METHODS FOR AGGREGATING PERFORMANCE INDICATORS

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Abstract

This paper develops a method for deriving a trade-off based index of environmental quality which can serve as an operational indicator of environmental quality. The index is based on the economic paradigm that value is determined by people's willingness to make trade-offs, but it is not expressed in monetary terms so it may be more acceptable to non-economists. In addition, it may avoid some of the potential sources of bias which have made contingent valuation such a controversial technique and avoids some of the pitfalls of typically employed indices such as those used in the Environmental Monitoring and Assessment Program of the USEPA. The trade-off based index which is suggested is shown to be completely analogous to Gross Domestic Product (GDP), and can be used to evaluate policy with respect to issues of efficiency, sustainability and equity.
I. INTRODUCTION:

Every student who takes the first course in principles of economics learns that GDP is not a measure of social welfare. However, sometimes by default and sometimes by intent, GDP is used in a variety of policy contexts as a measure of social welfare. Of course, this has led to a significant discussion of the problems associated with using GDP as a measure of social welfare. At the same time, increasing concern with the environment and sustainable development have lead to criticisms of GDP and traditional measured NDP, as these measures do not capture the consumption of environmental capital which occurs during the process of generating current income. Many authors have suggested ways of “greening” measures of GDP and NDP to better capture the loss of environmental capital, and have a measure of economic performance that is better related to the concept of sustainable development.

However, it is important to recognize that the environment contributes to social welfare independent of its contribution to GDP or green GDP. If one is to embark on a set of environmental and economic policies to improve social welfare, a mechanism is needed to ascertain all the impacts of the policies on social welfare. In an ideal world, one would endeavor to estimate a social welfare function to forecast these impacts, but this process is exceedingly difficult both in terms of data requirements and in terms of specification.\(^1\) In the absence of a social welfare function (and as a precursor to attempts to estimate a social welfare function), an operational indicator of environmental quality can give insight into the impacts of policies on social welfare, just as GDP is an operational indicator of the health of the economy.

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\(^1\) See Boadway and Bruce for a discussion of the Arrow Impossibility Theorem and the practical implications of the theory for the identification and estimation of social welfare functions.
The development of such an operational indicator of environmental quality is the question that this paper addresses, by developing an environmental analog to GDP. This indicator focuses on the measurement of elements of the stock of environmental capital (and services flowing from the capital) that directly impact social welfare. It is not an attempt to follow in the footsteps of Daly and Cobb (1989), Moffat and Wilson (1994) and others in redesigning GDP and NDP to account for the depreciation of income producing environmental capital. The second section of the paper explains this distinction in greater detail, by diagraming the relationships among the economy, the ecosystem and social welfare. The third section of the paper discusses other efforts to develop indicators of environmental quality, while the fourth section discusses the approach suggested in this paper, a trade-off weighted index of environmental quality. The fifth section presents a discussion of how the index can contribute to the policy-making process.

II The Relationship Between the Environment and Social Welfare

Figure 1 illustrates the relationships among four different aspects of the quality of life and social welfare. These facets of the quality of life include the health of the economy, the health of the population and the health of the environment. Although there are many other important influences on social welfare, this paper diagrams only these four factors, in an effort to focus on the direct and indirect impacts of the environment on social welfare. Direct impacts are depicted by the purple arrow and represent environmental resources (or services flowing from environmental resources) that appear as individual arguments in an individual’s utility function. In

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2 If one were looking at this problem in a household production function approach, then these environmental resources and services would be inputs to the production of a final service flow.
Figure 1 Selected Determinants of Social Welfare

closest, environmental quality also indirectly impacts social welfare through its effects on the economy, health of the population, and social justice.

It is important to note that we have already developed operational indicators associated with non-environmental direct impacts (the blue arrow and the inner red arrows). For example,
GDP, green GDP, unemployment rates, and inflation rates are all operational indicators of the health of the economy. Similarly, infant mortality, birth weights and longevity are used as operational indicators of the health of the population, while variables such as the inequality of income distribution (Gini Coefficient), literacy rates and incarcerated proportion of the population are used as indicators of social justice.

One can use these indicators to evaluate policy, even in the absence of a social welfare function. For instance, ceteris paribus, if longevity or literacy rates increase, social welfare will be increasing. The difficult policy question arises in terms of trade-offs, for example, if reducing infant mortality rates requires a sacrifice in terms of potential GDP. Methods for examining this trade-off will be further discussed in Section V, but for now, the crucial point is that we have not developed a corresponding environmental indicator for the health of the environment.

