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SPECIAL ASSESSMENT TAX FOR WATER QUALITY IMPROVEMENT*

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Abstract: Although there exists an unequal distribution of benefits associated with urban lake improvement projects, financing of such projects typically relies on property taxes which do not make this distinction. A more equitable tax, based upon a property value impact model, is proposed whereby costs levied are commensurate with benefits received.

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Past research has demonstrated that location dependent amenities, such as urban lakes impact surrounding property values differently depending on the distance of the property from the resource (Kitchen and Hendon; Hammer, Horn, and Coughlin; Ridker and Henning). Correspondingly, an improvement of that amenity, such as an increase in water quality (WQ), will provide property value benefits that diminish as distance from the resource increases. Typically, the financing of these amenity improvement projects is accomplished by levying uniform property taxes that do not recognize this unequal distribution of benefits. An example of this problem can be found in Wisconsin where a lake protection and rehabilitation program was established in 1974 (Wisconsin State Statutes). This legislation provides for the creation of lake districts by specifying the managerial and financial powers that enable districts to implement lake improvement programs. Of particular interest here are the financial powers the districts are authorized to use. The general property tax is prescribed for activities such as feasibility studies and administrative expenses that <u>do not</u> specifically impact individual properties. Such a tax has to be uniformly applied to all taxable properties within a district. For major project expenses that <u>do</u> directly impact individual properties, however, it is necessary to determine the benefits accruing to each property, considering such factors as size, proximity to the lake and present use of the land. After the benefits to each parcel has been determined, special assessments are to be made in an aggregate amount equal to the local project costs that the district has to pay. Using the "benefits received" criteria, each property owner is to pay taxes proportional to the benefits expected to be capitalized in the property as a result of the project.

In reality, the special assessment section of Wisconsin's Inland Lake Management Law has been ignored by the local lake district commissioners, who have relied exclusively upon uniform property tax levies for local funding of project costs. The result of this reliance upon a uniform property tax is that there does not exist conformity between the impact of benefits and costs of a project and thereby distributional inequities are created among the property owners within a lake district.

The purpose of this paper is to propose a tax that allocates costs in proportion to the "benefits received" by property owners. This tax is constructed with the aid of a property value impact model developed in an earlier study that yielded a general method to assess the property value impact from any WQ improvement project (Dornbusch). This model is first described and then an empirical application to the Shadow Lake Rehabilitation Project is used to illustrate the distributional inequities that resulted when this lake district failed to make special assessments based on a "benefits received" criteria.

<u>The Property Value Impact Model</u>

Since WQ is not sold in the open market, there is no directly observable price that can conveniently be interpreted as the consumer's marginal willingness-to-pay for an improvement in WQ. Consequently, a technique must be employed that allows these benefits to be imputed. One such method is the property value impact model.

The basic premise of this model is that water resource projects have value to the general public which are adequately reflected in the market prices of those properties which are situated near the resource. Often a public project serves to enhance the productivity or utility of a resource, thereby increasing its value. Classical rent theory asserts this change in value can be measured in land rents. Benefits from a public project, then, can be measured by the sum of the changes in these rents over all firms and households.

The benefits from a water resource depend on both the quantity and quality of the resource available to the consumer. The quantity of benefits or services from a water resource is a function of one's accessibility to that water resource. It is reasonable to assume, then, that more benefits accrue to residents living closer to the resource than do those living further away (Weicher & Zerbst). Consequently, the benefits from a change in the WQ, and hence its effect on property values, ought to diminish with greater distance from the water resource. Since the supply of residential homes at any given distance from the resource is fixed at any given point in time, then the residential home market supply (quantity) used in the determination of property values remains constant and perfectly inelastic. This is demonstrated in figure 1 where an increase in WQ from WQ_a to WQ_b (if viewed as an amenity possessing positive utility) can be represented by an upward shift in the demand schedule from D_1 to D_2. The resulting change in property price, $\Delta P=P_2-P_1$, is equal to the marginal value of WQ change, for a given quantity of residential properties at a distance DW_j from the water. Since the supply of residential properties at a given distance from the lake at a given point in time is inelastic and constant, an observed ΔP in property values could not be the result of a change in supply factors. Consequently, it can be seen that DW provides a theoretically adequate and operationally convenient proxy for the quantity aspect of water resource services.

