ENVIRONMENTAL VALUATION TECHNIQUES

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Abstract. This paper is about the valuation methods of the environment. The purpose of this paper is to present shortly the possible methods of environmental valuation. Environmental changes are difficult to value because there is no price or market associated with the change. This is the reason of so many technical difficulties and ethical issues, that this domain arose in front of our days' scientists.

1. Introduction

The economic sustainable development is the main concern of our days' decision makers. We need to improve continuously our living standard that is the social command, especially through economic development, but in the same time to maintain or to grow the welfare recording to the natural resources and environmental abusive utilization. A rational balance between economic development and natural resources and environmental exploitation is the task for assuring the welfare. Looking for a solution in that way the most reasonable is to start up the building of this balance with every economic project with impact on environment and to calculate the balance between economic and ecologic aspects. The balance is relevantly a question of welfare. In the future the economists and decision makers have to consider this requirement in their decision. One of the first steps in this process is to evaluate the cost of environmental damage. The research resulting in this paper is part of the Research Project ID-1239/2007, funded by the Romanian Education and Research Ministry.

2. Benefit-Cost Analysis and Microeconomic Valuation Methods

The benefit-cost (B/C) criterion is a well-applied technique for judging the acceptability of a certain development project. In the context of B/C analysis, the acceptance of a proposed project whose implementation has negative and significant impact on the environment is based on the following criterion:

$$B_e / (C_e + C_n) > 1, \qquad (2.\ 1)$$

where B_e is the discounted total economic benefits to be derived from the project, C_e is the discounted total economic costs and C_n is the discounted total environment costs. C_n is measured either as the value of environment benefits which is preserved if the proposed project is discontinued or, symmetrically, the value of environment costs if it is pursued.

For an environment -friendly development project, the equivalent B/C criterion is

$$(B_e + B_n) / C_e > 1, \qquad (2.2)$$

where B_n is the discounted environment benefits which is measured as the value of lost environment gain if the project is not pursued, or symmetrically, the value of the environment benefit if the project is implemented.

The measurement of the environment cost, C_n, and the environment benefit, B_n, is usually done using microeconomic valuation methods. Actually, however, most B/C analysis excludes natural resources and environment costs and benefit valuation. A reason for this is that almost all natural resources and environment goods are under-priced, if not freely provided. This makes their "true" values difficult to measure. Several microeconomic valuation methods are employed in natural resources and environment analysis. As stated earlier, the reason for reviewing these methods is that they are potentially useful for the project management, especially for investments in fix assets with high impact on environment and natural resources.

3. Microeconomic Valuation Methods

Microeconomic valuation methods can be classified into market-oriented and survey-oriented methods. Market-oriented methods are further disaggregated into methods using actual markets and those employing surrogate markets.

3.1 Methods Using Actual Markets

3.1.1 Productivity Change Method

The productivity change method measures the NRE impacts of a project by looking into its on-site and off-site effects on the on the productivity of man-made or natural production systems. Theoretically, the method assumes that NRE quality is another input in the production process. Therefore, the production function can be reformulated as

$$X = f(L, N, K, E) \qquad (3.3)$$

where X is the output, L, N and K are the usual inputs land, labor and capital and E stands for NRE quality. In this revised production function, it is supposed that a change in E will change production costs which, in turn, either change the quantity and price of the output or the returns to the other inputs or both.

The general steps followed in quantifying productivity gains or losses from NRE changes using the productivity change method are:

a. measuring the production response to the NRE quality change and as consequence quantifying the gains or losses of producers in terms of increases or decreases in profits;
b. measuring the consumption response to the production changes and as consequence quantifying the gains or losses of consumers in terms of changes in consumer surplus;
c. measuring the gains or losses of owners of factor of production in terms of increases or decreases in factor returns;
d. measuring the total benefits or losses from the quality changes by aggregation of the different values attained in the previous computations.

Where efficient markets exist, the valuation of productivity gains or loses from NRE quality changes in each of the above steps is based on actual market prices. On the other hand, when markets are distorted, adjustment will be made so prices used in valuation to reflect true prices.

The productivity change method is often used in valuing the productivity effects of projects affecting the land, such as projects which cause the soil erosion, improve the quality of irrigation water or abate water pollution caused by industries.

