Economic Valuation: Concepts and Empirical Methods

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Abstract
Commensurate valuation of market and nonmarket public goods allows for a more valid benefit-cost analysis. Economic methods for valuing nonmarket public goods include actual behavior-based revealed preference methods such as the hedonic property method for urban-suburban public goods and travel cost-based models for outdoor recreation. For valuing proposed public goods for which there is no current behavior or valuing the existence or passive use values of public goods, economists can rely upon stated preference methods. While there is skepticism among some economists for relying upon what people say they will pay rather than what their actual behavior suggests they will pay, there is general acceptance of stated preference methods. These stated preference methods include the well-known contingent valuation method and choice experiments (sometimes called conjoint analysis). Lastly, in situations where there is neither time nor money to conduct an original revealed or stated preference study, economists typically rely upon benefit transfers from existing revealed preference and stated preference studies to provide rough estimates of the values of public goods such as water quality, air quality, wetlands, recreation, and endangered species.

49.1 Introduction

One of the long-standing deviations from economic efficiency of even a perfectly competitive market with no subsidies to producers or consumers is that of negative externalities and provision of *public goods*. In the face of these market failures, government intervention has the potential to improve economic efficiency by imposing pollution taxes or tradeable permits to internalize the negative externalities into prices of the goods associated with pollution. Further, government has the *potential* to improve economic efficiency by supplying or financing the supply of optimal amounts of the public good.

However, the emphasis here is on the potential to improve economic efficiency through government action. For this potential to be realized, the level of the pollution taxes must be set equal to the marginal environmental cost at the socially optimum level of output. Thus, to achieve this optimum requires having an estimate of the marginal environmental cost of pollution or, alternatively, the marginal benefits of improving environmental quality (e.g., air quality, water quality). The same is true of public goods: the government has to determine the marginal benefits of these public goods to society so as to compare to the cost of producing alternative levels of the public goods to determine an optimum.

Benefit-cost analysis is a technique used by government to determine if the benefits of increased environmental quality or public goods are worth the cost. One of the greatest challenges of benefit-cost analysis is estimating nonmarket benefits of regulations imposed on industry to internalize negative externalities (e.g., installation of pollution control devices) or government supply of public goods (e.g., preservation of remote wilderness areas).

This chapter is devoted to a review of environmental valuation methods frequently used by a wide variety of economists (i.e., academic, government, consultants) to estimate the economic benefits of improving environmental quality and public goods. The conceptual foundation of all environmental valuation methods is reviewed first. This is followed by a discussion of actual behavior-based environmental valuation methods. These methods are usually referred to as revealed preference methods and include the hedonic property method and the travel cost method. This section is followed by a review of stated preferences methods including the contingent valuation method and choice experiments. The next to the last section discusses how revealed preference and stated methods can be combined to provide more robust environmental valuations. Finally, "shortcut" methods called benefit transfer are reviewed.

49.2 Benefit Measures

Value has many different meanings, and it is important for economists to be precise as to what they mean by economic value or benefits of environmental quality or public goods. The economic value or benefit received by a person for any good whether marketed or nonmarketed is the maximum amount they would pay for it. The term economists used for this is maximum *willingness to pay* (WTP). WTP is short hand for willingness and ability to pay. When estimated as the area under a consumer's demand curve, it is usually referred to as consumer surplus. While there are many theoretical refinements to this measure, for an applied economist, consumer surplus is generally considered a reasonable approximation to these more theoretically correct concepts of consumer well-being.

It is worth noting that nothing has been said about jobs created by production of a public good as an economic efficiency benefit or jobs lost with environmental regulation as a cost. Except in times of unusually high and persistent unemployment, gains in jobs in one industrial sector are usually made up in another. Likewise, jobs lost in one geographic area are usually made up in another. Hence, jobs are considered transfers of economic activity from one industrial sector or geographic area to another. In other words, changes in jobs are not net gains or net losses to the economy as a whole and are usually excluded from an economic efficiency analysis such as benefit-cost analysis.

49.2.1 Use Values

For most market and nonmarket goods and services, the benefits are largely received by individuals who actually consume or directly use the good. The benefits of another hamburger or a new reservoir are primarily to the consumers who use it. In the reservoir example, use values would accrue to those who receive drinking water from the reservoir, receive flood protection, or water ski at the reservoir. The vast majority of benefits from a project or policy typically fall into the use category as this is a very broad category. Use values also include the value of publicly provided recreation, scenic visibility at national parks, and commonly seen wildlife such as deer. Use values also relate to reduction in health damages from cleaning up hazardous waste sites and improving air and water quality. These use values are also measured by the users' maximum willingness to pay, so that there is consistency between valuation of market goods and nonmarket goods, i.e., the dollars are commensurate.

49.2.2 Nonuse or *Passive Use Values*

There are, however, unique natural resources such as Yellowstone National Park, rare/endangered species such as condors or panda bears from which people often receive benefits from just knowing these exist in the wild. This type of value is known as *existence value* (Krutilla 1967; Freeman 2003). Receiving this benefit does not require an on-site visit. Rather, there is an enjoyment from reflecting on the existence of the Arctic National Wildlife Refuge in Alaska undisturbed by oil and gas drilling. Likewise some people receive enjoyment and satisfaction that protection of these unique natural environments or species today will provide to future generations. This "bequest value" also does not require the current lived person to set foot in the area or personally view it.

