, no explicit adjustment was made by the appraiser for water quality.

While appraisals were made for individual lots, the released data were aggregated for each lake. Hence, each observation is a lake and there may be more than one lot per lake. Consequently, the estimation can be viewed as explaining the average price (per lot or per front foot) for a lake. As a result, the question of what factors (like terrain or tree cover) might effect individual lots on a particular lake is not being addressed.

As a result of using lakes as cases, there are three ways in which price, the dependent variable, might be measured. They are: total price of all lots on lake (TPRICE); average price per lot on lake (PPERLOT); and average price per front foot on lake (PPERFF). Each of these will be used in the estimation process and comparable results for water quality will be found. Also, it might be noted that when total price is used as the dependent variable a higher R^2 is obtained. However, this is simply reflecting the correlation between TPRICE and the independent variables (e.g. TLOTS and TLOTAC) which are measuring scale. When the data are scaled (i.e. per lot or per front foot) the R^2 values are much lower.

In addition to the water quality variables, other factors about the lake influencing land values were considered and tested, including lake size, lake depth, and accessibility. However, none of these proved significant and so they were not used.

Given the focus on water quality, alternative measures were considered. These data were obtained from a data base maintained by the Minnesota Department of Natural Resources for each lake in the state. While the readings were not taken on each lake in the same year, the temporal changes in the lakes were considered small relative to the cross-sectional variation which is of interest. The objective measures of water quality considered were: the percentage littoral (shallow water); a measure based on amount of suspended organic material in water, and WSCD, the number of feet below the surface a secchi disc reading can be observed. There was little multicollinearity between the water quality variables and when used in the estimation WSCD was the only water quality variable to be consistently significant. Consequently, the regression equation results in Table 1 only use this measure of water quality.

Table 1 provides results using the three specifications of price. In each, the WSCD variable is significant and has the expected sign. Likewise, the measures of land size (acreage and front feet) have the correct signs in specifications 1

Table 1. Results of regression analysis for hedonic price equations

Specification	1	1	3
Dependent variable	PPERLOT	TPRICE	PPERFF
Constant	4048.33	−32249.63	50.98
WSCD	206.00	3383.79	1.99
T-value	(4.25)	(2.74)	(4.73)
ACPERLOT	3295.96		
T-value	(1.17)		
FFPERLOT	10.70		
T-value	(0.92)		
TFFOOT		73.77	
T-value		(1.52)	
TLOTAC		3159.69	
T-value		(0.73)	
TLOTS		−571.71	
T-value		(−0.13)	
ACPERFF			2235.34
T-value			(0.69)
R Square	0.31	0.74	0.31
Number of cases	53	53	53

(Y = PPERLOT) and 3 (Y = PPERFF). Specification 1 may be interpreted as indicating that, given the same acreage, lots with more frontage are more valuable, as would be expected. On the other hand, when front footage is controlled for (specification 3) more acreage is more valuable.

Specification 2, which uses TPRICE as the dependent variable, gives a higher R^2 but this can be attributed to the equation explaining scale. While TLOTS is insignificant in specification 2, its negative sign can be interpreted as saying that, given a certain number of front feet and acres, the total value of lots on the lake (TPRICE) will be increased by having fewer (large) lots.

Given the means of TLOTS (19.6) and TFFOOT (2180), the results for WSCD are similar for each of the specifications in Table 1. For example, specification 1 indicates each additional foot of WSCD will raise the value of a lot $ 206 while specification 3 shows the value of a front foot to be $ 1.99. If the $ 1.99 in specification 3 is multiplied by the average front feet per lot (121), the result ($ 240 per lot) is comparable to the result in specification 1. Thus the effect of water quality on land values is not varied by the specification of price. Viewed together, the results in Table 1 provide evidence that the measure of water quality tested, WSCD, has a definite effect on land values regardless of how these values are measured. Also, this conclusion was also obtained when estimation was done using logs and forcing the regression through the origin.

III. Conclusion

The results presented suggest that the effects of water quality on land values can be determined using a hedonic approach. The approach taken and the data used represent a departure from previous studies which have tried to explain both land and structure values by using the sale prices of houses as the dependent variable. Given water quality only influences the land value, it follows that a data set like the one used, which has land value as the dependent variable, offers greater potential for measuring the economic value of water quality.

One potential dilemma posed by the results is that economic value, at least in terms of land, is found to be derived from what may be a perceived, rather than actual, measure of water quality. That is, secchi disc readings are low in many of the lakes because tannic acid is present, which gives water a dark brown color. However, this coloration does not lower the quality of the water in any scientific sense. This may be another example, like acid rain making a lake clear, where perceptions of water quality differ from the reality of water quality. The presence of such differences may limit the ability of hedonic valuation to distinguish between perceived and actual water quality but, on the other hand, other techniques may have similar problems. Consequently, the economic valuation of water quality remains both a theoretical and empirical problem which may be best resolved by social and natural scientists working together. Only such coordination can develop a coherent public policy regarding water quality.

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