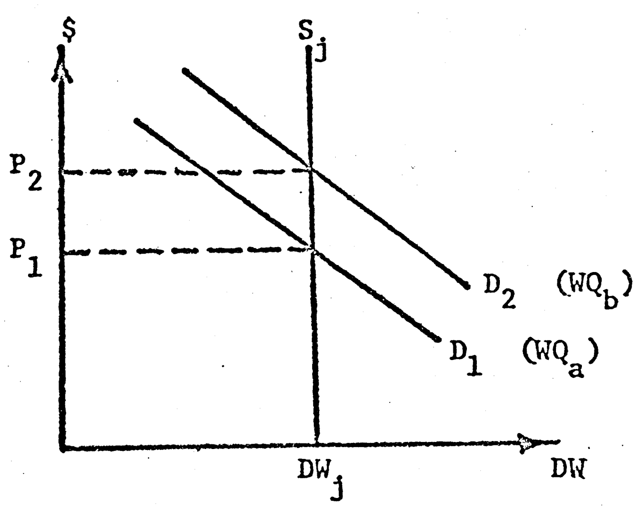

Figure 1. Supply as a Function of Distance to the Water (DW)

The magnitude of the property value changes is dependent in part upon the amount and value of the land which is considered to be impacted by the project. Industrial land benefits are excluded since industrial production costs are relatively insensitive to WQ, and property value benefits for those lands are expected to be too insignificant to warrant their inclusion. Commercial properties should be included as increased trade due to better WQ will provide benefits. However, in the example presented here we are dealing primarily with local daytrippers rather than nonlocal recreators who would have likely increased business sales. Consequently, the analysis at hand is restricted to the impact on residential property values.

The qualitative aspect of the causal chain that has been postulated between a change in WQ and property values is more complicated than figure 1 suggests. A change in the quality of a water resource must be perceived by residents of the area, and it is this perception of WQ changes that affects the value of their properties. If an actual WQ change remains unnoticed, or if what is noticed is not valued, no benefits will result. Perceived change may have little or no correspondence to factual changes. Likewise, what is technically important in WQ may bear little, if any, resemblance to what the lay public considers valuable. Consequently, the property value impact model requires the inclusion of an explanatory variable that captures the WQ aspects that are perceived by people. Also, these perceptions must be weighted according to residents' valuation of the different WQ characteristics comprising the change. To deal with this problem an index of subjective perceptions of WQ characteristics was developed using a general opinion survey of 135 respondents at nine representative sites throughout the U.S. (Dornbusch). The primary WQ aspects understood by lay people were found to be: (1) industrial wastes in the water; (2) debris in or on the water; (3) clearness of the water; (4) algae in the water; (5) odor from the water; (6) wildlife support capacity of the water body; and (7) the recreational opportunities offered by the water body.

These respondents also rated the degree of acceptability for each of five WQ conditions (A = excellent to E = poor) for each of these seven characteristics of water quality on a scale of zero for totally unacceptable to twelve for totally acceptable. A standardized grid was then developed to transform the vertical axis to percent attainable benefits. A curve was then fitted to the respondents' mean level of acceptability for each WQ condition. This was done for all seven characteristics. An example is shown in figure 2 for recreation opportunities. Here, as with the other measures of WQ, the curve exhibits an "S" shape which is both intuitively and theoretically appealing as it indicates that a certain threshold in the WQ has to be reached before an improvement will yield benefits, and that there exists a point beyond which further improvement yields diminishing returns in terms of residents' evaluation of the change.

The respondents also weighted the relative importance of each of the seven WQ parameters. The capacity to support recreational opportunity and wildlife provided by the water resource were viewed as the most important characteristics while the presence of algae in the water was deemed the least offensive.

This information would be used to determine the amount of perceived WQ change in the following manner: After a change in WQ has been achieved for a given resource, the consensus of the community with regard to the amount of change for each of the seven categories would be ascertained through a survey. The amount of change would take the form of "from condition ______ to _____ condition." The corresponding value is then determined from the relevant figure (for ease of compilation these values have been transferred to tables, and multiplied by the relative weighting for that category. This would be done for all seven categories, and the resulting values summed to give a value representing the Perceived Water Quality Index by residents. Mathematically this is presented by:

$$PWQI_{Res} = \sum_{k=1}^{7} a_k B_{ijk} \qquad (1)$$

where $PWQI_{Res}$ is the perceived water quality index by residents; a_k is the relative weighting of category k, and B_{ijk} is the corresponding value from Table 1, reflecting the change from condition i to condition j for the k^{th} category.

For the purpose of designing a tax it is necessary to develop an *ex ante* procedure that will predict the residents' perceived changes in WQ. Thus, it was necessary to determine the relationship between experts' and residents' perceptions of WQ. This relationship, as represented by equation 2, was estimated by using pooled, cross-sectional data from 17 sites across the U.S. where lake restoration projects had already taken place (Dornbusch). The perceived WQ index of residents is now estimated by:

$$PWQI_{Res} = -24.778 + 0.463(PWQI_{Exp}) + 15.50(\text{Public Access}) - 7.056(\text{River}) \quad (2)$$

where River is a dummy variable; where Public Access varies from 3 to 1 as shoreline becomes more accessible; and $PWQI_{Exp}$ is the perceived WQ index of experts calculated in the same manner as equation (1).

