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RESEARCH METHODOLOGY

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MEASUREMENT OF ENVIRONMENTAL VALUES

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ABSTRACT

This paper deals with measurement of environmental values. It throws light the theory of environmental valuation including the total economic value. It also discusses different values like direct and indirect values that have the great relevance in economics of environment further the unit reveal various Environment valuation techniques to help readers have the clear understanding of these techniques. We will familiarize you with some elementary concepts of welfare economics and social sector. It also deals with measurement of environmental values using appropriate measures that are being used across the globe.

KEYWORDS

concepts and theory of environment valuation and total economic values, total economic value (TEV), environmental valuation techniques, different techniques of environment valuation.

1.1 INTRODUCTION

Valuation is the heart of environmental economics; it is a very active and rapidly expanding field. The basic strategy for environmental valuation is the 'co - modification' of the services that the natural environment provides. It serves to assess individual and group priorities and tradeoffs in the case of unpriced scarce commodities. It has been used to assess the desirability of specific Government investments in environmental improvement and to assess the desirability of new regulations to protect certain aspects of the environment from further degradation. It has also been used to rank the seriousness of environmental problems in order to provide guidance to environmental agencies as they decide on how to focus their efforts.

In its simplest form economic valuation is the process of identifying the relevant changes in consumer demand and producer supply arising from a (project induced) change in environmental quality, or the change in the provision of an environmental resource. In brief Environmental Valuation is concerned with the analysis of methods for obtaining empirical estimates of environmental values, such as the benefits of improved river water quality, or the cost of losing an area of wilderness to development.

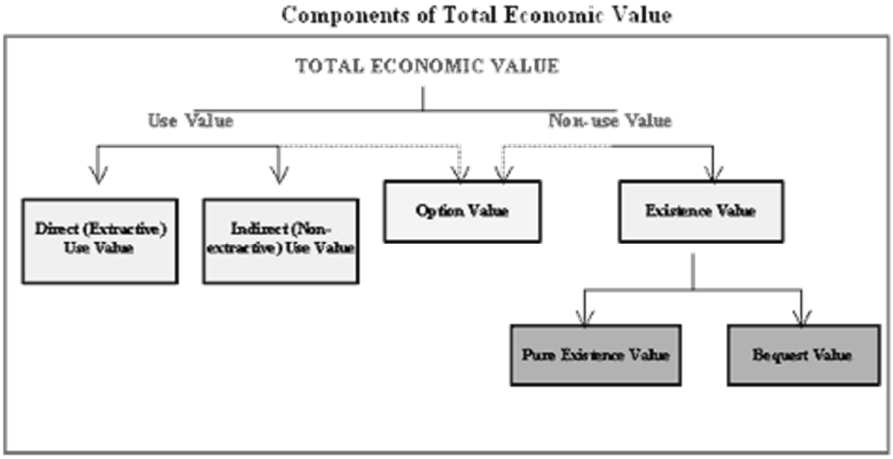
1.2 THE THEORY OF ENVIRONMENTAL VALUATION AND THE TOTAL ECONOMIC VALUE (TEV)

For some goods and services (e.g. a net or a boat purchased by a capture fishery operator), the market provides prices that reasonably reflect the value society places on that good or service. For other goods and services however, market prices either only partially reflect the value society places on them (e.g. electricity) or do not exist at all (e.g. the use of a Lake or the atmosphere as a discharge sink). To simplify the task of valuation, therefore, economists like to disaggregate project impacts on the environment into individual components of value. The most commonly used approach is based on the concept of Total Economic Value (TEV).

Under the Total Economic Value (TEV) approach an impact on an environmental resource, for example, a waterborne pollutant on a river, is broken down into a number of categories of value. The logic behind the approach is that a good or service comprises of various attributes, some of which are tangible and readily measured, while others are less tangible and thus more difficult to quantify. The total value of the good or service however, is given by the sum of all categories of value, and not simply those that are easy to measure.

The Total Economic Value is generally decomposed into three categories of value: (1) direct use value; (2) indirect use value; and (3) nonuse value. The former two categories are sometimes collectively referred to as "use value". Further subdivision of these categories is also possible as shown in the figure.

