Distributional Issues and Nonmarket Benefit Measurement

Nancy E. Bockstael and Ivar E. Strand

The use of willingness to pay as a welfare criteria has several inherent weaknesses. Its potential for causing inequitable redistribution of income as well as ambiguity in project evaluation is explored. An empirical example is offered in a natural resource context. A travel cost model which includes both time and money costs is used for valuation and produces ambiguous results.

In this paper, our discussion of the distributional consequences of environmental changes leads inevitably to a revival of the controversies of welfare measurement. This is not surprising since distributional issues arise only in the process of aggregating benefits, and it is in aggregation that so many difficulties arise in welfare economics. Here we argue that the issues are not solely esoteric ones but can have perplexing implications when conventional welfare measures are used to assess the distributional implications of policy actions. The anomalies become apparent when both time and money constraints on individuals' utility maximizing decisions are recognized.

Measuring the Benefits of Environmental Policies

Hicksian compensation measures of welfare have attained an almost universal acceptance in the applied economics profession. Just *et al.* describe these as "key concepts" which "form the foundation of applied welfare economics." Their appeal is in their uniqueness relative to consumer surplus, their basis as willingness-to-pay measures, and their obvious connection with Hicks–Kaldor compensation criteria. In fact in many economists' minds, they have acquired the stature of "exact welfare measures."

The use of such "welfare measures" to evaluate policy actions, however, requires that we move from the effect **on an individual** to the effects on society as a whole. The greatest and altogether most insurmountable difficulty in welfare evaluation has always been the aggregation of these effects **over individuals.** Once having obtained compensating or equivalent variation measures for individuals, it has been the convention simply to add them. In defense of this, economists have appealed to the compensation principle. If the simple unweighted sum of all compensating variations is positive, then gainers could potentially compensate losers and no one would be worse off. Those who have persisted in their objections to this method of aggregation have criticized its implicit designation of the status quo as optimal. The compensation principle presumes the initial state to be a desirable distribution, since it compares potential changes to this state. Yet, the status quo

The authors are Associate Professors in the Department of Agricultural and Resource Economics at the University of Maryland.

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(or initial state) may not represent a particularly desirable income distribution. Applying the compensation principle, in either its potential or actual form, implies a use of an arbitrarily chosen standard [see for example the arguments of Rowley and Peacock and Sen].

Disregarding the obvious inequity of equating a dollar of benefit to the rich with one to the poor, application of the compensation principle in the absence of actual compensation will lead to undesirable effects on income distribution. If two individuals with precisely the same utility function and initial endowment of a public good have different initial incomes, they will have different amounts of money compensation for the same increase in the public good when it is a normal good. The consequence is that these two individuals with identical, albeit immeasurable and unobservable, utility changes would possess different Hicksian compensation measures. Using Hicksian measures, the wealthier individual would appear to gain (or lose) more from the positive (or negative) policy change.

These arguments in the abstract are more or less well known by economists, but their relevance to environmental policy has infrequently been considered. Often economists are asked to calculate the "benefits" of a particular action such as improving air or water quality, providing new parks, or recreation sites, or enhancing wildlife. In such studies, the task of coming up with respectable measures of individual consumer surplus or compensating variation from cross-sectional survey data is generally so overwhelming as to leave little time or energy for distributional issues. There has been an implicit understanding in this research that if the sum of individuals' compensating (or equivalent) variations (i.e., their willingness to pay for the improvement) exceeds the cost of pollution control, then the policy action is worth undertaking. The question of distribution has rarely received attention in these environmental policy assessments.

However, the need for considering income distribution when assessing environmental policies is more convincingly argued from another perspective. No projects/policies are without alternatives; it is always legitimate to ask in what other ways "public funds" might be used. In any of the cases where alternative policies are relevant, income distribution considerations play a potentially critical role. As we argued above, Hicksian compensation measures are increasing in income. Thus if we consider two identical projects which provide normal goods and would have identical effects on two groups of people with identical tastes but different incomes, we would always find the project awarded to the wealthier group—upon seemingly rational and objective cost–benefit criteria. The implementation of environmental policies continually modifies the distribution of welfare, especially if compensation is not paid. Thus if the compensation criterion is used to evaluate policies, there will be a tendency toward redistribution of welfare to the wealthier.