Again, it is emphasized that this paper is not suggesting a new “green” method for measuring GDP, which incorporates environmental influences on GDP. The blue arrows of Figure 1 show the influence of the environment of the health of the economy, and are the subject of focus for improved measures of green GDP or green NDP such as those suggested by Daly and Cobb and Moffat and Wilson. This paper focuses on developing an operational indicator of the health of the environment which focuses primarily on the purple arrow, but can also encompass some aspects of the indirect impacts associated with the chain of red arrows.

It should be noted that any choice of an operational indicator of the environment will have both advantages and disadvantages and will not be an “ideal indicator.” For example, the unemployment rate is an operational indicator of the health of the economy, but it has its flaws. It does not include those who are so discouraged that they are not actively seeking work, and
aggregate unemployment rates understate the true unemployment rates for some sectors of society, such as young people in the inner cities. However, if one understands the idiosyncracies of an operational indicator, it can be used in the policy formulation process.

III A Discussion of Past Efforts to Develop an Operational Indicator of Environmental Quality

At least four methods have been suggested or employed to develop operational indicators of environmental quality. These include use of “representative” environmental variables, the development of satellite accounts for the National Income and Product Accounts, green GDP/NDP and indices of sets of environmental variables.

Representative environmental variables

Measures of individual species of pollution have been used in many studies, with the underlying assumption being that the trends associated with these individual pollutants are somehow representative of environmental quality. For example, sulfur dioxide pollution has been used as an indicator of overall environmental quality in the estimation of “environmental Kuznet’s curves”, which purportedly show a u-shaped relationship between environmental quality and income (an inverse u-shaped relationship between income and concentrations of pollution). The use of particular pollutant to proxy for environmental quality in general is conceptually similar to using output in the steel industry as a proxy for GDP or incidence of lung cancer as a general indicator of the health of the population, and has been criticized by Arrow et al and O’Neill et al, among others. In particular, the measure is completely unrelated to both land use changes (such as deforestation and desertification) and water quality changes (with the exception of acidification of water bodies). In addition, sulfur dioxide is a fund or flow pollutant which does not accumulate
overtime, unlike carbon dioxide, chlorofluorocarbons, or heavy metals.

Green GDP

Many economists, including Daly (1991), Peskin (1976), Prince and Gordon (1994), and Repetto (1989) have argued that disastrous consequences can occur when macroeconomic policy is based on promoting the growth of GDP. They argue that not only does this ignore other aspects of the quality of life, but that GDP has a serious flaw as a measure of economic progress.

This flaw has to do with the fact that measures of Net Domestic Product (NDP) subtract the depreciation of human-made capital, but do not subtract the depreciation of natural capital. Thus, when a machine is worn-out to produce current income, the loss in income producing ability is subtracted from the measure of current income. The consumption of human-made capital is subtracted from GDP to give NDP, a more accurate measure of the current economic well-being of a nation. However, when a forest is clear-cut, soil degraded, or stocks of minerals depleted in order to produce current income, a similar debit is not made.

Although one can argue that this is just a definitional issue, and that all definitions are arbitrary in nature; there are serious implications when national economic policy is based on this flawed measure of NDP. If increasing current NDP is a primary policy goal, then natural capital and its ability to produce future income (or other services) may be expended even if this is detrimental to producing future social welfare. Although this is a crucial problem in developed countries such as the United States, it is perhaps even more important in developing countries where pressing needs to increase current income have caused catastrophic deforestation, pollution, soil erosion and desertification.

As Repetto indicates, this difference in the treatment of natural capital and human-made
capital

...reinforces the false dichotomy between the economy and the "environment" that leads policy makers to ignore or destroy the latter in the name of economic development. It confuses the depletion of valuable assets with the generation of income. Thus, it promotes and seems to validate the idea that rapid rates of growth can be achieved and sustained by exploiting the resource base. The result can be illusory growth and permanent losses in wealth.

Therefore, Repetto and others argue that the depreciation of natural capital should be factored into GDP in a fashion analogous to the depreciation of human-made capital. Repetto recomputes Indonesia's national income and product accounts making corrections for deforestation, soil erosion and oil reserves. Repetto found that the measured 7.1% annual growth rate of GDP is actually only 4% when these corrections are made.