FIGURE 1



Source: Boyd (forthcoming)

DIRECT USE VALUE

The Direct use value is derived from goods, which can be extracted, consumed or directly enjoyed. It is also therefore known as extractive or consumptive use value. In the context of a river, for example, Direct (extractive) use value is derived from the harvesting of fish.

INDIRECT USE VALUE

Indirect use value is referred to as non-extractive use value, derived from the services that an environmental resource provides. A wetland, for example, acts as a water filter, often improving water quality for downstream users. This service is valued by downstream users, but does not require any good to be extracted / consumed.

In terms of measurement, indirect use values differ from direct use values in two ways: (1) the 'quantity' of the service provided is often hard to define and (2) the types of services in question are often not traded in established markets, and therefore have no readily observable 'prices'. For these reasons, measuring indirect use value is relatively more difficult than measuring direct use value.

NON-USE VALUES

Non-use values are defined as those benefits or welfare gains/losses to individuals that arise from environmental changes independently of any direct or indirect use of the environment. This category can be further subdivided into (1) option value and (2) existence value.

The former is a benefit expressed through an option to use the environment - that is, the value of the environment as a potential benefit as opposed to an actual present use benefit. If you are unsure whether you will use an environmental service or not, you might be willing to pay a positive sum to guarantee that the service will still be available in case you desire to use it at a later date. Option values consequently arise when you are uncertain about whether you will demand a commodity in some future time period and are faced with uncertainty concerning the future supply or availability of that commodity. It is distinct from a use value in that it arises not from the use of the site itself but from uncertainty over the site's availability to meet future demands. In this way option value is akin to an insurance policy against future uncertainty.

As option value is the value derived from maintaining the option to use a good or service at some point in the future, it is sometimes treated as a special case of use value (hence the dashed line in (figure) Existence value can be defined in various ways. Most definitions however contain two main components: (1) pure existence values and (2) bequest values.

A pure existence value relates to the worth you associate with an environmental good or service, which is completely unrelated to current or future use of that commodity, by yourself, your descendants, or others. These values are intrinsic in nature, i.e. they represent a value that resides in something. Some possible motivations or rationales for the presence of such values include the preservation of, concern for, sympathy with, respect for the rights of, any other altruistic motives with respect to non-human beings. A number of pure existence values are related to ecological attributes. Support for the protection of endangered species and the protection of critical habitats for those species represents an intrinsic valuation process.

Bequest value derive from our desire to preserve the environment for relatives and friends, and also for all other people living today and future generations, so that they may benefit from conservation of the environment. Since in most cases non-use value is not, by definition, reflected in individual's behaviour and is thus not observable, it is the most difficult component of TEV to measure.

TOTAL ECONOMIC VALUE = DIRECT AND INDIRECT USE VALUES + OPTION VALUES + EXISTENCE VALUES

It is of crucial importance to assess the change in the TEV arising from a project-induced change in environmental quality, or a change in the provision of an environmental resource. It will often be the case that the 'true' benefits (change in TEV) of a proposed project or policy will be much greater than its direct use value, but the direct use value may be less than the cost of the resource inputs.

1.3 ENVIRONMENTAL VALUATION TECHNIQUES

Environmental valuation techniques can be broadly classified into two sets. The first set is based on technical (physical) linkages that formally describe cause and effect relationships. Included in this set of techniques are the change in the output (or input) of marketable goods, the cost of illness and the replacement cost methods. The second set of techniques is based on behavioural linkages between a change in the state of the environment and the actions of individuals, whereby values are either stated or revealed in actual or hypothetical market behaviour. Using revealed behaviour, we examine the trade-offs individuals make between the state of the environment and goods or service traded in actual markets. These so-called revealed preference approaches include the hedonic property, wage-risk, travel cost and averting expenditures approaches. When environmental goods or services cannot be valued, even indirectly using revealed preference approaches, we can ask individuals directly to express how much they are WTP for a certain level of that environmental good or service. Contingent valuation and constructed markets are the two main types of so-called stated preference techniques. Another approach to benefit valuation in CBA is benefit transfer, although strictly speaking not a valuation method.