The existence and bequest values are sometimes called nonuse values (Freeman 2003) or passive use values (US District Court of Appeals 1989; Arrow et al. 1993). These values have been the focus of natural resource damage assessment (e.g., damages from oil spills in remote areas of Alaska from the Exxon Valdez oil tanker spill – see Carson et al. 2003) and biodiversity (see Abdullah et al. (2011) for a review of these valuation studies).

Given that everyone can simultaneously enjoy the knowledge that a given unique natural environment exists, existence values have the characteristics of public goods. If valuing public goods were not difficult enough, these nonuse public goods are particularly challenging since there is little tie to a consumer's behavior. However, as discussed later in this chapter, economists have developed and implemented stated preference valuation methods that can measure the benefits of these special types of public goods. These passive use values are also measured by the maximum amount that people who benefit from these public goods would pay for them. This insures consistency between passive use values and use values and market values.

49.3 Overview of Methods and How They Relate to Values

There are two broad classes of valuation methods for nonmarket resources. Revealed preference methods refer to methods that indirectly infer WTP based on market transactions for other related goods. For example, estimating a demand curve for recreation based on the variation in visitors' travel costs. From the demand curve, visitors' WTP or consumer surplus can be calculated. The generic label for this type of revealed preference method is *Travel Cost Model* because it relies on travel behavior and travel costs. Another revealed preference method is the *Hedonic Property Method.* This method disaggregates the price of a house purchased into the attributes of the house itself (e.g., bedrooms, bathrooms), the neighborhood (e.g., school quality), and the surrounding environment (e.g., distance to work, distance to an amenity or disamenity to be valued). Since houses with proximity to desirable environmental attributes are demanded by more households, this pushes up their prices. The price premium for a location close to an amenity such as open space or a park or good air quality can then be inferred.

In contrast, stated preference methods such as the *Contingent Valuation Method* or *Choice Experiments* rely upon what people say they would intend to pay if a certain scenario occurs. For example, how much more I would pay in trip cost for access to a recreation site with better water quality or how much more I would pay in taxes to protect an endangered species in a remote area. As will be discussed in more detail below, stated preference methods have the advantage of being quite flexible so it can measure both use and passive use values. Stated preference methods can also value a wide range of public goods including health, air quality, water quality, recreation, and endangered species. This flexibility comes at a price of potential hypothetical bias where respondents to the survey may state they will pay more for the public good than they would actually pay when they must hand over their own hard-earned money. Below we talk about what the literature finds with regard to when hypothetical bias is more likely to occur and what can be done to reduce it.

It is important to emphasize that all these estimation methods are just alternative tools for measuring WTP. They do it differently, but the measure of value is still the same. At the end of this chapter, we will also talk about how revealed preference and stated preference data can be combined to utilize the strengths of each method. But for now, we will discuss each method separately.

49.4 Hedonic Property Method

This revealed that preference technique has been applied to estimating house price differentials with natural hazards (e.g., earthquakes, floods, fires), environmental quality (air pollution, water pollution), and recreation access (e.g., open space, beaches). To understand how this versatile technique works, we will first review the theory underlying it, the data requirements, then the econometric estimation, and finally how WTP is calculated from the regression results.

49.4.1 Economic Theory Underlying the Hedonic Property Method

Competition for houses with desirable amenities pushes the prices of these houses up. Likewise, to entice home buyers to purchase homes with less desirable locations or disamenities, sellers must lower their prices. These premiums and discounts are intuitive but in order to develop valid estimates of WTP, there must be a close link between the theoretical foundation and the empirical estimation. Further, any empirical model is based on a set of assumptions, which are often embedded in the theory. Below, we summarize the theory (see Taylor 2003 for more comprehensive discussion of the theory and empirical methods discussed below).

In the hedonic property method, the standard assumptions that consumers maximize utility and sellers maximize profits are employed. The consumer's utility function is Lancasterian in nature being specified in terms of the attributes of the house structure itself and its location. A stylized representation of the utility function is

$$U_i\,(X, A_s, A_n, A_e) \tag{49.1}$$

where U_i is utility of person i and X represents all other nonhousing goods and is sometimes referred to as a composite commodity. The A's represent attributes of the housing structure itself (A_s) (e.g., bedrooms, baths), the neighborhood (A_n) (e.g., education levels), and the environment (A_e) (e.g., air quality, water quality). This utility function is maximized subject to the consumer's budget constraint (where the price of the composite commodity is normalized to 1). The consumer optimum is where

$$\partial Ph/\partial A_i = (\partial U/\partial A_i)/(\partial U/\partial X) \tag{49.2}$$

where Ph is the price of the house.

The interaction of the producers' minimum willingness to accept to supply attributes and consumers' maximum WTP for attributes results in an equilibrium price schedule for attributes A_s, A_n, and A_e. In an equilibrium between the producer and consumers, $\partial Ph/\partial A_i$ is the marginal WTP for small changes in A_i.