Although this type of analysis can aid in the formulation of macro-environmental policy, it does not give complete information about the relationship between the health of the environment and social welfare. As stated above, this measure only takes into account one pathway for the environment to affect social welfare, and most importantly, it ignores the direct effect of the health of the environment on social welfare. Although the value of these direct effects or non-pecuniary environmental services could be incorporated into national income and product accounts, this would be difficult, if not impossible to do. It is much more difficult to monetize these other aspects of environmental quality than it is to monetize environmental effects such as oil depletion and soil erosion. Thus, the monetary conversion problem associated with willingness-to-pay measures is not eliminated with national income and product accounts, it has simply been transferred to the national income and product accounts.
This paper is not intended to provide a discussion of the pros and cons of contingent valuation. However, it will be noted that there is such controversy associated with measuring the willingness to pay for individual environmental resource, that it is likely to be some time before the method progresses to the point where there are generally accepted estimates of the willingness to pay for environmental quality in general. It should be noted that in terms of other indicators of social progress, we don’t necessarily use willingness to pay measures as a guide for measuring progress. For example, when we look at reducing infant mortality rates, we are conscious of the cost effectiveness of programs, but do not attempt to measure progress in this social arena through willingness to pay to reduce infant mortality.

An additional problem with these macroeconomic approaches is that there is a tendency to focus on environmental resources that are part of the economic production process and focus less on environmental resources that contribute more basic life support services or amenity benefits. More importantly, GDP and NDP are measures of the health of the economy, not the health of the environment. Separate measures of the health of the environment must be developed to better understand the relationship between environmental quality and social welfare.

Even though the “greening” of the National Income and Product accounts can not create an operational indicator of the health of the environment, it should be pursued to give a more accurate indication of the health of the economy. Prince and Gordon provide a detailed discussion of this type of modification of the U.S. National Income and Product Accounts.

**Satellite Accounts**

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3 This discussion is provided in many places including Portney, Hanneman, Diamond and Hauseman, and Bjornstad and Kahn.
In addition to the types of modifications of GDP discussed above, the UN Statistical Division recommends the development of a system of environmental satellite accounts, to monitor environmental change.

Satellite Accounts try to integrate environmental data sets with existing national accounts information, while maintaining SNA concepts and principles as far as possible. Environmental costs, benefits and natural resource assets, as well as expenditures for environmental protection, are presented in flow accounts and balance sheets in a consistent manner. That way, the accounting identities of the SNA are maintained. One of the values of the SEEA framework compared to more partial approaches is that it permits balancing, so that rough monetary estimates can be made for residual categories. (Hamilton and Lutz, p 5)

However, satellite accounts (by intent) represent a disaggregation of measures of environmental change, rather than an aggregation. They could serve as inputs for developing operational indicators of environmental change, but as an independent set of indicators they would suffer from the same problem as the indicators that EMAP collects. This problem revolves around the large number of measures which make the examination of trade-offs and overall trends more difficult. However, these satellite accounts could serve as a basis of an aggregate measure, in which the individual variables categorized in the satellite accounts are aggregate into a more general index.

**Aggregate Indices**

The Environmental Monitoring and Assessment Program (EMAP) of the US Environmental Protection Agency represents an effort to develop indicators of environmental quality. EMAP attempts to develop overall indicators for individual ecosystems (such as forests, wetlands or estuaries). In the case of estuaries, EMAP develops a series of over twenty indicators, but
creates an aggregate index by summing the indicators based on water clarity, the benthic index, and the presence of trash (Schimmel, et al, 1994). This is indicative of a general procedure employed by natural scientists to create aggregate indicators by summing all individual environmental indicators and dividing by the number of indicators to create an unweighted index. This unweighted index is virtually meaningless, because it implicitly and arbitrarily uses equal weights for each individual indicator. For instance, why should a 10% increase in the benthic index and a ten percent increase in the presence of trash receive the same weight in the index? Additional there is a potential problem of the level of the index being a function of the choice of the unit of measurement of each of the individual variables. For example, if one variable is measured in parts per million and another is measured in parts per billion, they will have very different impacts on the index. One way to get around this measurement problem is to normalize each variable by dividing by its maximum level, so that all the variables are then numbers between zero and one.

While normalization solves the unit of measurement problem, it does not solve the problem associated with an arbitrary choice of equal weights for each variable. One way of developing more meaningful weights is to base them on expert opinion. This could be done through a Delphi process or through averaging the weights that each expert has assigned. While this is certainly an improvement over the arbitrary choice of equal weights, the following section outlines a more formal procedure for defining weights that is consistent with the way decisions are made with respect to private goods, by examining individuals’ willingness to make trade-offs.