Two Standards of Welfare Measurement

The fundamental difficulty inherent in using money to measure welfare effects is that individuals with different money–utility tradeoffs will have different money bids for a policy change which elicits the same utility change. Now we will see that if money is recognized as **only one** of a set of plausible standards by which to measure welfare changes, this "fundamental difficulty" provokes ambiguities in the assessment of distributional implications.

Compensating variation has been defined as the amount of **money** an individual would be willing to pay to accept a change in the state of the world and be left indifferent. Money is the obvious choice of a standard because market goods are valued in these terms, but it "works" from a theoretical perspective because money has a utility shadow value. It is because the consumer's problem is viewed as a utility maximization problem subject to a constraint on **income** that money measures of compensation are clearly definable. Compensating and equivalent variations measure the changes in the dual to this problem; that is, they measure how the constraining resource allocation must be changed to accommodate the change in the state of the world so as to leave utility unchanged. What happens, though, when money is either 1) **not** an exogenous constraint or 2) not the **only** exogenous constraint?

Economists are increasingly acknowledging that money is not the only constraining factor in economic decisions. In the household production literature, households are seen as "producing" commodities for consumption by combining purchased inputs, durable goods, and individuals' time. The role of time as a scarce and constraining resource is central to this literature. It has also been adopted as the broad basis of the travel cost models used extensively in recreational demand modelling.[1] The core of the argument is that the budget line may be kinked because different wage rates are effective over different amounts of labor time and may have "holes" in it because some jobs are on an "all-or-nothing" basis (e.g., 40 hours per week or nothing, see Killingsworth). As we observe them to do, individuals may choose to be along segments of the budget line representing jobs with flexible work hours or they may choose to be at corners or kinks (either no employment or a fixed work week). Those at interior solutions will equate their marginal rate of substitution between income and leisure to the wage rate, but for an individual at a corner solution there is no predictable relationship between his wage rate and his valuation of time.

What does this imply for the valuation of environmental quality and the distribution of benefits from environmental improvements? Once we admit the importance of time in economic decisions (and particularly recreational behavior), we are forced to modify the conventional statement of the consumer's problem, that of maximizing utility subject to an income constraint. The modification of this conventional construct of the consumer's decision problem has consequences for the measurement of welfare effects.

Let us begin with a model recognizing time and income constraints. [For a more comprehensive description of this model, see Bockstael *et al.*] In general, we have

$$\max_{x} U(x) + \lambda(\bar{Y} - \Sigma\, p_i x_i) + \mu(\bar{T} - \Sigma t_i x_i) \quad (1)$$

where U(x) is a quasi-concave, twice-differentiable utility function; $\bar{Y}$ is effective income from all sources; $\bar{T}$ is time available (after job activities); p_i is the price of the i^{th} good; t_i is the time requirement associated with the i^{th} good; and x_i is the amount of the i^{th} good. When the two constraints are collapsible (i.e., the individual can trade time for money at the wage rate), then equation (1) collapses to

$$\max_{x} U(x) + \lambda[\bar{F} - \Sigma(p_i + w_D t_i)x_i] \quad (2)$$

where $\bar{F}$ is "full income" which includes nonwage income, any income earned at a job with fixed hours, and the discretionary wage times the number of hours available for discretionary work.

In applying the logic of welfare theory

[1] For many publicly supplied recreational resources (e.g. parks, beaches, oceans, etc.), the monetary cost of use is low but the time cost is high. A random telephone survey of Baltimore and Washington, D.C., for example, found forty-five percent of the nonusers of the Chesapeake Bay in 1984 responded that time was the critical factor in their decision not to use the Bay. Only five percent stated the money costs were prohibitive. The 1980 Fish and Wildlife Survey of Hunting and Fishing recorded an even higher response to the time constraint question.

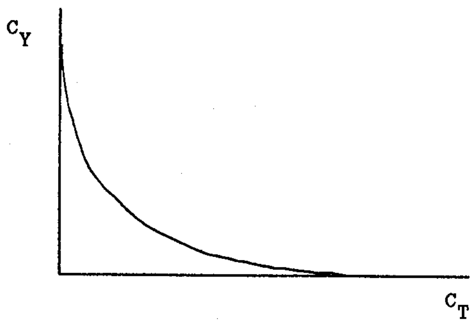

Figure 1. Compensation Combinations in Money (C_Y) and Time (C_T) in the Collapsed Constraint Case.