From the theory comes an estimable hedonic price function. In Eq. (49.3), we present an illustrative form of it:

$$Ph = \beta_0 + \beta_1(HA) + \beta_2(SQ) + \beta_3(NInc) + \beta_4(DWork) + \beta_5(EQ) \tag{49.3}$$

where Ph is the price of the house; HA is housing structure size; SQ is school quality, e.g., graduation rates; NInc is neighborhood income – often proxied by census tract or zip code; DWork is distance to employment centers; and EQ, e.g., air quality (parts per million of key pollutants), is distance to open space or a disamenity like a landfill.

The implicit price or marginal WTP for a small change in any attribute of the house structure, neighborhood, or environmental quality is simply the regression slope coefficient if the hedonic price function is linear. If the house price function is nonlinear, as it typically is, then the contribution of each additional unit of attribute to the house price is also related to the absolute level of house price. In this case, the formula for marginal WTP is slightly more complicated. Taylor (2003) provides formulas for the implicit price function for a variety of nonlinear functional forms.

Since the implicit price function is for a marginal change in attribute levels, it will overstate the benefits of a large increase in attributes but understate the loss of large changes in attributes. In order to accurately estimate the benefits for large gains or losses in attributes, a second-stage hedonic demand for the specific attribute must be estimated. Discussion of this is beyond the scope and space available in this chapter so the interested reader should see Taylor (2003) for more details.

49.4.2 Data Requirements

The data required for this method is of course quite detailed. The analyst needs house sale prices, characteristics of the home, characteristics of the neighborhood, and characteristics of the environment. This requires obtaining at least three different data sources. House sale prices and house characteristics are often available from county tax assessors' offices or from third-party real estate services. Characteristics of the neighborhood such as income, ethnicity, and average age are often found in block level data available from a government's population census office or sold by third-party vendors. Data on environmental quality of the neighborhood is often obtained from some form of monitoring station or field data. Location of houses relative to the amenity or the disamenity must often be calculated using Geographic Information System software. This requires that housing data be "georeferenced" in some form whether street address or coordinates. Needless to say that assembling the data can be time consuming, but no more so than the other methods we will review.

49.4.3 Econometric Modeling Including Spatial Dimensions

Since the implicit prices are essentially the regression coefficients, an econometric model must be estimated using the data assembled above. Historically, nearly all hedonic price functions were estimated using ordinary least squares regression in one form or another. Recently, there have been concerns that there may be spatial dependence of prices between houses located in close proximity to one another (e.g., same neighborhoods). This dependence may be due to real estate agents and appraisers' use of "comparable houses" when determining fair market value or appraised value for houses. It may also be due to there being some unobservable (to the analyst) characteristic of a particular neighborhood shared by houses in that neighborhood. Since this characteristic is unobservable to the analyst, it is an omitted variable in the regression equation. In the last few years, spatial econometric methods have been developed to address these problems (Anselin 1988). At present, some studies show that using these more advanced methods may result in more accurate estimates of the implicit prices, but in other cases, there is little difference (Mueller and Loomis 2008). The interested reader should see Anselin (1988) for more details.

49.5 Travel Cost Models

The revealed preference travel cost models essentially involve estimating a demand function for recreation. As such, the underlying theory is that of consumer demand theory. A visitor is assumed to maximize their utility subject to a budget constraint. Much like consumer demand theory, there are a number of admissible utility functions which result in different demand specifications. Besides the own price of visiting the recreation site of interest, these demand functions should ideally include the visitor's income and the price of visiting substitute sites. The details of how this conceptual demand model is implemented are specific to the different forms of the travel cost models which we will now be reviewing.

49.5.1 *Trip Frequency Models* of Recreation Demand

While many public recreation sites have no entrance fee or a minimal administratively set fee, nearly all the implicit price paid for access to the recreation site is the travel cost incurred by the visitor. Thus, travel costs act as a proxy for price in estimating the demand curve. The use of travel cost as a proxy for price hinges on a couple of key assumptions: (a) all travel costs are incurred exclusively to visit this site, and only this site on a trip from home; and (b) there are no significant benefits derived from the travel enroute to the recreation area, i.e., the sightseeing on the way to the site has little value. To meet assumption (a), visitors are queried if they are visiting multiple sites on the same trip and, if so, excluded from the estimation data in most simple trip frequency models but can be included in more complex trip frequency models (Loomis et al. 2000).

Travel cost models employ cross-sectional data that uses spatial variation in visitors' travel costs. There is variation in visitors' travel costs because visitors live at varying distances from the site. With a trip frequency model, the dependent variable is the number of trips each visitor takes over the year or the season to a particular recreation area. The price variable includes the transportation costs (e.g. gasoline), but there may be other variable costs of the trip that would be included in the travel cost variable. These might include lodging or camping fees. Other variables that are usually included as an independent variable in a travel cost model include the visitor's travel time to the site. However, sometimes this variable will be so highly correlated with travel cost that it cannot be included by itself. In that case, the monetary opportunity cost of this time is used to combine the cost of travel time with the transportation cost. Since we are estimating a demand function, other independent variables such as visitor income are usually appropriate to include. Ideally price of the nearest substitute site would be included as well, although this variable is often so correlated with travel cost to the site under study that it is difficult to include. Visitor demographics are also useful as other explanatory variables to act as proxies to control for differences in tastes and preferences.