**IV The Trade-Off Weighted Index of Environmental Quality**

An operational indicator can be developed, *that is consistent with the economic paradigm,*
by looking at how people prefer one state of the world to another. While it is a difficult task to ask people to place a value on a state of the world, stating a preference for one state over another is consistent with the way people make many decisions such as locational choice, whether to get married and/or have children, or whether to vote Democrat or Republican. It should be noted that people do not contemplate the marriage decision by asking themselves what their willingness to pay for being married to one potential spouse versus being married to another potential spouse versus being single, but which choice gives them the highest quality of life. These optimizing choices may be constrained by ethical or moral rules that people have imposed upon themselves.

A choice, or trade-off based indicator can be developed by using discrete choice-based conjoint analysis to present alternative states of the environment to the individual. The alternative states would be defined by different levels of physical characteristics of the environment, including the characteristics of important sub-systems of the environment. These include, but are not limited to, characteristics of the state of forests, estuaries, rivers, wetlands, atmospheric chemistry, ambient air and water quality, and presence of toxic sites.

Indices could be established to account for those environmental resources which directly impact social welfare (purple arrow in Figure 1) and those that impact it through human health and social justice (red chain of arrows in Figure 2). Presumably, a properly constructed green GDP would appropriately account for many of the relationships which comprise the blue arrow.

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4 See Louviere (1988, 1996) for a general discussion of conjoint analysis and Kahn and Maynard (1996) for a discussion of conjoint analysis in environmental applications. Conjoint analysis could be applied to evaluate other areas of social policy, but the focus of this paper is environmental policy.

5 It is not the purpose of this paper to define which characteristics should be included, that is a topic of further research. Rather, this paper focuses on the development and justification of a method with which to develop an indicator of the health of the environment.
However, a “sustainability index” could also be developed which incorporated those environmental resources which provide ecological services. Some of these resources would be easy to incorporate into a green GDP, such as soil fertility, since it is relatively easy to measure the marginal value of declining soil fertility. In addition, environmental resources such as stocks of timber, reserves of fossil fuels and minerals, and the impact of tropospheric ozone on agriculture can be easily computed from studies published in the peer reviewed literature.

However, other ecological services such as biodiversity, watershed protection, production of oxygen, habitat, primary productivity and so on have important but more difficult to measure links to future social welfare, both directly and indirectly through future impacts on GDP. A separate sustainability index would allow us to track these important ecological resources and ecological services to see if current actions are increasing or reducing our ability to develop in a sustainable fashion.

Whether one was developing an environmental index or a sustainability index, people would be asked to choose which set of physical environmental characteristics they prefer, with each person presented with several different choice sets to evaluate. One could conduct this choice process with either ordinary citizens, or with experts in environmental sciences (both social and natural sciences). The level of the physical environmental characteristics in the choice sets would be varied both within the choice sets presented to individuals, and across individuals. This variation in the level of the characteristics of the alternative states of the environment would allow the estimation of a preference function. In this preference function, the probability of preference is estimated as a function of the levels of the physical characteristics. The derivatives (with respect to each physical characteristics) of the preference function can then be used as weights to
aggregate the physical characteristics into a single index or set of indices. In other words, if the estimated preference function was of the form,

$$PROB=\theta(C_1, C_2, C_3, \ldots C_n)$$  \hspace{1cm} (1)

where the C’s refer to the levels of the environmental characteristics that define the alternative states of the world.

After estimating equation (1), the index could be computed as

$$I = \sum_{i=1}^{n} \frac{\partial \theta}{\partial C_i} C_i$$  \hspace{1cm} (2)

At first glance, this method for deriving these weights may seem to be a re-cast version of contingent valuation, as both this method and contingent valuation ask the respondent hypothetical questions about willingness to make trade-offs concerning environmental quality. However, the two are based on fundamentally different mental models. Contingent valuation asks people to state a willingness to pay for a non-market good, but people are not accustomed to purchasing non-market goods. This forced employment of an unfamiliar mental model may be what gives rise to the biases which many people argue are associated with contingent valuation. However, conjoint analysis asks people to chose among alternative states of the world. Even though these alternative states may involve non-market goods, people are accustomed to making this type of choice. For example, the choices of whether to get married or stay single, have children or not have children, vote Republican or Democrat, live downtown versus the suburbs,
or go into academics versus consulting, are all alternative states of existence which are associated
with different bundles of non-market goods. (They may also be associated with changes in
income and bundles of market goods.)

