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The use of valuation and weighting sets in environmental impact assessment

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ABSTRACT

In environmental impact assessment of policies and product design results need to be presented in a comprehensible way to make alternatives easily comparable. One way of doing this is to aggregate results to a manageable set by using weighting methods. Valuing the environmental impacts can be a challenging task that can also be quite time-consuming. To the aid of practitioners, several weighting sets with readily available weights have been developed over the last decade. The scope and coverage of these sets vary, and it is important to be aware of the implications of using different valuation methods and weighting sets.

The aim of this paper is to map valuation and weighting techniques and indicate the methods that are suitable to use, depending on the purpose of the analysis. Furthermore, we give an overview over sets of generic values or weights and their properties, and give an illustration of how different sets may influence the results. It is very useful to use several weighting sets, and discuss the results thoroughly. It is often a very interesting and fruitful exercise to see if and how the results differ, why they differ, and which one seems to be the best alternative to base any recommendation on.

The example provided in this article demonstrates that looking at aggregate results is not enough. Since many weighting sets are not sufficiently transparent as to how they are constructed and what their impact categories actually include, a general recommendation is to provide weighting sets with a declaration of content, providing a clear picture of what is included and what is not, and a recommendation of suitable uses of the weighting set.

1. Introduction

Today there is a widespread awareness that most of our actions may have consequences on the environment. Decision makers need to take environmental impacts into account when making decisions about projects and investments. Results from impact assessments can however be both extensive and diverse, which makes comparison of alternatives difficult. To help decision makers to interpret the results, many impact assessment tools include a possibility to aggregate results to an index or a few indicators, by translating them into a common unit. In economic tools like cost-benefit analysis, impacts on non-marketed goods are monetized to make them comparable to monetary costs and benefits. In other tools, e.g. life-cycle assessment (Udo de Haes et al., 2002) and strategic environmental assessment (Brown and Therivel, 2000), weighting in order to aggregate the results is often made by monetary valuation, but need not be. Valuation can be done in monetary terms or just as a value judgement, expressed as weights. To avoid confusion, we will henceforth follow the shorthand often used in economics and use the term valuation when we mean monetary valuation. Weighting will be used as a general term, the weights being in any unit, monetary or non-monetary.

There are several methods for valuing environmental goods, each with its advantages and disadvantages. The scope of the methods varies significantly: some cover pure economic losses (e.g. damage costs using market prices), some impute values by using different types of costs (imputed willingness to pay methods) and some attempt to measure welfare losses (expressed willingness to pay methods). The latter may include both use and non-use values. Non-use values refer to the value that people derive from goods independent of any use, present or future, that they might make use of those goods, in contrast to use values, which people derive from direct use of the good (Mitchell and Carson, 1989). Non-use values may include quasi-option values (the value of preserving options for future use given some expectation of expanding knowledge), existence values (the value of knowing that an amenity exists) and values to future generations.

The purpose of this paper is to map valuation and weighting techniques, and give an overview over sets of generic values or

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weights that are readily available for use in life cycle assessments and cost benefit analyses.

The first section maps methods for assessing environmental impacts, followed by a discussion on which methods are suitable to use, depending on the purpose of the analysis.

In the next section, an overview of available weighting/valuation sets is given. Lastly, a comparison of results from using some of the weighting sets is done.

2. Methods for weighting of environmental impacts and potential uses

In this section, an overview of valuation/weighting methods is given. We use the taxonomy developed by Ahlroth et al. (2011), where a more comprehensive list and description of each method can be found.

As pointed out in Section 1, valuation can be done in both monetary and non-monetary terms. Both can give a cardinal ranking, but of course only the monetary methods are fully comparable to costs and benefits of marketed goods and services.

2.1. Monetary valuation

Monetary valuation provides added information to non-monetary weighting in two ways: it makes it possible to

(1) rank impacts from a welfare perspective,
(2) estimate whether benefits of a certain policy or action exceed the costs.

This means that monetary valuation has a wider field of potential uses than non-monetary weighting. On the other hand, there are several caveats attached to the monetary valuation methods, which are added to the uncertainties inherent in the non-monetary weighting methods. In both cases, it is useful to see the weighting results as indicative and to use them for further discussion of the merits of the analyzed alternatives.