As single-site trip frequency model is useful if the analyst is interested only in (a) what is the value of current recreation at the site and (b) what would be the loss in consumer surplus if the site were closed due to agency budget cuts or reallocation of the land to an alternative use (e.g., mine). An example single-site demand curve specification is given in Eq. (49.4) for visitor i:

$$AnTrips_i = \beta_0 - \beta_1 TC_i + \beta_2 TTime_i + \beta_3\, Income_i \tag{49.4}$$

where $AnTrips_i$ is annual trips of visitor i to the site, TC is roundtrip travel cost of visitor i, TTime is travel time in hours of visitor i, and Income is household income of visitor i. To address the limitations of this single-site model, a multiple-site model can be estimated. We now turn to a discussion of one such type of multiple-site model.

A multiple-site trip frequency model allows answering a wider range of policy and management questions including how WTP would change for changes in environmental quality or size of the recreation area protected. In order to observe how visitation changes with size of the water body or facilities or environmental quality, there must be variation in recreation site quality or characteristics. While at one recreation site, these attributes are generally fixed, these characteristics usually vary across sites. Therefore, if the analyst pools or combines visitation data from several recreation areas which have varying levels of these attributes, then visitor response to these attributes can be estimated in the demand coefficients. This allows the analyst to estimate how the demand curve shifts with more of a desirable attribute. The area between the original demand curve and the demand curve with increased size or level of environmental quality provides an estimate of the incremental or additional WTP for the increased amount of the attribute. This feature allows the analyst and manager to answer a wide range of policy relevant questions: (a) How the recreation benefits would change with management enhancements such as additional facilities, clean up of water quality, or wildlife management. These marginal benefits can be compared to the marginal costs of carrying out the management action to determine if the added benefits justify the added costs; (b) The change in site quality with allowing an incompatible use to occur at or nearby the site, such as drawing the reservoir level down for irrigation, reducing river flows to produce hydropower, or allowing a nearby mine which would add pollution to a lake. Equation (49.5) specifies what a stylized multiple-site trip frequency demand model would look like for individual i visiting site j:

$$AnTrips_{ij} = \beta_0 - \beta_1 TC_{ij} - \beta_2 TTime_{ij} + \beta_3 Income_i + \beta_4 SS_j + \beta_5 SQ_j \tag{49.5}$$

where $AnTrips_i$ is annual trips of visitor i to the site j, TC_{ij} is round trip travel cost of visitor i to site j, $TTime_{ij}$ is travel time in hours of visitor i to site j, $Income_i$ is household income of visitor i, and SS_j and SQ_j are site size of site j (e.g., number of acres) and site quality of j (e.g., water clarity, fish catch), respectively. The coefficients on the site quality variables indicate how trip changes with a one unit change in site quality. That is, how much the demand curve will shift with a one unit change in site quality? It is from this shift in the demand curve which allows calculation of the marginal benefit of the quality change. This calculation is done by integrating the area between the current and changed (positively or negatively) demand curve and expanding that to the population of visitors at the site.

There are several econometric specifications of trip frequency models. Historically most trip frequency models were estimated with ordinary least squares regression. However, since 1990, count data regression models have been used since the number of trips taken is a nonnegative integer. Count data models include the Poisson and the Negative Binomial. Negative Binomial count data models do not require that the mean of trips to equal the variance of trips as do the Poisson model.

Since count data models are exponential models, they are equivalent to the semilog of the dependent variable functional form. As such the consumer surplus per trip is simply the reciprocal of the Travel Cost coefficient (Creel and Loomis 1990). See Parsons (2003) or Haab and McConnell (2002) for more details on the count data models.

49.5.2 Multisite Selection Models

Since the 1990s, multiple-site selection models have become popular. These models view the potential visitor as selecting a site to visit from a large choice set of possible recreation sites. These sites differ in terms of travel cost to the site and each sites quality. The individual is assumed to select the site which maximizes their utility given their budget constraint. A repeated discrete choice model has the visitor repeatedly making this site selection decision for each choice occasions (e.g., weekend) over the season and then sums up these trips over all choice occasions in a season.

The theoretical foundation of this model is known as a random utility model since not all the variables in the visitor's utility function are believed to be observable to the analyst. Thus, some of these unobservable variables are treated as random by the analyst, hence the name random utility model. Nonetheless, the site selected by the visitor reflects the one site on any given choice occasion that the visitor views as having the highest net utility. By dividing this utility by the coefficient on travel cost (which is also interpreted as the marginal utility of income), a monetary measure of WTP is calculated. The versatility of this model is that being a multisite model it can value changes in site quality or closure of one or more sites. The strong suite of this model is ability to reflect the influence of substitute sites in the choice of a site to visit. Thus, the loss of value with closing one site is just the incremental loss in utility from having to visit their second best site.

The econometric specification of multisite selection models is quite different from that of trip frequency demand models. Now the dependent variable of the site visited on a particular choice occasion takes on a value 1, and the remainder of sites in the choice set takes a value of zero on that choice occasion. A discrete choice or qualitative response model such as multinomial logit is often estimated. With this model, an increase environmental quality at one site (call it site A) is reflected by some visitors switching away from other sites to visit site A. By linking multinomial logit site choice model to the trip frequency model discussed above, the analyst can also estimate the benefits of a change in site quality on both site selection and trip frequency. Herriges and Kling (1999) as well as Haab and McConnell (2002) and Parsons (2003) provide an in-depth discussion of these models.

