Economic-environmental Impact and Evaluation Model: a case study of Hydro-power /Water Supply/ Railway

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Abstract: This work aims at measuring the marginal effect of a key variable such as a hydropower generation/ water supply or railway system upon a set of relevant policy variable such as Economic variables, Environmental Impact Analysis. Only the impacts of the social-economic subsystem (E) and geographic-demographic subsystem (G) upon the environmental subsystem (M) is assessed. Therefore, the environmental profile is the central pivot of the analysis. Cost- benefit analysis was criticized for several reasons such as neglect of the equity criteria, does not incorporate uncertainties etc. in the survey of environmental evaluation, it is evident that in the framework of neoclassical or cost benefit analysis the evaluation of environmental commodities has to be based on market prices. When market prices do not exist for environmental commodities artificial price e.g. shadow prices have to be calculated in order to ensure an operational result. Methodology involves an Integrated Structure of Economic-environmental survey which was investigated in greater detail. In conclusion several methods developed and employed so far cannot be regarded as satisfactory evaluation techniques in an operational environmental policy analysis, because intangible and incommensurable effects are very hard to in corporate in all these methods. The conclusion is justified that any attempt to transform an un-priced impact into a single dimension must fail, unless corrected with Bayesian decision model or Markov chains, which could take care of uncertainties, equity, risk, time effect, and poor data availability etc

Keywords: economic, environmental, intangible, interaction, Bayesian Markov models.

1 INTRODUCTION

Neoclassical economics has dominated the post-war development of Economic thinking. In the Neoclassical framework, the Economic meaning of phenomena arises from the fact that they influence the level of individual or social utility in the case of scarcity (in an absolute or a relative sense). Utility is here a psychological variable associated with the level of want satisfaction that emerges from the use of scarce goods and services.

The inclusion of environmental commodities in a neoclassical framework can be defended on the following grounds: the environment can be used for alternative purposes (for example, supply of energy and resources, source of recreation and education, socio-ecological stabilizer etc.); the (relative and/or absolute) scarcity holds true for environmental commodities; there are competing uses (or functions) of the environment.

In the neoclassical framework, the value of a commodity is related to its price, so that the utility of a commodity can be reflected by means of an unambiguous quantitative measure. Free commodities (such as air and water) are assumed to have no price. The positive contribution of environmental commodities to human welfare (individual and social utility) is not reflected in the price mechanism, because these commodities are not sold and bought on a normal market; in addition, there are no clear proprietary rights for environmental commodities.

Consequently, there is no foundation for assigning a monetary value to these commodities. This situation implies that in a normal competitive system of a market economy an over-use of environmental commodities (i.e. a decline in the stock of environmental capital) will occur. Neoclassical economics may provide a closed explanatory framework for an economic analysis of environmental problems, but this framework may be too restrictive for an operational policy analysis due to the neglect or non-monetary values and of information from other sciences (for example, the materials balance principle).

The view that the quantitative and monetary value of production does not run parallel to the perceived individual and social utility was shared by Hirsch [1976], who has demonstrated that the production process of the advanced countries does not break down upon the physical limits to growth, but rather upon the social limits (such as stress, long-lasting illness, dissatisfaction with the quality of working life, etc.). This indicates once more that human well-being is not a unit-dimensional variable which can adequately be represented by means of a single indicator or a scalar function. Instead, human well-being is a multidimensional variable composed of several elements (such as income, environmental quality, distribution of power; quality of work life, etc);

The problem is that Neoclassical or cost-benefit analysis goes essentially one step further than an environmental impact analysis method because it assigns a value (a price) to all impact assessments, and can be criticized for several reasons: (i). it neglects the equity criteria (ii) it is partially base on shadow prices which is ambiguously determined (iii). it is very hard to in corporate uncertainties, risks and time effects (iv). in-tangibles can be hardly be incorporated in a meaningful way in a traditional cost-benefit analysis.

2 METHODS

Methodology involves a scheme of simplified Integrated structure of Economic – Environmental survey fig 1 and 2 which was investigated in detail. A section is devoted to Environmental Impact Analysis and a brief survey of Environmental Evaluation Analysis modified with Markov model as shown below

In developing this concept, effort was concentrated on the use of the gardener example, due to the nature of life problems encountered in most situations of conflict and to make it more understandable.

Markovian decision theory was developed by Andrei Markov in [1856-1922]. He was a distinguished Russian mathematician who developed the new mathematical tools for inventory modeling of all statistical probability. And the problems resulting from the game theory and dynamic programming motivated the improvement of the discipline such as Markovian Decision theory and Bayesian Decision theory which provided a new basis of inventory theory. Markov process originated in the problem formulated by Francis Galton.