In Fig. 1, methods for monetary valuation are listed. A market price is what people are willing to pay for a certain good at the current level of supply. Environmental damages can be valued by the loss of production that the damages infer – often called damage cost valuation. One example of this is decreased crop yield due to tropospherical ozone. To value goods and services that are not sold on a market, we can try to simulate markets or to deduce the willingness to pay for a good from the price of related marketed good. The latter is called *revealed willingness to pay*, since people's preferences are revealed from what they pay for the related good (Champ et al., 2003). In the *travel cost method*, willingness to pay (WTP) for e.g. visiting a nature area is elicited from the costs to travel there, as well as other costs incurred, e.g. food and equipment needed. *Hedonic pricing* is most often used to value real estates, by trying to identify different qualities that influence the price. Environmental amenities valued might be proximity to swimmable water, good fishing water or a nature park. Disamenities may also be valued, such as contaminated sites. The *production function approach* is applicable in cases where the environmental goods/services are some (or one) of the inputs to produce a marketed good (Champ et al., 2003). An appropriately specified production function may indicate the contribution of these inputs to the output. From this information one may deduce the benefit due to the inputs. All these three methods give a lower bound of the value, since they can only capture part of the value of a certain good or service (Hanley et al., 2007).

In the *expressed willingness to pay methods*, hypothetical markets are constructed, where people are asked for their preferences and what they would be willing to pay to have access to environmental amenities. These methods are the most comprehensive, in that they capture the total value to the relevant population, including non-use values (Hanley et al., 2007). In the most frequently used method, *contingent valuation*, the respondents are asked to state their willingness to pay for an increase in environmental quality, contingent on a carefully structured hypothetical market (Hanley and Spash, 1993). *Choice modelling* includes a range of methods, e.g. contingent ranking, paired comparisons and choice experiments (Louviere et al., 2000). In choice experiments, respondents are asked to choose between alternative goods, defined in terms of their attributes, one attribute being a monetary cost. This allows the analyst to derive a monetary value of each of the attributes.

Imputed WTP methods include several cost methods such as *damage cost avoided*, *replacement cost*, and *substitute cost method* (Mishra, 2006). These cost methods are based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. The advantage of these methods is that they reflect actual costs that may be imposed on households and businesses. Cost approaches are however problematic (depending on the application) since the costs are not linked to the extent of the damages, and are thus not related to the perceived severity of the problem.

Political willingness to pay is similar to revealed WTP, but in this case it is the political decisions that reveal the preferences. Finnveden et al. (2002) note that societal values may be different from the sum of individual values, and that it may therefore be reasonable to deduce values from the behaviour of e.g. governments. The costs for reaching established targets can be interpreted as society's willingness to pay, mediated by the political process. The targets should be enforced by a political decision, i.e. there is an explicit will to pay the costs (Kopp et al., 1996). Another way is to use environmental taxes, which can be interpreted as a price on environmental damage, e.g. incurred by a certain emission (Finnveden et al., 2002).

As we will see in the next section, another way to monetize impacts is to use the cost of reducing either the pressure (e.g. the cost of reducing emission) or the impact (e.g. liming of acidified lakes). The former are usually labelled *avoidance costs* or *prevention costs*, the latter *restoration costs* (UN, 2003). These approaches are not willingness to pay measures, since there is no relation to any decision to actually enforce the measures and take on the costs.

2.2. Non-monetary weighting

Non-monetary weights are typically used to show the relative importance of different types of environmental impacts, according to experts, the general public or a specific population. *Proxy methods* in our classification scheme (Fig. 2) use one or a few quantitative measures stated to be indicative for the total environmental impacts (Lindeijer, 1996). An example of this is an approach sometimes used in Environmental Management Systems, where each environmental aspect is rated on a scale of 1–3 on the basis of a few criteria. There are also specific methods developed with the purpose of displaying environmental impact, e.g. TMR (total material requirement) (Adriansee et al., 1997) and Ecological Footprints (Rees and Wackernagel, 1994).

Weights in non-monetary units are often derived by some form of panel weighting method (Ascher and Steelman, 2006). This is similar to the expressed WTP methods, with the difference that monetary values are not included in the parameters. Using panels for eliciting preferences and judgments can be done in many different ways. Panels can consist of experts, stakeholders or lay people, and the elicitation process can be organized in many ways (Seppälä, 1999). Ad hoc methods are used in many instances, and there are