1.3.1 HEDONIC PRICE METHOD

It is based on consumer theory, which postulates that every good provides a bundle of characteristics or attributes. Market goods are often regarded as intermediate inputs into production of more basic attributes that the individuals really demand. For example the demand for housing can be considered a derived demand. A house yields shelter but through its location it also yields access to different quantities and qualities of public services (example: schools, cultural activities etc.) and different quantities and qualities of environmental goods (open space, woodland etc.). Thus HPM relies on the proposition that an individual's utility for a good or service is based on the attributes, which it possesses. If the hedonic analysis is conducted on housing data, it is referred to as the property value approach. When applied to wage data – to measure the value of changes in morbidity/mortality risks – it is often referred to as the wage differential or wage-risk approach.

The hedonic property value approach measures the welfare effects of changes in environmental goods or services by estimating the influence of environmental attributes on the value (or price) of properties. In order to obtain a measure of how a specific environmental attribute of interest affects the welfare of individuals, the technique attempts to: (1) identify how much of a property price differential is due to a particular environmental difference between properties and (2) infer how much people are willing-to-pay for an improvement in the environmental quality and to estimate the social value of improvements.

In attempting to isolate the effects of specific environmental attributes on the price of houses we have to "explain" the price of a house as a function of its key characteristics. If we take house price to be a function of all the physical features of the house (e.g. number of rooms, central heating, garage space etc.), neighbourhood characteristics, and environmental attributes, then the following relationship can be identified:

$$P^h = f\,[S, N, E]$$

where

Ph= The market price of the property.

f = The function that relates the house characteristics to price.

S = The different structural characteristics of the property.

N = The different neighbourhood characteristics of the property.

E = The different environmental attributes of the property.

This function is called a hedonic price function. Fixing the level of all the structural characteristics of a property and the neighbourhood characteristics, we are able to focus on the relationship between the property price and the environmental attribute under investigation. By partially differentiating the hedonic price function with respect to E we obtain the implicit price (or implicit price curve) of the environmental attribute.

This partial derivative is interpreted as the price paid by the individuals for the last unit of the environmental attribute, purchased by choosing a given property instead of another one with a unit less of the environmental attribute, other things being equal. Estimated implicit prices for different properties refer to different individuals. Every estimated implicit price is only one observation of the true individual demand curve and corresponds to the individual WTP for a marginal unit of environmental good only for that specific level of environmental good purchased. Therefore, the implicit price (curve) cannot be viewed as an inverse demand

curve. Hence, it does not represent the maximum marginal WTP of the individual for one more unit of the environmental attribute, unless we assume that all the individuals have the same structure of preferences and the same income. If this assumption does not hold, the various individuals will have different inverse demand curves. Nevertheless, the implicit price can be regressed on the observed quantities of the environmental attribute and some socio-economic characteristics of individuals. This "second stage" regression could allow the identification of the inverse individual demand function. The area under the inverse demand curve between two levels of the environmental attribute represents the change in the consumer surplus caused by the change in this attribute. By aggregating all individuals' consumer surpluses, we obtain the overall value of the environmental change.

In practice, especially in developing countries, only the first stage of the process is usually carried out, and the results used to obtain only rough values for the impact of the attribute in question. A summary of the main steps followed in undertaking a hedonic property value study is outlined in Figure below.

TABLE 1: STEP-BY-STEP PROCEDURE FOR THE CALCULATION OF THE CONSUMER SURPLUS WITH THE HEDONIC PROPERTY VALUE APPROACH

Steps	⟵	Assumptions-Notes
Collection of data on proces and houses features	⟵	Various methods exist to collect these data. For complex studies this data must be complemented with information on the socio-economic characteristics of households investigated
Estimation of the hedonic price function	⟵	This relates the price of houses to the characteristics explaining the house price.
Calculation of the implicit price of the environmental attribute in question	⟵	This is the first derivative of the house price function with respect to the environmental attribute
Estimation of the inverse demand curve of the environmental attribute	⟵	The price paid is explained by the quantity/quality of the environmental attribute but also by the socio-economic characteristics of households
Calculation of the consumer surplus	⟵	Integration of the implicit demand curve between the former level of environmental quality/quantity and the new one.