The use of the gardener example for modification of the traditional cost-benefit analysis in this work is with the underlying philosophy that the example paraphrases several important applications in the areas of real life, inventory, maintenance, replacement, cash flow management, and regulation of electric power, hydro and water resources and environmental engineering. This work presents an application of dynamic programming to the solution of a stochastic decision process that can be described by a finite or infinite number of states. The transition probabilities between the states are described by a Markov chain. The reward structure of the process is also described by a matrix whose individual elements represent the revenue (or cost) resulting from moving from one state to another. Both the transition and revenue matrices depend on the decision alternatives available to the decision maker. And in the multi-purpose/and multi-objective nature of this work, the purposes and the objectives are in conflict to be satisfied with available limited resources. Therefore, objective of the problem is to determine the optimal policy or strategy, or action that maximizes the expected revenue over a finite or infinite number of stages.

Every year, at the beginning of the gardening season (March through September), a gardener applies chemical test to check the soils condition. Depending on the out comes of the test, the gardener's productivity for the new season falls in one of three states: (1) good (2) fair and (3) poor.

1. Over the years, the gardener observed that current year's productivity depends only on last year's soil condition. The transition probabilities over

a-1-year period from one productivity state to another can be represented in terms of the following Markov chain.

$$\overbrace{\begin{array}{ccc} 1 & 2 & 3 \end{array}}^{\text{State of the System next year}}$$

$$\begin{array}{c} 1 \end{array} \begin{pmatrix} .2 & .5 & .3 \end{pmatrix}$$

State of the system this year

$$\begin{array}{c|ccc} 2 & 0 & .5 & .5 \\ 3 & 0 & 0 & 1 \end{array} = P^1$$

2. The transition probabilities in P_1 indicate that the productivity for a current year can not be better than last year's. For example, if the soil condition for this year is fair (state2), next year's probability.0. 5, or become poor (state 3), also with probability0.5.
3. The gardener can alter the transition probabilities P_1 by invoking other courses of action. Typically, fertilizer is applied to boost the soil condition, which yields the following transition matrix P^2

$$P_2 = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{pmatrix} .3 & .6 & .1 \\ .1 & .6 & .3 \\ .05 & .4 & .55 \end{pmatrix} \end{array}$$

4. To put the decision problem in perspective, the gardener associates a return function (or a reward structure) with the transition from one state to another. The return function expresses the gain or loss during a 1-year period, depending on the state between which the transition is made. Because the gardener has the option of using or not using fertilizer, gain and loses vary depending on the decision made. The matrices R^1 and R^2 summarize the return functions in millions of Naira associated with the matrices P^1 and P^2, respectively.

$$R^1 = \left\| r^1{}_i{}^j \right\| = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{pmatrix} 7 & 6 & 3 \\ 0 & 5 & 1 \\ 0 & 0 & -1 \end{pmatrix} \end{array}$$

$$R^2 = \left\| r^2{}_i{}^j \right\| = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{pmatrix} 6 & 5 & -1 \\ 7 & 4 & 0 \\ 6 & 3 & -2 \end{pmatrix} \end{array}$$

The elements $r^{2}_{ij}{}^{1}$ of R^2 consider the cost of applying the fertilizer. For example, if the system is in states 1 and remains in state I during next year, its gain will be $r_{ij}{}^2 = 6$ compared with $r^1{}_{ij} = 7$ when no fertilizer is used.
5. What kind of a decision problem does the gardener have?
First, we must know whether the gardening activity will continue for a limited number of years or indefinitely. These situations are referred to as finite and infinite stage decision problems. In both cases, the gardener would determine the best course of action (fertilize or do not fertilize) given the outcome of the chemical tests (state of the system). The optimization will be based on the maximization of expected revenue.
6. The gardener may also be interested in evaluating the expected revenue resulting from pre-specified course of action for a given state of the system. For example, fertilizer may be applied whenever the soil condition is poor (state 3). The decision making process in this case is said to be represented by a stationary policy.
Each stationary policy will be associated with a different transition and return matrices, which are constructed from the matrices P^1, P^2, R^1, and R^2,

For example, for the stationary policy calling for applying fertilizer only when the soil condition is poor (state 3), the resulting transition and return matrices are
given as

$$P = \begin{pmatrix} .2 & .5 & .3 \\ 0 & .5 & .5 \\ .05 & .4 & .55 \end{pmatrix}, R = \begin{pmatrix} 7 & 6 & 3 \\ 0 & 5 & 1 \\ 6 & 3 & -2 \end{pmatrix}$$

These matrices differ from P^1 and R^1 in the third rows only, which are taken directly from P^2 and R^2 are the matrices that result when fertilizer is applied in every state.