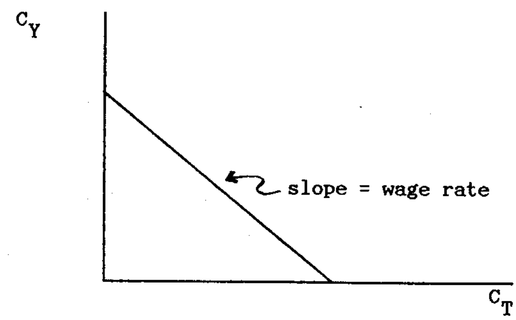

Figure 2. Compensation Combinations in Money and Time (C_T) in the Collapsed Constraint Case.

to the problem with two constraints (1), we immediately encounter confusion. It is still possible to define a compensating variation measure as the change in income necessary to return an individual to his initial level of utility after a change in some exogenous parameter. However, it is equally possible to define Hicksian variation measures in terms of time or in terms of a combination of time and money.

To see this, it is useful to look at the indirect utility function which is determined by substituting the optimal choice functions for the x's in (1) into the utility function. The result is an indirect utility function of the form

$$U = V^c(p,t,\bar{Y},\bar{T}).$$

Now consider a price change and the possible compensations in time or income or both which could maintain utility at its initial level. Money and time compensations are denoted by C_Y and C_T, respectively, in the following expression:

$$V^c(p^0,t^0,\bar{Y}^0,\bar{T}^0) = V^c(p^1,t^0,\bar{Y}^0 + C_Y,\bar{T}^0 + C_T). \quad (3)$$

Clearly the above describes a locus of compensation combinations (C_Y,C_T).

In the two polar cases where compensation is paid either all in money ($C_T = 0$) or all in time ($C_Y = 0$), there exist well-behaved analogies to neoclassical welfare economics. That is, there are two well-defined duals to problem (5a): one in which money expenditures are minimized subject to utility and time constraints and one in which time expenditures are minimized subject to utility and income constraints. [For more discussion of the properties of the two constraint problems, see Smith.]

Nevertheless, as can be seen from (3), there is an entire frontier of possible combinations of compensation, with (C_Y, 0) and (0, C_T) being only the two extreme cases. The frontier between these points implies a compensation indifference frontier such as that portrayed in Figure 1. The curvature of this indifference locus is determined by the properties of the indirect utility function (which itself reflects properties of household production and utlity) and under reasonable assumptions could be convex as pictured.[2]

Turning to problem (2), income is not strictly speaking a constraint because it is endogenously chosen. However, there is a constraint implied by available time and wage opportunities. This can be expressed as a full-income constraint. Once again compensation may be measured in time or money units or some combination, but here the terms of trade equals the wage rate. This implies a linear indifference locus such as depicted in Figure 2.

Of particular importance here is that there is a multitude of compensation plans

[2] We are grateful to Dennis Corey for emphasizing this existence of this frontier.

possible for any price (or other exogenous) change **and** there are **no** possible grounds for choosing among these compensation plans. They are, by definition, all equally good from the individual's perspective. That is, individuals could be compensated, if indeed compensation were paid or received, in terms of money or time or a combination.[3]

An Illustration

In this section, the general model of (5) is made operational with the specification of a form for the utility function according to the work by Bockstael *et al.* The model is then used to estimate relevant parameters for the group of Southern California boat-owning sportfishermen [see National Coalition for Marine Conservation for descriptive material on the sample]. The welfare effects of hypothetical public policies which could affect their catch rates and/or time costs are analyzed.

The utility function chosen for illustration is

$$U(x) = \frac{(\gamma_1 + \gamma_2)x_1 + \beta}{(\gamma_1 + \gamma_2)^2} \cdot \exp\left[\frac{(\gamma_1 + \gamma_2)(\alpha + \gamma_1 x_2 + \gamma_2 x_3 - x_1 + \gamma_3 q + \epsilon)}{(\gamma_1 + \gamma_2)x_1 + \beta}\right]. \quad (6)$$

This function is a modification of the two good utility function which is implied by a linear demand function for x_1. The modification involves extending the utility function to incorporate three goods so that two constraints can be binding. In the above expression α, β, γ_1, γ_2 and γ_3 are parameters assumed for estimation purposes to be common to all individuals. The variable q represents a predetermined quality variable associated with the recreational good, x_1. The random variable, ϵ, reflecting the distribution of preferences is assumed to be distributed normally with mean zero and constant variance, σ^2.