Source: Markandya *et al* (forthcoming)

The hedonic wage-risk method is very similar, and is only briefly discussed here. Basically, to estimate the relationship between wages and risks we must control for other variables that influence earnings - as in the hedonic property value approach above - except this time we estimate a hedonic wage function:

$$W = f(Q, X, R)$$

where

W = Wage rate in each occupation.
Q = Qualifications of workers.
X = Job attributes such as unionisation, desirability, etc.
R = Workplace risk, e.g. risk of death.

The partial derivative of this function with respect to R is the wage premium for accepting, say, an additional risk of death of 1 in 10,000. To estimate a 'value of a statistical life' (VOSL) from this, the wage premium is factored by the additional risk (in this case 10,000). For example, if the 'average' wage premium is $45 in this case, then the VOSL is given by

$$\uparrow \frac{1}{100{,}000} \times 100{,}000 = 1 \Rightarrow \$45 \times 100{,}000 = \$4{,}500{,}000$$

The hedonic technique has several advantages. Firstly, hedonic analysis uses market, i.e. observed, data on property sales or wage rates. The method is versatile and can be adapted to consider several possible interactions between market goods and environmental quality. Moreover, estimated values obtained from one study can be used in other policy areas if the environments have similar demand and supply characteristics. On the negative side, the results of hedonic studies are sensitive to the econometric assumptions adopted. Furthermore, the assumptions necessary to interpret the results as measures of WTP are restrictive and, in many real world settings, unrealistic. From a practical perspective, full hedonic pricing studies require a considerable amount of data, which may be difficult and expensive to collect, such studies tend not to be done quickly.

1.3.2 THE TRAVEL COST METHOD

The Travel Cost (TC) method is an example of a technique, which attempts to deduce values from observed (i.e. revealed) behaviour. The TC model and its many variants is the most commonly used indirect approach to valuing site-specific levels of environmental resource provision. Basically, information on visitors' total expenditure to visit a site is used to derive their demand curve for the services provided by the site. Among other things, the TC model assumes that changes in total travel expenditures are equivalent to changes in an admission fee Given this, the model is used to predict changes in demand in response to changes in 'admission fees', thereby tracing out a demand curve for the site. This demand curve may then be used to measure the total benefits visitors accrue from the site. There are two main variants of the TC model: (1) the Zonal TC model (ZTCM) and (2) the Individual TC model (ITCM). The ZTCM divides the entire area from which visitors originate into a set of visitor zones and then defines the dependent variable as the visitor or visitation rate (i.e. the number of visits made from a particular zone in a period divided by the population of that zone). The ITCM defines the dependent variable as the number of site visits made by each visitor over a specified period.

The basic (zonal) travel cost model defines a trip demand curve for a given recreational site from zone as

$$\frac{V_j}{P_j} = f(TC_j, X_j)$$

V_j = The total number of trips by individuals from zone j to the recreational site per unit of time,

f = The function that relates travel cost and socio-economic characteristics to visitation rates,

P_j = The population of zone j,

TC_j = The travel cost from zone j to the recreational site and

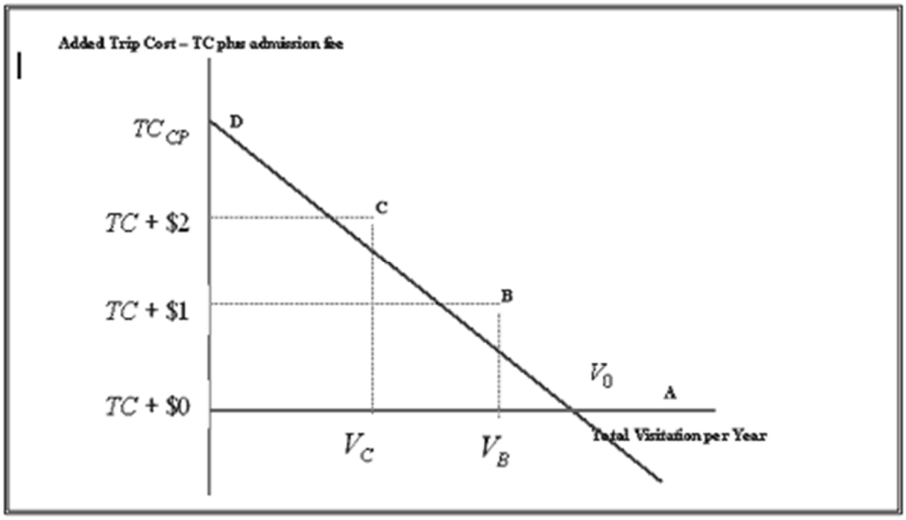
X_j = The socio-economic characteristics of the population of zone j, which include, amongst others, factors such as income levels, spending on other goods, the existence of substitute sites, entrance fees and quality indices of n substitute sites