The basic model, recall, postulates first that a perceived change in WQ by area residents will be represented by a change in property values and secondly that the impact on property values decreases as distance from the resource increases. This relationship can be expressed as:

$$\Delta P\% = B_o + B_1 \quad (1/DW) \qquad (3)$$

where ΔP% equals the percentage change in property value; B_o is a constant term that is required to bring the value of the function to zero for the limiting factor of DW; and B_1 measures the impact of a perceived change in the quality aspects of the water resource on residential property value. A two stage least-squares procedure was used to estimate B_1; the results were:

$$b_1 = e^{6.398}(PWQI_{Res})^{0.492} e^{1.180(\text{WBT Lake})} e^{0.991(\text{WBT Bay})} \qquad (4)$$

where WBT Lake and WBT Bay are dummy variables that take on the value of 1 if the water body type in question is a lake or bay, respectively and 0 otherwise.

The final, estimated, property value impact model to be employed in the forecasting of the economic benefits of a WQ improvement project on each residential property within a lake district is:

(a) $PWQI_{Exp} = \sum_{k=1}^{7} a_k B_{ijk}$

(b) $PWQI_{Res} = -24.778 + 0.463(PWQI_{Exp}) + 15.50(\text{Public Access}) - 7.056(\text{River})$

(c) $b_1 = e^{6.398}(PWQI_{Res})^{0.492} e^{1.180(\text{WBT Lake})} e^{0.991(\text{WBT Bay})}$

(d) $b_o = -b_1(1/DW_{max})$

(e) $\Delta P\%_d = b_o + b_1 \ (1/\overline{DW}_d).$

The use of property value impacts as a measure of project benefits has two limitations. First, the increase in property values caused by an increase in the amenity schedule also leads to higher taxes which are capitalized into the property price. Therefore, only part of the value of the increase in benefits will be reflected in the market price of the property. Consequently, there exists an underevaluation of benefits to the extent that these impacts are capitalized into the property value (McMillan). Secondly, the use of property values disregards the benefits that accrue to users who reside outside the impacted area (Darling).

For the purposes of designing an equitable tax these two limitations do not present a problem. First, the capitalization of future tax impacts into the property values are relative to the expected benefits, consequently, the relative tax burdens will not be changed in the approach proposed here. Secondly, it is assumed that the federal, state and local cost shares for the project have been appropriately determined to reflect the benefits to users from outside the area.

Application to Shadow Lake (Waupaca, Wisconsin)

In 1975 the Waupaca Lake District was formed when it became apparent that Shadow Lake was experiencing WQ problems. The District requested and received state and federal aid for the implementation of a storm water diversion project, which consisted of storm sewer diversion, alum treatment and lake aeration.

The utilization of the property value impact model to design a tax to cover this requires the following information:

(a) Annual estimates by a water quality expert of changes expected in the seven WQ parameters both with and without the project;

(b) the percentage of shoreline that is accessible to the public;

(c) the relevant maximum distance-from-the-lake for the residential area considered to be impacted by the project;

(d) the property values for residential properties within the impacted area and their distance to the lake; and

(e) the effective time period of the analysis.

With this information the annual, incremental percentage change in property values for each year is calculated. To simplify our calculations, the impact area around Shadow Lake was divided into ten concentric zones. The total direct project benefits were then determined by multiplying the incremental percentage change in property values for each distance zone by the corresponding sum of property values in the zone; this was done for each year a change in WQ occurred. The 1977 present value of these benefits were calculated for each zone by using a 7-1/8% discount rate as specified by the Water Resources Council for federal projects. In Table 1 the total estimated percentage of "benefits received" for the residential property owners of each zone along with the percentage of costs borne by the respective property owners is presented. An examination of this information readily reveals that while each residential property owner paid for a portion of the project according to the before-the-project, property value, the well-being that each residential property owner enjoys as a result of the project did not vary in the same manner as the amount of taxes each had to pay. This is caused by the fact that the predicted impact on property values, due to perceived improvements in WQ, diminishes as distance from the lake increases. Consequently, the increase in the well-being of residential property owners close to the lake has, in part, come at the expense of the property owners situated further from the lake. Therefore, the tax which is being proposed here will require that the percentage of costs borne by each zone be proportional to the benefits received by that zone. The costs would then be allocated by property value within the zone.

Conclusions

In the process of estimating the property value impacts associated with the Shadow Lake Rehabilitation Project it became clear that the distribution of benefits was not commensurate with the taxes levied to pay the local cost share of the project. This discrepancy in the distribution of the benefits and costs is attributable to the difference in the proximity of the impacted properties to the water. Consequently, the increases in the well-being of the property owners closer to the resources comes at the expense of those further away.

If the goal of local decision makers is to design a more equitable property tax, based upon the welfare criteria of "benefits received", then it is necessary to provide as much conformity as possible between the incidence of project benefits and costs. This can be readily and inexpensively accomplished using the property value impact model presented above to predict what the benefit to property owners will be in a district and then allocating the project costs in proportion to those benefits.

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