3.1.2. Human Capital Method

The human capital method is used to assess the impacts of NRE changes on people. It is founded on the generally accepted notion that NRE damage can have negative and significant costs on human health. The human capital method measures the human costs of NRE damage by valuing the foregone opportunities of people resulting from NRE-induced health problems. In the case of premature illness or death of an individual, the following general formula of Mishan (1972) can be used as the measure of the value of the life:

$$L_1 = \sum_{t=T}^{\infty} Y_t \, P_T^t (1 + r_t)^{-(t-T)}. \qquad (3.4)$$

where L_1 is the discounted value of the labor of individual 1; Y_t is his expected gross earnings, or value added, in the t-th year outside of returns from non-human resources he owns; P^t_T is the current (year T) likelihood that he will be alive in year t; and r_t is the social discount rate in year t. The sum of the cost of death of the individual is L_1 plus the medical costs. However, these costs can be expanded further to include the cost of the disutility related to the suffering of the family and friends of the individual. This method is used to estimate the value of morbidity and mortality associated to air and water pollution. The value of the health effects of air pollution is significantly greater than the value of the health impact of water pollution although both types of pollution substantially affect the health.

3.1.3 Opportunity Cost Method

The opportunity cost method is based on the opportunity cost concept which, for a given resource, is defined as the value of the benefit that accrues from the best alternative use of resource. In NRE valuation, there are basically two kinds of opportunity costs: the opportunity cost of development, which is measured as the present value of the benefits from preservation, and the opportunity cost of preservation, which is estimated as the present value of the benefits from development. Empirically, the opportunity cost method is more often used to measure the opportunity cost of preservation only. This is because the benefit from development, or the opportunity cost of preservation, can be easily quantified from the existing markets. The method is seldom used to measure the opportunity cost of development which is the value of preservation benefits, because many of the goods produced by preservation are not traded and are difficult to estimate.

An opportunity cost technique often used for assessing the cost of preservation is the computation of the net present value of value (NPV) from a project. The general form of the net present value formula is

$$NPV_0 = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1 + r)^n} \qquad (3.5)$$

where NPV_0 is the net present value in year 0, B_t and C_t are the values of the total benefits and total costs in year t, r is the discount rate and n is the number of years of project life. If the NPV of the project is small relative to some estimated value of preservation, the project is rejected.

3.1.4 Cost-Effectiveness Method

The cost-effectiveness (C-E) method is useful for comparing projects that have comparable outputs. The method selects among projects the one which either minimizes costs given a fixed output or maximizes output with a fixed cost. In the case of the NRE sector, the output of concern may be some kind of NRE quality level, such as a certain pollution standard for instance.

Sometimes the application of the C-E method leads to mathematical optimization and programming models which generate optimal solutions for selecting the optimal project. The method, however, may use also the traditional approach of simply comparing financial estimates between competing projects. There are studies in practice using optimization and programming models for C-E analysis.

3.1.5 Preventive Expenditures Method

The preventive expenditures method is a valuation approach which measures the value people attached to NRE quality through the expenditures people in order to prevent quality decline.

The preventive expenditures method assumes that when faced by a decline in NRE quality, e.g. neighborhood air pollution, the affected individual has the choice of ignoring the problem, moving to another area or spending on measures which mitigate the problem. The amount spent by the individual to prevent the quality decline is taken as his personal valuation of the NRE quality before the deterioration occurred. The total expenses of all affected individuals for preventive measures are then used as the substitute demand curve for NRE quality. The preventive expenditures method has been fairly applied internationally.

3.1.6 Replacement Cost Method

Similar to the preventive expenditures method, the replacement cost method provides a value of environment quality. In contrast, however, the method takes as proxy measure the cost of replacing productive assets destroyed or rendered unproductive by the deterioration in environment quality. The cost of replacement is usually counted in terms of market values of physical replacements (e.g. cost of fertilizer to solve soil fertility loss). Therefore, the replacement cost method is a relatively straight-forward one to implement, assuming that it is technically feasible to replace damaged systems.

3.1.7 Shadow Project Method

The shadow project method is a special type of the replacement cost method which uses the cost of putting up a hypothetical shadow project which provides an alternative source of environment goods lost to development as the substitute estimate of the value of the natural resources and environmental goods. Assuming technical feasibility of a shadow project, the method is straightforward to apply although understatement of costs will likely occur since the total value of the lost environmental good may always significantly outweigh the cost of the shadow project.

3.1.8 Relocation Cost Method

The relocation cost method is similar to the preventive expenditures method but instead of estimating expenditures on prevention, it uses the cost of relocation from the area where there is an environment problem to an area where the environment amenity is better as a proxy measure for environment quality. The amount an individual is willing to spend for the relocation is taken as his valuation of the benefits of an improved environment quality in the new area or the cost of disbarment in the old location.

3.2 Methods Using Surrogate Markets

In contrast to the valuation methods directly using actual markets reviewed above, the methods reviewed below indirectly use actual markets only. These methods are called surrogate methods because they estimate the value of un-marketed environment goods by using the values of other marketed goods. These methods are also known as hedonic price methods and have been introduced in 1974.