49.5.3 Data Requirements for Travel Cost Models

Obtaining the individual level trip making and travel cost data for travel cost models usually requires a survey of visitors. If a single-site model is being estimated, the task is quite simple since only one site must be visited to collect the data or obtain names/addresses of visitors to send a survey to. However, with multiple-site trip frequency or site selection models, visitation data is needed on many sites. This then increases the data collection costs, especially if on-site surveys are to be used. Alternatively, it may be possible for some activities such as hunting or fishing where licenses are required to do a mail survey and ask the user about all the sites they visit in one survey. This is of course burdensome on the respondent and may reduce the overall survey response rate. However, the payoff from such a detailed survey is the ability to value changes in site quality and account for availability of substitute sites when calculating the demand function and consumer surplus.

49.6 Stated Preference Models

When the change in environmental quality is outside of the prior observed range or the desired value is one of nonuse, then the analyst cannot rely upon actual behavior as there is none. However, economists can construct or simulate a market or a voter referendum to ask people how much they would pay if quality was improved or a unique natural environment protected. The first stated preference method is called contingent valuation method.

We first discuss the contingent valuation method and then a newer stated preference method called the conjoint or choice experiment method. The two stated preference methods share many similarities in that (a) a resource scenario is described to respondents in words, often supplemented by graphs, diagrams, drawings, or pictures to clearly communicate what the resource being valued is and the quantity and quality of that resource. The scenario includes a baseline status quo with no additional cost or no tax cost, and then one or more action alternatives with an associated cost; (b) a means of payment by which the respondent pays the cost of provision of the increased quantity or quality of the natural resource or public good. The means of payment is tailored to the scenario, such that if it is nonuse some form of increased taxes (income, sales, property) or utility bill would be explained as being the mechanism in which the increment of the public good is financed; (c) the WTP question is typically a discrete choice with the respondent being asked if they personally would pay this amount (e.g., in the recreation setting) or vote to pay this amount (e.g., in a public goods setting). The magnitude of the monetary amount varies across the sample, allowing a quasi-inverse demand curve to be estimated. Given the discrete nature of the WTP question, a logit or probit model is often estimated in order to calculate the maximum amount a respondent would pay.

49.6.1 Contingent Valuation Method

Typically, contingent valuation method is used to estimate a single WTP value for a single scenario offering just one combination of quantity and quality of a public good. For example, in the Exxon Valdez oil spill contingent valuation study (Carson et al. 2003), a one-time WTP for the single scenario of avoiding another equivalently large and damaging oil spill was elicited using in-person interviews. However, some contingent valuation surveys provide multiple scenarios along a common quantity or quality scale. Then, a series of WTP questions are asked, allowing estimation of a WTP function for that increasing quality or quantity of a public good. For example, Walsh et al. (1984) asked annual WTP for four different amounts of land protected as wilderness. Multiple regressions were then used to estimate WTP as a function of acreage protected along with demographics of the visitor.

In terms of the format of the WTP question, Carson et al. used the closed-ended approach in its in-person interviews where respondents were asked if they would pay a particular monetary amount which varied across the sample. Typically at least five, and more often ten, different levels of the monetary amount are asked so as to estimate the quasi-inverse demand curve. An example scenario and a binary closed-ended or *dichotomous choice* referendum WTP question format used by Loomis (1996) for dam removal contingent valuation survey is:

> "*If an increase in your federal taxes for the next 10 years cost your household $YY each year to remove the two dams and restore both the river and fish populations would you vote in favor? YES NO*"

The $YY were 15 different bid levels ranging from $3 to $190, with most of the bid levels being in between $15 to $45.

To estimate the quasi-inverse demand curve, a binary logit model of the following stylized form might be estimated as in Eq. (49.6):

$$\log(\text{Prob Yes}/(1\text{-Prob Yes})) = \beta_0 - \beta_1(\$\text{Bid}) + \beta_2 X_2 + \beta_3 X_3 \qquad (49.6)$$

where $Bid are the $YY levels asked of the particular respondent, Xs are the values of the non-bid independent variables that may represent tastes and preferences toward the resource of interest.

From this equation, median WTP are calculated following Hanemann (1984) as

$$\text{Median WTP} = (\beta_0 + \beta_2 X_{2m} + \beta_3 X_{3m}))/|\beta_1| \qquad (49.7)$$

where $X_{2m}, X_{3m}, \ldots, X_{nm}$ are the means of the non-bid Xs. Collectively β_0 plus the sum of all the products is sometimes called the grand constant.

Many early contingent valuation method studies from the late 1970s through the 1980s used an open-ended WTP question format where the individual writes into the survey the maximum amount they would pay. This can be analyzed using simple descriptive statistics or ordinary least squares regression. Another popular technique for mail surveys is the payment card, where individuals' circle one of the preprinted monetary amounts representing the maximum amount they would pay. See Boyle (2003) for a more complete description of these alternative WTP question formats and Haab and McConnell (2002) for a detail of the econometric models associated with these question formats.