The set of other goods is partitioned such that x_2 is a bundle of goods with money but no significant time costs, and Hicksian bundle x_3 is a bundle of goods with time but no significant money costs. Thus the general constraint set is

$$\bar{Y} - p_1x_1 - p_2x_2 = 0$$

and

$$\bar{T} - t_1x_1 - t_3x_3 = 0$$

where p_2 and t_3 are assumed to be equal to one, forthwith.

Solving the system for the optimum value of x_1, and denoting $\beta/(\gamma_1 + \gamma_2)$ as β', yields ordinary recreational demand functions, conditioned on each labor supply decision, of the form

$$x_1 = \alpha + \gamma_1\bar{Y} + \gamma_2\bar{T} + \beta'\gamma_1 p_1 + \beta'\gamma_2 t_1 + \gamma_3 q + \epsilon \quad (7)$$

for individuals at corner solutions in the labor market, and

$$x_1 = \alpha + \gamma_1(\bar{Y} + w_D\bar{T}) + \beta'\gamma_1(p_1 + w_D t_1) + \gamma_3 q + \epsilon \quad (8)$$

for individuals at interior solutions in the labor market.

For individuals at interior solutions, there is only one expenditure function, but it can be defined in terms of either money or time compensation. The expenditure function in terms of income is

$$m_Y = u\{\exp[\gamma_1(p_1 + w_D t_1)] - (x^0 + \beta')\}/\gamma_1$$

and in terms of time it is

$$m_T = u \exp[\gamma_1(p_1 + w_D t_1)] - (x^0 + \beta')/\gamma_1 w_D.$$

There are two expenditure functions for the corner solution individuals:

$$m_Y = u \exp[\gamma_1 p_1 + \gamma_2 t_1](\gamma_1 + \gamma_2)/\gamma_1 - (x^0 + \beta')/\gamma_1$$

[3] The court system has certainly recognized the compensation issue in the presence of two constraints. Wealthy individuals are often required to do public service rather than pay inconsequential fines. Likewise, the very poor are often required to do public service in lieu of paying fines for which they have insufficient income.

TABLE 1. Estimated Maximum Likelihood Parameters.

Parameters	α	β'	γ_1	γ_2	γ_3	σ
Estimate (t-ratio)	−3.838 (−.743)	−1.019 (−2.563)	.024 (.899)	2.982 (3.715)	.712 (3.208)	15.543 (12.486)

and

$$m_T = u \exp[\gamma_1 p_1 - \gamma_2 t_1](\gamma_1 + \gamma_2)/\gamma_2 - (x^0 - \beta')/\gamma_2.$$

If we consider the compensating variation of a price change which drives x_1 to zero, there are both money and time measures which can be defined for each labor market group. These are

$$CV_Y = \exp[\gamma_1(p_1^1 - p_1^0)] \cdot (x^0 + \beta')/\gamma_1 - \beta'/\gamma_1$$
$$CV_T = \exp[\gamma_1(p_1^1 - p_1^0)] \cdot (x^0 + \beta')/\gamma_2 - \beta'/\gamma_2$$

for people at corner solutions, and

$$CV_Y = \exp[\gamma_1(p_1^1 - p_1^0)] \cdot (x^0 + \beta')/\gamma_1 - \beta'/\gamma_1$$
$$CV_T = \exp[\gamma_1(p_1^1 - p_1^0)] \cdot (x^0 + \beta')/\gamma_1 w_D - \beta'/\gamma_1 w_D$$

for individuals at interior solutions.[4]

Estimation of the model was accomplished using maximum likelihood procedures and the Berndt-Hall-Hall-Hausman algorithm. The estimated coefficients produced by this procedure are presented in Table 1 and welfare measures for both time and money compensation are reported in Table 2. They are the compensating and equivalent variation and ordinary surplus associated with the elimination of the resource. Note that it is possible to calculate an ordinary "time" surplus which is the area behind the Marshallian demand function plotted in time price and quantity space rather than money price and quantity space.

The first observation is that money measures of compensating and equivalent variation deviate from ordinary (money) surplus by less than two percent. This is not surprising since the income effect is small. Likewise, time measures of compensating variation and equivalent variation fall within two percent of the ordinary (time) surplus. Given the closeness, we use compensating variation as our welfare measure hereafter.