3.2.1 Marketed Goods as Environment Goods Surrogate Method

This method is useful for measuring the benefits of environment improvement in situations where a privately marketed good is a perfect substitute for an environment good. In such a case, the value of costs or benefits from the fall or rise in the supply of the non-marketed environment good is approximated by the value of the increase or decrease in the demand of the marketed private good. The marketed goods as environment goods surrogate method is easy to apply since the demand for the substitute goods that are marketed are usually easily known and, thus, measured. A constraint of the method is that isolating the change in the demand for the marketed substitute good specifically induced by the change in the supply of the un-marketed environment good can prove difficult.

3.2.2. Property Value Method

The property value method estimates the value that people attach to an environment improvement, such as a decline in air pollution in a certain locality, by studying the actual market for real properties, such as housing, that are affected by the improvement. Taking the housing and air pollution example, the property value method is applied by first assuming that the area analyzed is a single, well-functioning and competitive market for housing. Under these assumptions, the following relationship can be defined

$$R_i = f\ (P_i, A_i, N_i, E_i) \qquad (3.6)$$

where:

R_i are the prices of housing (usually measured as rent per unit of time);

P_i are the physical characteristics of housing such as house size, lot size, number of rooms, age of house, type of construction materials, etc.;

A_i are the accessibility characteristics such as distance to market, school, church, place of employment, etc.;

N_i are the neighborhood characteristics such as average income of neighborhood residents and crime rate of neighborhood, etc.;

E_i denote the air quality or pollution level in the housing location.

Computationally, the method proceeds by assuming a functional form for the relationship in equation (3.6). Assuming a linear function, the estimated equation is

$$R_i = a_0 + a_1 C_{1i} + a_2 C_{2i} + ...+ a_n C_n + a_e E_i + e_i \qquad (3.7)$$

where a_0 is the intercept, the a_i-s are the coefficients, C_i-s are the housing characteristics, a_e is the coefficient for the air quality variable, E_i and e_i are the error bounds. With a linear equation, the marginal willingness-to-pay (WTP) for an additional unit of improvement in the air quality is measured by the coefficient a_e. The total incremental benefits of an air pollution reduction program that improves air quality is estimated by

$$V = \sum_{i=1}^{s} a_{ni}(Q_2 - Q_1) \qquad (3.8)$$

where V is the total incremental benefit, Q_2-Q_1 is the improvement in air quality, and s is the number of housing in the study site.

3.2.3. Wage Differential Approach

The wage differential method is similar to the property value method except that here, instead of the market for real property, the market for labor is used as the surrogate market for environment quality. The wage differential method starts by assuming a competitive labor market situation where the main motivation of workers for accepting jobs associated with greater exposure to environment hazard is higher remuneration. Then, it assumes a wage equation of the form

$$W_i = f\ (J_i, L_i) \qquad (3.9)$$

Where: W_i is the wage level i; J_i is the non-environment related job attributes such as distance from residence, etc.; L_i is the environment-related job attributes such as exposure to air pollution, etc.

Equation (3.9) is estimated assuming a specific functional form. If the functional form is linear and the environment-related factor considered is air pollution at the job site, then the estimated equation is

$$W_i = b_0 + b_1 D_{1i} + b_2 D_{2i} + ...+ b_n D_n + b_e A_i + u_i \qquad (3.10)$$

where b_0 is the intercept, the b_i-s are the coefficients, the D_i-s are the job characteristics, a_e is the coefficient for the air quality at the site variable A_i and u_i is the error term. The marginal willingness-to-accept (WTA) a higher or lower wage for a unit of additional unit of decrease or increase in air quality at the site is given by the coefficient be. The total amount workers are willing to accept for a reduction in air pollution at the job site is estimated by

$$V = \sum_{i=1}^{s} b_{ni}(W_2 - W_1) \qquad (3.11)$$

where V is the total change in wage and W_2-W_1 is the change in air quality.

3.2.4. Travel Cost Method

The travel cost method is an approach used for measuring the value of public recreational services such as parks, amusement centers and similar amenities. The method was developed because directly estimating the value attached to these places by users based on subsidized admission fees will grossly underestimate true values. For the analysis of a specific recreation site, application of the travel cost method contains the following steps:

a) zoning of surrounding areas of the recreation site (where visitors come from) based on distance from the site;

b) surveying the site users to get information on zones of origin, visitation rates, travel costs and socioeconomic characteristics;

c) estimating the following visitation rate function of each zone:

$$V_i = f(T_C, X_1, ..., X_n) \qquad (3.12)$$

where: V_i is the visitation rate computed as the number of visitors from the zone i divided by the population of the zone (this can be varied by further subdividing the zone into specific areas, e.g. districts); T_C is the travel cost (time and resources costs) of each visitor from the residence to the site; X_1, ..., X_n are socioeconomic variables associated to each visitor;

d) using the information from step c) to create a demand curve for each zone relating travel cost to total visitation;

e) computing the consumer surplus from each zone assuming an actual user admission fee;

f) summing the consumer surpluses for all zones to arrive at total consumer surplus.