If use values are obtained, these values are expanded to the user population. For example, if the WTP of asthmatics to reduce air pollution is obtained, the sample would generalize to exogenous estimates of the number of asthmatics in the population of interest. However, if nonuse values such as existence values for a pure public good like protection of the Grand Canyon or an endangered species, the relevant public could conceivably be the entire country.

For the interested reader, a recent but edited book on contingent valuation is Alberini and Kahn (2006). This book provides chapters that included updated guides for designing and implementing a contingent valuation survey, econometric methods, and applications of contingent valuation.

49.6.2 Choice Experiments

In some cases, policy makers do not have a well-defined single scenario but rather are interested in the values of individual natural resource management options that they might combine into an overall management program or project. For example, when restoring wetlands, emphasis could be placed on providing endangered species habitat, but this might require prohibition of all hunting, wildlife viewing, and camping. Alternatively, the area could be managed for waterfowl hunting in one area, wildlife viewing in another, and camping in another part of the wetland. Each of these management options has different direct monetary costs and opportunity costs in terms of other options. Policy makers and managers want to know which of the many possible combinations of management actions would yield the greatest overall net benefits. Choice experiments are designed to answer these questions by estimating the marginal values or part worths of each management option or attribute.

Thinking about this from the viewpoint of the marketing literature, where this method originated, different combinations of management options yield different "product profiles." In our example below, Restoration Option A is 200 acres, with 100 % T&E species habitat and zero hunting and viewing. Restoration Option B might be 200 acres of wetland with one-third available for waterfowl hunting, two-thirds for wildlife viewing, and zero for T&E habitat. The No Action (status quo) or Current Situation usually has a zero cost and serves as a baseline. In our example, the area may currently a "de facto" wetland caused by excess agricultural drainage and used primarily as a "duck club" for private hunting. These product profiles are laid out in choice sets in a table such as Table 49.1

Table 49.1 Example choice set #1

Allocation of restored wetland	No action/current situation (acres and % of land)	Restoration option A (acres and % of land)	Restoration option B (acres and % of land)
T&E species	0 acres and 0 %	200 acres and 100 %	0 acres and 0 %
Hunting	160 acres and 80 %	0 acres and 0 %	66 acres and 33 %
Viewing	40 acres and 20 %	0 acres and 0 %	134 acres and 67 %
Annual cost per taxpayer	$00.00	$50.00	$75.00
Choose one	[]	[]	[]

Table 49.1's "Choose One" is typical of most Choice Experiments and consistent with the standard random utility formulation that underlies most choice experiments and recreation site selection models. However, this Choose One format does not obtain a great deal of valuation information from each choice, i.e., it is statistically inefficient. One solution typically used is to ask a respondent several of these choice sets. The pros and cons of this approach are briefly discussed below.

In a choice experiment, there are a large number of possible combinations of attributes. This yields a large number of possible choice sets, the exact number depending on how many levels of the four attributes. If there are eight levels of costs to get a precise estimate of the critical "price coefficient" and five levels of the other three attributes, there are dozens of possible combinations in what is called a full factorial design. A more compact design with fewer combinations is a fractional factorial design such as an orthogonal design usually focusing on just the main effects (or what will be the regression coefficient on that variable). In our example, a main effects design has 24 different product profiles, i.e., Restoration Options. The particular 24 combinations that minimize colinearity among the attribute levels are often determined using a SAS statistical software procedure (e.g., OPTEX) or other design choices discussed in Louviere et al. (2000).

The next design decision is how many of these 24 combinations to give each respondent. Generally respondent fatigue begins to set in after answering four such choice sets, and most authors argue against using more than eight (Holmes and Adamowciz 2003).

Once the survey versions are assembled and administered, analyzing the resulting data depends on the format of the choice question. Our example in Table 49.1 is typical with three options per choice set, so a multinomial logit model is usually estimated when there are three or more options in a choice set. If there are just two options, the current situation and one "action" option, then analysis of this is similar to dichotomous choice contingent valuation and uses a binary logit model.

The multinomial econometric specification for a choice example as depicted in Table 49.1 would be

$$\mathrm{Prob}(i|3) = \frac{\exp\left(\beta_0 + \beta_1 A_{i1} + \beta_2 A_{i2} + \beta_3 A_{i3} + \beta_p(\$A_i)\right)}{\Sigma \exp\left(\beta_0 + \beta_1 A_{j1} + \beta_2 A_{j2} + \beta_3 A_{j3} + \beta_p(\$A_j)\right)} \quad (49.8)$$
$$j = 1, 2, 3$$

where in our example with just three choices the sum is of the three alternatives. Essentially the individual is comparing the value of the non-cost attributes with the cost attribute to select the bundle that maximizes the relative utility in option 1 versus options 2 and 3 in our example. See Holmes and Adamowciz (2003) for a more in-depth treatment of the econometric models for these types of choice experiment data.

Once the coefficients from this equation are estimated, the marginal values of each attribute are calculated by dividing the attribute coefficient by the coefficient on cost. With this estimated Eq., the economic values of the different management options can be calculated. Comparing all the values of the different management options allows the analyst to determine the particular combination yields the greatest value. As sometimes happens, the choice experiment survey may have to be conducted prior to managers exogenously arriving at their preferred option based on other criteria. However, once the preferred option is known, the choice experiment results could be used to value that management option for a benefit-cost analysis of that preferred option. This flexibility to value options not identical to what was asked in the survey is also an advantage in many benefit transfers (see Rolfe and Bennett (2006) for a discussion of the advantages of choice experiments for benefit transfer).