3 RESULTS AND DISCUSSION

Integrated structure on economic-environmental interactions (3); in this section a first attempt is made to construct a framework for an Integrated Economic-environmental Analysis. This integrated system is subdivided into three subsystems, such as a socio-economic subsystem (E), an environmental subsystem (M) and a geographic-demographic subsystem (G). In the framework, a central role is played by the environmental subsystem.

The environmental subsystem is composed of two parts, such as: a first part which represents the general quality indicators of an ecosystem (such as ecological stability etc), and a second part which represents the direct environmental consequences of human activities such as pollution of air water and soil. The environmental variables in the first part called ecological variable (c), while the variables from the second part called intermediate variable (I). These intermediate variables transform economic and technical indicators (such as production hydro-power, water supply railway investment, traffic etc.) into environmental categories (such as pollution). Next, these environmental categories can be transformed into relevant ecological variables (such as the impact on the variety of an ecosystem).

Therefore, the most simplified representation of an integrated economic-environmental system is as shown in fig 1. It is clear that one may also distinguish intra-relationships (within each subsystem) and interrelationships (between the subsystems). It should be noted that the element of space may play a double role in fig 1, such as the medium through which the subsystems are linked together and as the geographical location of all activities performed in the system (e.g. land use)

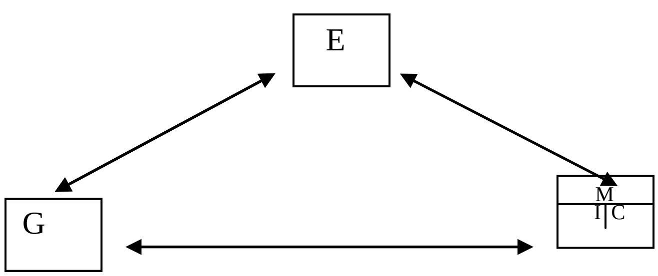

Fig. 1 scheme of a simple integrated economic-environmental system

The choice of the variables of the E-, G-, and M- system is a matter which is co-determined by the aim of the analysis (for example, a structural description, aintegrated impact analysis, a detailed prediction or an estimation of consequences of policy scenarios). In general, the number of variable and the number of relationships were kept as low as possible.

The elements of each subsystem can be incorporated in a multidimensional profile or vector In general, the E-, G- and M- profiles contain the following elements (functions, quality indicators, state indicators etc.), respectively: E-profile: Production (divided among sectors); Investments (including abatement investments);Supply and demand of labour (per category);

Value added and expenditure pattern (including income distribution); etc. G- Profile : demographic structure: migration and commuting ;population density and urbanization rate,

recreation; urban facilities;congestion; etc.M-profile : The M-profile can be divided into C-subprofile and an I-subprofile: C-sub-profile: Natural areas; types and quality of flora and fauna; ecological quality indicators (such as diversity, stability etc.); descriptive indicators for various landscape structures. I-sub-profile: air, water, and soil pollution; noise annoyance;

extraction of raw materials; land use.

The above-mentioned three profiles make the basic Structure of an Integrated Economic-environmental Analysis. Clearly, one might also add a social profile, but this would make the system more complex, while the possibilities of operating a social profile are fairly limited for the moment. In addition to the first step of this integrated analysis, such as the identification of all systems components, one has to specify the various relationships between the elements (both the intra-and the interrelationships). A first step may then be to construct the relations matrix between E,G, and M (fig 2). This matrix may serve as a Boolean matrix to indicate the existence of relationships. (in a 0-1sense), as a directional matrix to indicate the directions of the influence (in a positive or negative sense), as a qualitative structural matrix to indicate the order,

	E	G	M
Error			
G			
M			

Fig 2 A relations matrix between the profiles.

of magnitude of the various relationships (e.g by means of ordinal numbers), or as a quantitative structure matrix to indicate the metric impacts of all variables of the total system. Normally, one starts with the first step and then tries to reach the final step during a series of experiments. It will be shown later in this study that metric (cardinal) information is not always necessary to draw reliable conclusions concerning certain analytical or policy aspects. The various linkages of an Integrated Economic-environmental Model can also be reflected by means of an interaction scheme for the intra- and inter-relationships within the total system.