The visitor or visitation rate V_j/P_j is generally calculated as visits per unit of population, usually expressed in thousand persons, in zone.

Based on data obtained from a survey of site users, the above equation is estimated using regression analysis. This leads to the creation of a so-called 'whole experience' demand curve based on visitation rates and not the number of actual visits made. To estimate the consumer surplus accruing from the site, the 'whole experience' demand curve is used to estimate the actual number of visitors and how the numbers would change subject to increases in admissions 'prices' – in essence constructing a classic inverse demand curve.

The base data set, from which the 'whole experience' demand curve is created, defines one point on the inverse demand curve for the study site – that is, the intersection of the present zero price line and the inverse demand curve (V_o). In Fig this is given by point A, where admission fees or added trip cost is zero.

FIGURE 2: ZONAL TRAVEL COST



As mentioned above, the remainder of is derived by assuming that visitors will respond to increases in admission fees in the same way they would to equal increases in travel cost. For each incremental increase in admission fees, the expected visitation rate from each travel origin zone is calculated using the above equation. The 'new' zone-specific visitation rates are then converted to expected numbers of visitors using data on. These values are summed across all travel origin zones to find the predicted total number of visitors to the site at the added trip cost (i.e. original travel cost plus, say, $1). For example, a $1 increase in trip costs may lead to point B in Fig a $2 increase in trip costs may lead to point C, etc. This process is repeated until the added trip cost is sufficient to result in zero visitors to the site (the so-called choke price given by point D in Fig) – until the entire inverse demand curve (V_O) is traced.

The area under V_O provides an estimate of the total consumer surplus enjoyed by present users of the study site.

The basic (individual) travel cost model relates individual's annual visits to the costs of those visits – that is (Markandya et al, forthcoming),

$$V_i = f(TC_i, X_i)$$

where Vi = The number of visits made in a time period, say a year, by individual i to the site. TCi= Travel cost faced by individual i to visit the site. Xi= All other factors determining individual i's visits (income, time, and other socio-economic characteristics).

This demand function can be extended to allow for the specification of a number of explanatory variables. These include the individual's estimate of the proportion of the enjoyment of the overall trip imputed to the specific site under investigation, the individual's view of the availability of substitute sites, size of individual's household and whether the individual is a member of an environmental organization, as well as other socio-economic data. Integrating the demand curve between the actual travel cost TCi and the choke price gives an estimate of the individual annual consumer surplus (ICS) for individuals.

The total annual consumer surplus for the site is obtained by multiplying the ICS by the number of individuals visiting the site annually. The modelling of individual socio-economic features enables the estimation of consumer surplus for different socio-economic groups of visitors. Alternatively, the average ICS per visit can be calculated and then multiplied by the total annual number of visits to the site to get the total annual consumer surplus of the site.

Like hedonic techniques, the TC method has the advantage that it is based on observed behaviour. Also, TC is a well-tried technique, which is generally accepted, yields plausible results. The individual TC model, the zonal TC model, or similar specifications, have been used to assess changes in site quality, which include the degradation of water quality, changes in fish catches, etc. However, they are more commonly used to value the total benefit of a resource, rather than changes in that resource. The TC method is not without its disadvantages however. To start, in complex situations, especially when changes in environmental quality are being assessed, the data requirements are considerable. Moreover, "a whole host of issues arises in the specification and estimation of the model and subsequent calculation of consumer surplus, all of which have enormous bearing on the final benefit estimates". These issues include the development of multi-site models, the valuation of travel time and the treatment of non-visitors. As a result, TC studies tend to be conducted as self-standing research studies, with sufficient resources to adequately address these complex issues.