The average money compensation varies between $2,700 and $4,280 per year for the two groups. In 1983, these individuals spent on average around $4,800 in fixed costs for their boats (items such as insurance, mortgage payments, and slippage fees). Individuals also responded that about three-fourths of the boat usage was for saltwater fishing. Thus, the surplus figures do not appear inordinantly large.

The average time compensation for the flexible-work-hours group is about 160 hours. This suggests a money–time tradeoff for these individuals of about $17/hour, which is approximately the average hourly wage for that sample of individuals. By contrast, the average individual with a fixed work week would require more income compensation (about $4,200/year) but less discretionary time compensation (about 68 hours). This suggests that individuals with fixed work weeks would trade time for money at about $60/hour, a much higher rate than the individuals with flexible work hours and a much higher rate

[4] The expressions for equivalent variation are

$$EV_Y = (X^0 + \beta^1)/\gamma_1 - \beta^1 \exp[\gamma_1(p^0 - p^1)]\gamma_1$$
$$EV_T = (X^0 + \beta^1)/\gamma_2 - \beta^1 \exp[\gamma_1(p^0 - p^1)]\gamma_2$$

for people at corner solutions, and

$$EV_Y = (X^0 + \beta^1)/\gamma_1 - \beta^1 \exp[\gamma_1(p^0 - p^1)]\gamma_1$$
$$EV_T = (X^0 + \beta^1)/\gamma_1 w_D - \beta^1 \exp[\gamma_1(p^0 - p^1)]\gamma_1 w_D$$

for people at interior solutions.

TABLE 2. Average Welfare Measures Associated with the Elimination of the Resource.

	Individuals with Fixed Work Hours	Individuals with Flexible Work Hours
Money Measures ($/Year):		
Ordinary Surplus	$4,192	$2,727
Compensating Variation	4,281	2,776
Equivalent Variation	4,148	2,703
Time Measures (Hours/Year):		
Ordinary Surplus	68 hours	159 hours
Compensating Variation	69 hours	162 hours
Equivalent Variation	67 hours	157 hours

than the labor market is likely to offer. Individuals with fixed working hours appear to value time much more highly than the wage rate and would be willing to trade work for leisure. In essence, they have relatively less free time because they have to work more hours than they desire. However they have fixed work weeks and probably face all-or-nothing decisions in the labor market, so that they can not adjust their work time.

Now, suppose we were interested in the losses which would accrue from the destruction of this fishery resource, we might simply have calculated the money compensation measures in the first three rows of Table 2. We would have been tempted to conclude that the group with fixed work hours would be hurt more by the elimination of this resource than the flexible work hour group. However, an examination of the time compensations in rows four through six suggests the reverse.

This apparent enigma is easy to explain. Despite the fact that we have assumed the same basic preference structure for all individuals (except for a random disturbance), individuals with different situations in the labor market value time and money quite differently. If there are two constraining resources, then each compensating variation will be a function of the relevant resource constraint and the ratio of compensating variations will not be constant over the population.

Conclusion

This paper is a preliminary attempt at exposing precisely what distributional implications are implicit in benefit–cost analysis. If we accomplish nothing else, we hope to revive in the minds of applied economists some of the ambiguities at the heart of theoretical welfare economics. There has always been, in the back of our minds, a concern about the role of the initial income distribution when making value judgments. However the intuitive appeal of the Pareto criteria buttressed by the compensation principle has usually triumphed.

In this paper we show that even if one is willing to accept the compensation principle, and the status quo income distribution, it is still not possible to accept current welfare evaluation procedures. First, use of the willingness-to-pay criterion without compensation paid will redistribute income to more wealthy individuals for normal goods. When the problem admits of more than one constraint on the individual (or when income is really endogenously determined) as is true in a broader definition of the individual's utility maximizing problem, the compensation can be measured in standards other than income. The result can lead to contradictions in the distributional implications of public policies. In another paper, the authors show that the dual standard can also lead to ambiguities in the choice among alternative public policies [Bockstael and Strand]. Groups with different relative resource endowments will benefit from the use of different standards. The compensation principle does not allow us to avoid distributional issues. In fact resolution of the ambiguities implied by different standards requires recourse to distributional criteria.

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