This total surplus estimates the gains by all users from the use of the site.

4. Contingent Valuation Methods

The contingent valuation methods (CVM) are techniques used to analyze the value people attach to Environment changes, not by using actual or surrogate markets, but hypothetical markets. The main source of data of the CVM is the survey which uses questionnaires asking preferences of respondents representing the population who are potentially going to be affected by an assumed Environment change. The name "contingent valuation" implies that the choices people reveal in the survey assuming a hypothetical market are contingent on the actual occurrence of the said market.

4.1. Bidding Game Approach

The bidding game is a CVM technique which directly asks respondents their willingness-to-pay (WTP) for a specific environment improvement or their willingness-to-accept (WTA) compensation for NRE environment. There are basically two bidding game systems, the single-bid system and converging-bid system.

The procedure in the bidding game approach is as follows. First, the interviewer describes accurately to the respondent the specific features of the environment improvement or damage in question, including its quantity, quality, location and the respondent's access rights. Next, the respondent is asked about his WTP or WTA associated to the improvement or damage by using a single-bid or converging-bid system. In the single-bid system, the respondent is asked only once about the amount he is willing to pay or accept in relation to the improvement or damage. In the converging-bid system, the respondent is given a starting bid which he is asked to accept or reject. Once a starting bid is accepted, higher or lower bids are given until the maximum WTP or the minimum WTA of the respondent for the improvement or damage is ascertained. Once the WTP or the WTA of all the respondents are known from the survey, individual WTPs or WTAs are then summed up vertically to come up with an aggregate bid curve for the environment improvement or damage. This bid curve serves as proxy of the income compensated demand curve in analyzing the total value attached by the affected population to the project which causes an improvement or damage.

4.2. Tradeoff Game Approach

The tradeoff game is a CVM approach which gives the respondent a choice between having a lower or higher level of an environment good at no expense made or compensation received (base option) or a higher or lower level of the good but with some level of expenses made or compensations received (alternative option). In its simplest form, the tradeoff game gives the respondent a base option and a particular alternative option (which has a stated amount of money the respondent has to spend or to receive) to choose from. If he chooses the alternative, higher or lower amounts of money the respondent has to spend or receive is set until he is indifferent between the base option and the alternative option. The final amount of money in the alternative option acceptable to the respondent is then taken as an approximation of his maximum WTP or minimum WTA for the difference in the levels of the environment good between the base and alternative options. As in the bidding game, the individual WTP or WTA are added vertically to come up with the aggregate bid curve for the good.

4.3. Costless Choice Approach

The costless choice is a CVM technique which provides the respondent an option to decide between quantities of goods, that are desirable to him and at the same time provided free of charge (thus, costless). In the two-alternative case, the respondent is usually given a choice between an NRE good and an economic good. If the NRE good is chosen, the value of the economic good is taken as a measure of the minimum value the respondent attaches to the NRE good because by choosing the NRE, the respondent must have valued it at least as much as the economic good. If, on the other hand, the economic good is chosen, its quantity will be reduced until the respondent will choose the NRE goods over it. Once this happens, the value of the final quantity of the economic good again serves as the minimum approximation of the value of the NRE good. The vertical sum of these minimum values across respondents serves as an estimate of the aggregate demand curve for the NRE good. The main difference of the costless choice approach from the other CVM approaches is that in making choices, the respondent will have his choice free of charge, that is, he will not have to pay anything for the NRE good if he chooses it or he will not have to lose any existing NRE good if he chooses the economic good instead.

4.4. Priority Evaluator Technique

The priority evaluator technique is similar to the costless choice technique in that respondents are also made to choose between goods, among which is an NRE good. The technique, however, is unique for three reasons. First, the technique allows adjustment of prices of the goods from their initially set levels, to encourage convergence to a set of equilibrium values. Second, the technique considers only goods which meet conditions that simulate a perfectly competitive market, that is, the goods must be independent in production, they must be continuously variable in production and consumption and their consumption utilities must be independent of any other consumption. Third, the technique allows the respondents to make choices between goods given constrained income. The specific steps followed in the application of the priority evaluator technique are relatively more complicated and lengthy than those of the other CVM techniques.

4.5. Delphi Techniques

Delphi techniques are different from other CVM methods in that instead of interviewing representatives of the affected population, they generate opinion of experts on the NRE good in question. The Delphi technique usually involves experts residing in different areas. Those experts are independently asked through written communication about their valuation of an environment good. The initial values gathered from the experts are tabulated and sent back to them for further examination. Continuous re-evaluation by the experts is conducted until the valuation organizers believe a satisfactory average value of the environment good has been derived. The Delphi technique is highly useful for checking results of valuation studies using the other CVM techniques.

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