The main application of TC in developing countries is to value tourist's WTP for national parks. For example, in Zimbabwe, a TC study of tourists found that they derived a benefit (consumer surplus) of about US$ 275 per person per trip to national parks. In Costa Rica, a TC valued trips to parks and reserves at US$ 1,150 per person.

RANDOM UTILITY MODELS

Random utility models (RUMs) are econometric models that, among other uses, permit the estimation of preferences among different recreational areas with varying characteristics. The RUM, with its ability to assess competing multiple sites with varying recreational characteristics, holds considerable appeal for economists. Consider three beaches with characteristics that vary based on location, water quality, landscape features, access, existence of lavatories, and other services. These characteristics can be transformed into discrete and continuous variables used to assess consumer preference by examining location preference and the total cost of trips taken (Table 4). Based on the data collected through surveys of various sites, the RUM estimates the probability that an individual will visit one site out of several sites based on site characteristics. Varying the quality of those characteristics (e.g., water quality, landscape features) permits the analyst to assess how recreational travelers value changes in environmental quality at particular sites. A RUM is not specific to surrogate market techniques. Rather, a RUM is an estimation procedure that can be combined with surrogate and non-market techniques used in valuing, for example, recreational areas and wetland area restoration. Travel cost studies often use RUMs; however, they may also be applied in stated preference studies that use choice experiments.

TABLE 2: EXPENDITURES PER TRIP AND NUMBER OF TRIPS TAKEN (ADAPTED FROM LIPTON 1995)

Individual	Travel Costs /Number of Trips	Site I	Site II	Site III
1	Travel Costs	$20	$40	$50
	Number of Trips	4	3	2
2	Travel Costs	$52	$26	$15
	Number of Trips	1	4	2
3	Travel Costs	$30	$30	$45
	Number of Trips	3	6	1

1.3.3 CONTINGENT VALUATION METHOD (CVM)

This method uses interview techniques to ask individuals to place values on environmental goods and services. The most common approach in the CVM is to ask individuals the maximum amount of money they are willing to pay (WTP) to use or preserve a good or service. Alternatively, the respondents could be asked the maximum amount of money they are willing to accept in compensation (WTA) to forgo the given environmental good or service. The basic notion underpinning CV is that a realistic, yet hypothetical market for buying or selling use and/or preservation of an environmental good/service can be described in detail to an individual. Individuals are then asked to participate in this hypothetical market, by responding to a series of questions.

The main features of the hypothetical market are as per following:

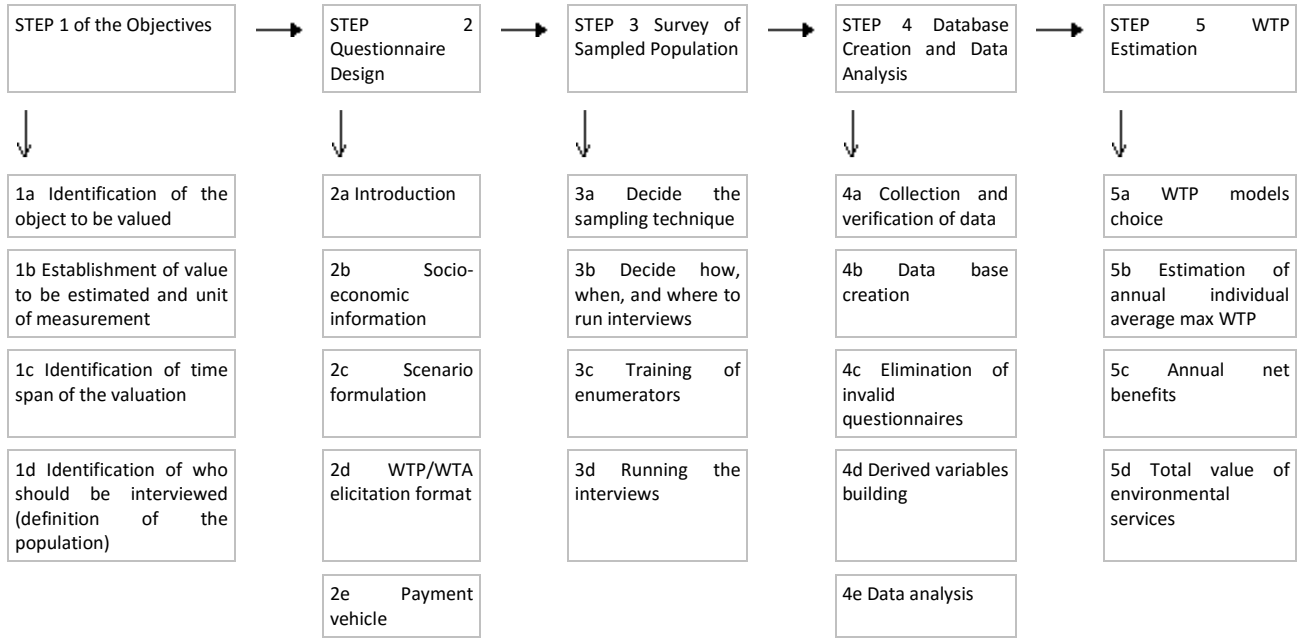
- A detailed description of the good/service being valued. The situation before and after any proposed change in environmental quality and subsequent provision of the good/service should be clearly stated. In addition, it is vital that the respondents perceive the correct good/service.
- A detailed description of the "payment vehicle", i.e. the means by which the respondent would pay for the change in provision of the good/service. The payment vehicle should be appropriate to the good/service and the hypothetical market. Moreover, it should be realistic and emotionally neutral.
- The procedure to elicit the respondent's valuation. The actual valuation can be obtained in a number of ways, for example, asking the respondent to name an amount, having them choose from a number of options. The respondent could also be asked whether they would pay a specific amount. In the case of the latter, follow-up questions with higher and lower amounts are often used. Statistical analysis of the responses is then undertaken to estimate the average WTP in this hypothetical market.

A general approach to follow when running a CV study is outlined in figure. The nature of CV means that, in principle, it can be used to value any change in environmental quality. Furthermore, CV can be used to accurately elicit values about very specific changes in the provision of goods/services, since it does not rely on observed data. Of course, this requires that the hypothetical market and elicitation questions be appropriately worded. An additional plus for CV is that, in contrast to the other valuation techniques described above, which only provide a partial estimate of the value of a good/service, CV can provide a measure of the TEV of a change in environmental quality. CV methods have nonetheless been the subject of much criticism, mainly relating to their reliance on hypothetical markets (In short, some economists argue that asking individuals hypothetical questions only provides you with hypothetical answers, which cannot be meaningfully used to value environmental quality changes. Following controversy of the use of CV to value damages from the 1989 Exxon Valdez oil spill, the US Department of Interior and the National Oceanic and Atmospheric Administration organized a "Blue Ribbon" panel to assess the validity of using CV to value environmental damage. The panel concluded that that CV could provide useful and reliable information for this type of assessment, as long as certain guidelines are followed. In general, the profession as a whole has also given CV qualified acceptance.

In addition to the above conceptual concerns over the validity of CV based benefits estimates, survey-based research is expensive and time-consuming, valid benefit estimates require properly designed sampling and enumeration procedures.

The key steps in conducting Contingent Valuation are as shown.

FIG. 3



ACTIVITY 2

1. Discuss the concept of environmental values.
2. Explain various methods of environment valuation with special reference to direct and indirect methods.
3. Write short notes on the following:

- use values
- non use values
- optional values
- The travel cost method

1.4 CONCLUSION

The objective of environmental valuation techniques is to reveal individuals' preferences by making use of a real or hypothetical environmental market. Some valuation techniques are direct and question individuals using surveys. These methods include the Contingent Valuation Method or the use of auctions. Other techniques are more indirect, that is they use other preference revelation methods, for instance the price of goods in a market that has links to environmental amenities. An example of this is the Travel Cost Method which uses the amount people are willing to pay, transport wise, to have access to a heritage site or a natural reserve. Similarly, method of hedonic prices has been discussed as based on consumer theory, which postulates that every good provides a bundle of characteristics or attributes.

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