49.6.3 The Issue of Bias in Stated Preference Surveys

A commonality of all stated preference methods is the concern about hypothetical bias, i.e., that the stated WTP is not equal to their actual WTP. If hypothetical bias exists, stated WTP is not a valid indicator or "true" WTP. Economists have been concerned about and have studied hypothetical bias for decades. Nonetheless, the issue leaps to the mainstream of economics during the early 1990s when contingent valuation was being applied to estimate the reduction in passive use values from the Exxon Valdez oil spill in Alaska. With hundreds of millions of dollars at stake, the strengths and weaknesses of the contingent valuation method were debated in the *Journal of Economic Perspectives*. Those interested in the debate should see Portney (1994), Hanemann (1994), and Diamond and Hausman (1994).

While the literature on hypothetical bias is voluminous (see Loomis 2011 for a summary), a few key results are worth noting. First, with use values, the bias is not always present. Studies that compare revealed preference techniques such as the hedonic property method to contingent valuation method show no statistical difference in WTP (Brookshire et al. 1982). Comparisons of benefit estimates from travel cost models and the contingent valuation method for recreation use values show, on average, no hypothetical bias (Carson et al. 1996). However, the less familiar the person is with the good being valued the more likely hypothetical bias. Thus, public goods that are largely existence or passive use values for which people do not have firsthand knowledge or prior choice experience do show significant hypothetical bias (Champ et al. 1997).

In response to this hypothetical bias, efforts have been made in survey design to reduce it via exhortations to respondents to behave as if it is a real market where they really have to pay their own money. Ex post calibrations of WTP values derived from the contingent valuation method have also been proposed based on respondent uncertainty (Champ et al. 1997).

Several other stated preference survey instrument design issues have been labeled as biases. One frequent concern here is payment vehicle bias. This bias occurs if WTP is influenced by how a respondent pays, e.g., via an income tax versus a utility bill. WTP elicitation format bias occurs if WTP is influenced by whether the valuation question is asked in an open-ended format or closed-ended format such as a dichotomous choice or payment card format. See Boyle (2003) for a discussion of these other biases.

49.7 Combining Stated and Revealed Preference Methods and Data

Both stated preference and revealed preference have their strength and weaknesses when estimating use values such as those that might arise from reductions in urban air pollution. Cameron (1992) was one of the first to recognize that perhaps combining revealed preference and stated preference data in environmental valuation might capitalize on their respective strengths while minimizing their weaknesses. In particular, Cameron (1992) talked about using the revealed preference data to "discipline" the stated preference data. This might help reduce the influence that any hypothetical bias might have in the WTP estimates. The marketing literature had been using this approach for more than a decade for a number of purposes including testing for hypothetical bias (see Louviere et al. 2001).

Since the early 1990s, there has been an explosion of combined revealed preference and stated preference studies, particularly in the recreation context. The most recent compendium of state-of-the art papers on combining revealed and stated valuation approaches is Whitehead et al. (2011). This book illustrates the wide variety of applications that the combined revealed preference and stated preference method has been used for. These include pesticide risk reduction, seafood, reservoir operations, as well as recreation.

Of course a reasonable question one might ask is "If you have revealed preference data, why would you want to combine it with stated preference data?" There are several reasons, all related to limitations in relying solely on revealed preference data: (a) revealed preference data may not have sufficient natural variation in amenities or environmental quality to estimate a statistically significant coefficient. This could arise because of limited data availability (e.g., only 1 year of data rather than a time series being available) or because there just isn't much natural variation in the quality or amenity attribute; (b) the attributes are highly correlated in the data set so that it is nearly impossible to estimate a statistically significant coefficient on each of them separately (e.g., air quality and traffic congestion); (c) the policy being valued would result in changes in quality or level of the amenity that is outside the current range of quality; and (d) introduction of a private good with a new attribute (e.g., locally grown organic corn) or new public good, similar to but not identical with existing public goods.

49.8 Benefit Transfer

Oftentimes economists with state and federal agencies are asked to perform a "quick and dirty" back of the envelope benefit-cost analysis to provide a rough estimate of the benefits and costs of a particular time-sensitive policy proposal or where there is not a sufficient budget that the cost of a survey is feasible.

In this case, environmental economists have developed a set of protocols to transfer existing valuation estimates from prior revealed preference and stated preference studies to evaluate the new policy in question. There are basically four main types of benefit transfer: (a) point estimate value transfer from the most similar study, (b) an average of the values from the prior literatures' most similar studies, (c) transferring the demand or WTP function from the prior study to the new policy study, and (d) using a *meta-analysis* regression equation estimated on the past valuation studies to calculate what the valuation per unit (e.g., visitor day, household) would be at the new policy site.

In principle, demand/WTP function transfer or meta-analysis have the advantage of being able to adapt the values from the existing literature to better match the criteria for an ideal benefit transfer than would a simple transfer of average values from the literature. Transferring a WTP function that contains demographic variables such as income and age would allow the demand function to be tailored to the sociodemographics surrounding the policy site. In principle, the WTP function approach should reduce benefit-transfer errors as compared to transferring point estimates.