Although conjoint analysis remains largely untested with respect to environmental goods,
its performance with market goods indicates a high degree of internal and external validity. In
particular, in comparisons of hypothetical and actual responses, conjoint analysis has been a good
predictor of actual responses. In comparison, in many experimental studies, contingent valuation
has been a poor predictor of actual responses. (See Cummings, 1996).

Even though the method proposed for deriving indexes is not based on willingness to pay,
one of its attractive features is that it is still based on the willingness of individuals to make trade-
offs. In contrast, the Environmental Monitoring and Assessment Program (EMAP) of EPA has
developed indices of physical characteristics based that are unweighted indices. In addition to the
inherent desirability (at least from the point of view of an economist) of basing the indicators on
willingness to make trade-offs, the trade-off based foundation of the indicators would make the
measures of the health of the environment analogous to the primary measure of the health of the
economy (GDP), as GDP is a set of physical quantities which are weighted by people's willingness
to make trade-offs, which in the case of GDP are measured by prices. An indicator of the health
of the environment which is based on "trade-off weighted" physical quantities would be
completely analogous to GDP, except in this case, the trade-offs are measured through a survey

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process, since market prices do not exist for the physical characteristics of the environment.  

One of the major criticisms by non-economists of willingness to pay measures and other methods which are based on individual choice is that they do not take into account expert knowledge of the consequences of environmental change. It is possible to incorporate expert knowledge into the trade-off based indicator of environmental quality or sustainability by implementing a parallel choice process and separate index among a sample of experts.

An important policy consideration is the determination of how much importance to place on the expert index in comparison to the ordinary citizen index. This expert index could be kept separately and then policies could be evaluated with respect to both indices. Alternatively, the indices could be merged into one index. One way to do this would be to include a statement in the survey to which citizens respond. This statement would indicate that experts are being asked to state preferences for alternative states of the environment in the same fashion. The citizens could then be asked (as part of the survey questionnaire) how much weight in the decision-making process expert opinion should be given relative to citizen opinion.

This paper has illustrated that a trade-off weighted index of environmental quality has the potential to meet many needs in understanding the relationship between the health of the environment and social welfare. However, outside of discussing conjoint analysis as a general framework in which the index could be estimated, the paper has not discussed the nuts and bolts of the estimation process. A comprehensive discussion of all the estimation issues is beyond the scope of this paper, but it is important to point out that the estimation process is quite complex. A

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The same procedures could be used to develop a single indicator variable for the other areas of social concern. For example, this process could be used to aggregate longevity, infant mortality and other health indicators into a single indicator variable of the health of the population.
schematic of the process for developing this indicator is contained in Figure 2. Each step of the process indicated in Figure 2 must be researched to determine the best means of implementation.

V. The Trade-off Based Index and Policy Evaluation

Evaluating Efficiency

The trade-off based index is not measured in dollar terms, so it can not be exactly determined if the benefits of a set of policies which are based on the index exceed the costs of the policies. However, the trade-off based index can still be used to shed light on the efficiency question. For example, assume that a particular set of policies only affect the health of the economy and the health of the environment. In Figure 3, each set of policies is associated with an environmental outcome and a GDP outcome, and the outcomes are plotted. An outer envelope can be constructed which would reveal that for any set of social indifference curves with the usual properties, the policies associated with interior outcomes are inferior to those associated with outcomes on or near the frontier. Potential Pareto improvements, such as movements from point E in the northeasterly direction can also be identified. Trade-offs between environmental quality and the health of the economy are explicitly defined by the slope of the frontier. This analysis, can be extended to multiple dimensions, to include social justice, the health of the population, and
other social objectives.

Of course, if the health of the economy is a function of the health of the environment, the production possibilities frontier might not have the characteristic shape associated with Figure 3. The shape of the frontier in Figure 3 assumes that promoting the health of the economy must always reduce the health of the environment and vice versa. If GDP is functionally dependent on environmental quality, where environmental quality is an input to the production process, then the
production possibilities frontier could have the shape illustrated in Figure 4. Many developing countries are likely to be in the backward bending portion of the function, where environmental quality has become so degraded that further degradation unambiguously lowers GDP. Of course, the location of a particular country on the frontier, and its proximity to the backward bending portion of the frontier is an empirical issue, but it underlines the importance of having an operational indicator of the health of the environment which can be used in empirical studies of

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8 A few examples of such countries would include those where massive (or complete) deforestation has lead to declines soil fertility and agricultural productivity (such as Haiti), countries where overgrazing has lead to desertification (such as the African countries in the Sahel region), and countries where air pollution has significantly impacted the health of the labor force (Central Europe).
the relationship between environmental quality and economic productivity.