Environmental impact analysis ; environmental impact analysis has become increasingly popular in the U.S. and Canada, while recently it has also received a great deal of attention in Europe. Since the U.S. National Environmental Policy Act (1969) many environmental impact statements have been made in the U.S. among others Daetz and Schlesinger, (1973); Kneese and Bower,(1972); Kreith, (1973);

Impact analysis aims at measuring the marginal effect of a key variable (for example, hydro power generation, water supply, the construction of a railway system) upon a set of relevant policy variables (economic variables). It is clear that the environmental profile M is the central pivot of the analysis. Only the impact of the E- and the G-profile upon the M-profile is assessed not the reverse impact. Consequently, environmental impact analysis is only a partial analysis. If the variables from the E-, the G- and M- profiles are denoted as x_1, x_2, and x_3, respectively, then one may assume the following matrix structure (on the basis of linear interactions):

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} A \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} B \end{pmatrix} \begin{pmatrix} e_1 \\ e_2 \\ e_3 \end{pmatrix} \qquad (1)$$

Where e_1, e_2 and e_3 are exogenous vectors (instruments, data, etc.). If A is a non singular matrix, (1) reduces to

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 1 - A \end{pmatrix}^{-1} \begin{pmatrix} B \end{pmatrix} \begin{pmatrix} e_1 \\ e_2 \\ e_3 \end{pmatrix} \qquad (2)$$

The matrix $[I - A]^{-1}$ B represents essentially the total impact structure and incorporates all direct and indirect multiplier effects. In this respect, model (2) can be regarded as an integrated impact model. In reality, however, many partial analyses are carried out due to lack of reliable data for the total impact structure.

Survey of the experiment on environmental evaluation, model ; environmental evaluation aims at assessing the social value of change in the quantity and of environmental commodities, so as to provide a tool for a trade-off between choice alternatives with different environmental and economic impacts. It is evident that in the framework of a neoclassical analysis the evaluation of environmental commodities was based on market prices. When market prices do not exist for environmental commodities, artificial prices (e.g. shadow prices) were calculated in order to ensure an operational result for a neoclassical analysis. Cost-benefit analysis can be regarded as the neoclassical too par excellence for evaluating environmental commodities. Cost-benefit analysis goes essentially one step further than an (environmental) impact analysis, because it assigns a value (a price) to all impact assessments. Cost-benefit analysis can be criticized for several reasons:

It is only an efficiency criterion and usually neglects the equity criteria; it is based on a blend of various costs (for example, real costs, artificial cost shadow costs etc.

It is partially base on shadow prices which are not unambiguously determined.(because they depend on the social welfare criterion at hand); It is very hard to incorporate uncertainties, risks and time effects in a cost-benefit analysis; Intangibles can hardly be incorporated in a meaningful way in a traditional cost-benefit analysis.

It must be added that several of the above-mentioned problems hold true for any evaluation, but the latter reason especially makes cost-benefit analysis inappropriate as an operational evaluation tool for environmental commodities. Even adjusted methods such as cost-effectiveness analysis and planning balance sheet analysis are not able to overcome this particular shortcoming.

In the field of ecology, several alternative evaluation methods have been developed. Examples are the functional evaluation method, the ecological quality methods, and the energetic method Nijkamp, (1977). Bayesian decision, Markov models, Eme (2011)

The functional method attempts to gauge all ecological and economic functions of environmental commodities in quantitative terms and then to aggregate all information to a functional environmental indicator. This aggregation, however, normally includes many arbitrary choices.

The ecological quality method aims at characterizing environmental goods by means of quantitative quality indicators (for example, quantity of natural area, diversity, etc,). These quality indicators can be used as an appropriate input for a multicriteria analysis. The energetic evaluation method attempts to assess the monetary value of environmental goods on the basis of the energy transfer and production in an ecosystem (via the average national energy price). This method is for the moment too arbitrary to be used as a reliable technique, although it may be improved in several ways.

4 CONCLUSION

On the basis of this brief survey of environmental evaluation methods one may draw the conclusion that several methods developed and employed so far cannot be regarded as satisfactory evaluation techniques in an operational environmental policy analysis. Intangible and incommensurable effects are very hard to incorporate in all these methods and the conclusion is justified that any attempt to transform a priori heterogeneous and un priced impact into a single dimension must fail, unless corrected with Bayesian decision model or Markov chains as surveyed in section 2 which could take care of uncertainties, equity, risk, time effect poor data availability etc.

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