Meta-analysis involves a regression with the value per unit (e.g., recreation day, acre of wetland, household) as the dependent variable and study site characteristics as the independent variables. There have been more than a dozen meta-analyses of environmental and natural resources including water (quality and quantity), electricity, value of statistical life, transportation noise and property values, and wetlands (see Nelson and Kennedy (2009) for a complete listing).

Using a meta-analysis regression equation as a benefit-transfer tool has three potential advantages over average value transfer in terms of an ideal benefit transfer: (a) ability to interpolate a value for a particular public good in a particular region that might not exist in the published literature (e.g., fish species X in region Y might not be available in the literature, only fish species Z in region Y or fish species X in region R); (b) ability to incorporate a nonlinear relationship between the value per unit and the quantity change (e.g., additional acres of wetlands may not have a constant value per acre as an average value transfer implicitly assumes); and (c) ability to account for other attributes of the good being valued (e.g., distinguishing between the value of a recreation activity on public land vs private land). Meta-analyses for benefit transfer are discussed in more detail in Bergstrom and Taylor (2006).

Interest in determining the accuracy of benefit transfer and especially comparing the accuracy of meta-analysis and average value transfers has spawned a substantial literature. This literature uses a comparison of original study values versus benefit-transfer estimates of those same values to calculate the error of benefit transfer. Rosenberger and Loomis (2003) catalog the various estimates of benefit-transfer errors from value transfers (e.g., point estimates or average values) and function transfers (e.g., primarily meta-analyses). While most of the value transfer errors are in the range of 4–40 %, several are off by 100–200 % (and occasionally more). Benefit function transfer generally does better, but it too can be off by 200 % or more.

One of the tools for improving the accuracy of benefit transfer is for analysts to have access to comprehensive databases and benefit functions. Significant progress has been made in this area in the last two decades. A major advance came with the cooperative Australia, Canada, France, New Zealand, UK, and USA's Environmental Values Reference Inventory (EVRI see http://www.environment.nsw.gov.au/publications/evri.htm). This database includes air quality, water quality, wildlife, recreation, and infrastructure. General recreation value databases include Loomis (2005 at http://www.fs.fed.us/pnw/pubs/pnw_gtr658.pdf). For average value tables, databases, and meta-analyses for hunting, fishing, wildlife viewing, wetlands, salmon, endangered species, and open space, see http://dare.colostate.edu/tools/benefittransfer.aspx or http://www.defenders.org/programs_and_policy/science_and_economics/conservation_economics/valuation/benefits_toolkit.php.

For the most recent comprehensive discussion of benefit transfer, see the special issue of Ecological Economics edited by Wilson and Hoehn (2006) and Rolfe and Bennett (2006) for a discussion of using Choice Experiments for benefit transfer.

Overall, each of these benefit-transfer methods have their strengths and weaknesses, and the choice is sometimes driven by the (lack) of available data. For example, if there are no similar studies for a similar geographic region, then a meta-analysis may be the best answer if a meta-analysis has already been previously estimated by someone else. If not, then an average of past valuation studies might be the best estimate the analyst can use given the time available to conduct the benefit transfer.

However, any of these benefit-transfer approaches is likely better than omitting completely a monetary value for that health effect or recreation activity. Oftentimes the net result of such an omission from the benefit-cost analysis is an implied value of zero. Benefit transfer, while not as accurate as conducting a primary study, is typically more accurate than an estimate of zero.

49.9 Conclusions

The gist of this chapter can perhaps be summed up in a few sentences. Economic theory provides a consistent measure to value market goods and nonmarket environmental externalities and public goods. Market price is just willingness to pay for one more unit. Where price does not exist, economists can infer willingness to pay using revealed preference methods or using a "constructed or simulated market" ask respondents to state their willingness to pay. The revealed preference and stated preference methods are based on the same utility maximization process economists use to estimate demand for market goods. While the econometric details of estimating an econometric model for recreation are slightly different than estimating the demand for gasoline, often times the basic structure of the data (e.g., cross-sectional data) and econometric issues dealt with have more in common than one might think.

What cannot be summed up in a few sentences is the wide variety of variations on these basic revealed and stated preference methods. These variations arise due to the need to tailor the valuation to the particular types of public goods. As highlighted in this chapter, the economists' toolkit has a wide variety of methods that can be applied to value nearly every type of public goods that are commonly dealt with in benefit-cost, policy, or regulatory analyses.

Environmental valuation theory and methods are evolving areas of research. While environmental valuation originated in the desire to value recreation in public water projects, it quickly saw application to value air and water quality in benefit-cost analyses of environmental regulation. Environmental valuation rose onto the popular presses radar screen with the application of valuation methods to natural resource damage assessments, including oil spills. In the last decades, as the recognition has grown that the environment provides valuable ecosystem services to people, all the valuation methods discussed above, and stated preference methods in particular, have been employed to monetize these values. Interest in developing computer packages to allow government agencies to monetize ecosystem services relies extensively upon benefit transfer. Environmental valuation techniques continue to see new policy applications and no doubt there will be many more in the future.

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