Evaluating Sustainability

Sustainability has become a much talked about goal, with many definitions as to what constitutes sustainability. The general thrust of many of the definitions is that sustainable development is a pattern of development which meets the needs of the current generation without diminishing the prospects of future generations. However, less has been done in terms of measuring sustainability. Many case studies have been conducted of projects and policies which are shown to be unsustainable, however, there is currently no accepted standard by which it can be determined whether an entire economy is on a sustainable path. The trade-off based index of environmental quality offers an opportunity to quantify the concept of sustainability.

Figure 4 Backward Bending Production Possibilities Frontier
If sustainability is related to the maintenance of our environmental assets⁹, then a sustainable set of policies can be defined as one in which the index of the health of the environment is non-declining. Note that since the index is a composite of physical characteristics, some characteristics could be declining, as long as other characteristics increase sufficiently to compensate for the declining characteristics. This allows considerably more flexibility in economic development than a constraint which implies that no physical characteristics may be declining and it also avoids the arbitrariness associated with unweighted indices. An examination of sustainability in the absence of an aggregated index would require one to look at the entire set of physical characteristics, and either impose a non-negative change constraint on each characteristic, or attempt to look at trade-offs. However, tradeoffs are difficult, if not impossible to examine in an ad hoc comparison, when there are literally thousands of environmental indicators. In terms of sustainability and whole ecosystem effects, the only analysis possible is to impose a non-negativity constraint on all relevant environmental variables. In other words, this type of analysis allows only ‘no decline’ changes in environmental endpoints. Almost every feasible policy option or project will violate at least one of the individual non-negativity constraints.

An alternative way to use the index to measure the sustainability of outcomes is to estimate the previously discussed relationship of green GDP or NDP as a function of the trade-off based index, among other variables. A sustainable outcome could then be estimated as one in which predicted national income variable was non-decreasing in every time period or over some

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⁹ Environmental assets are broadly defined here to include those assets which are directly used in production activities (such as timber, clean water, fertile soil and so on), those which are indirectly used in production activities, and those which contribute to social welfare either directly or indirectly through some mechanism other than the economy.
selected time path, where the effect of changes in the environment on future GDP was explicitly considered. However, since this would not take into account the direct effect of the environment on social welfare and other aspects of the quality of life, it could only be considered sustainable in a narrow GDP-related context.

*The Trade-off Based Index and Equity*

The trade-off based index may be a more equitable way of setting policy goals because it is less dependent than other methods on ability to pay. Willingness to pay measures and cost-benefit analysis are based on the principle of “one dollar, one vote,” and the willingness to pay is a function of the ability to pay. In contrast, as long as the survey sample which is used to estimate the index is representative of the population as a whole, the trade-off based index is based on the principle of “one person, one vote,” which is the principle upon which the U.S. constitutional democracy (and most other democracies) is based. This consistency with constitutional democracy is not obtained by abandoning the economic paradigm, as the trade-off based index is still based on peoples’ willingness to make trade-offs. Of course, people at different income levels may have different preferences for environmental quality, but the aggregation of these preferences into the index gives each person an equivalent weight, provided that the sampling process includes all preference groups.

Of course, other dimensions of equity, such as who pays for environmental improvements, whether some people have less access to environmental quality than others, and whether some people are disproportionately exposed to environmental hazards must still be addressed. Trade-off based indicators developed on a more local basis (in addition to the national indices) can help determine the “environmental justice” implications of alternative policy outcomes.
6. Conclusions

Since GDP is not a good measure of social welfare and since not all aspects of environmental quality and sustainability can be incorporated into GDP, it is important to develop an independent operational indicator of environmental quality. Various methods have been employed in an effort to due this, including the use representative environmental variables, satellite environmental accounts, and unweighted indices of environmental variables. Each of these methods has shortcomings that makes them less than ideal for formulating environmental and economic development policy.

However, a set of trade-off based operational indicators can be developed that are still consistent with the economic paradigm and that can be used to measure the efficiency and sustainability of alternative outcomes. In addition, these measures are more consistent with the principles of constitutional democracy and are more equitable, since they are based on “one-person, one vote”, rather than “one dollar, one vote.” Although the proposed method would require a substantial research effort to develop it to the point where one could contemplate implementation, there are significant potential welfare gains associated with the evaluation of environmental policy with such a measure.
References.


