

THE USE OF MONETARY VALUATION OF ENVIRONMENTAL IMPACTS IN LIFE CYCLE ASSESSMENT: STATE OF THE ART, STRENGTHS AND WEAKNESSES

Summary

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1 INTRODUCTION AND OBJECTIVES

Monetary valuation, or monetarisation, is the practice of converting measures of social and biophysical impacts into monetary units so that they can be compared against each other and against the costs and benefits already expressed in monetary units (Boardman et al., 2006). The fundamental question that monetarisation seeks to answer is how to value (impacts on) non-market goods (i.e. goods for which no market, and hence no price, exists, such as a clean atmosphere).

Monetary valuation is not a new idea. Its conceptual basis stems back to Sidgwick (1883) and was formalised by Pigou (1920). Since 1936, monetary valuation has been a common and essential practice in Cost Benefit Analysis of public and private projects with economic, environmental and social impacts. Monetary valuation allows for the overall assessment of a project, when the total monetarised and discounted environmental, economic and social impacts are aggregated into a single score (Net Present Value, NPV). If $NPV > 0$ the project is worth carrying out. Alternative projects can, hence, be compared and the one with the highest NPV is deemed superior to all others.

Monetary valuation methods have been developed within the utilitarian paradigm of welfare economics inherent to both neoclassical and ecological economics. Welfare economics is the study of economic efficiency, i.e. how to maximise social wellbeing. When this wellbeing is maximised among equal and autonomous agents in and across generations, the goal of welfare economics becomes identical to the goal of sustainable development.

Some Life Cycle Impact Assessment methods already include aspects of monetary valuation, notably LIME, EPS, EcoIndicator and Stepwise.

The main objectives of the study has been:

- To review systematically, analyse critically, and evaluate the existing methods available for converting (LCA) results quantified in physical units into monetary units and assess the applicability of the different methods in Life Cycle Assessment (LCA);
- To assess the use and barriers associated to the use of monetary valuation by the LCA community;
- To provide recommendations for the use of monetary valuation in the context of LCA.

The study includes a literature review and benchmarking of both monetary valuation methods and their applications in LCA, as well as a web-based survey of the extent of use and opinions on monetary valuation methods among LCA practitioners.

2 LITERATURE REVIEW AND BENCHMARKING

The literature review identified a lack of uniformity in both classification and nomenclature and a general absence of consistent definitions of the different methods for monetary valuation. The study therefore includes a new classification with definitions of monetary valuation methods; see Table 1.

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Table 1 Classification and definitions of monetary valuation approaches and methods.

<i>Approach</i>	<i>Principle</i>	<i>Method</i>	<i>Definition</i>
Observed Preferences	Determining willingness to pay in an existing market for a good	Market price	A monetarisation method where the marginal value of a good is identified on the basis of its market price
Revealed preferences	Determining willingness to pay in surrogate markets i.e. a market for a good that is indirectly affected by changes in availability of the primary good	Averting behaviour	A monetarisation method where the marginal value of a good is identified on the basis of the market price of a surrogate good, i.e. a good that is indirectly affected by changes in availability of the primary good A revealed preference valuation method where the marginal value of a good is identified on the basis of the expenses actually made for goods that are required to prevent or offset the change in availability of the primary good
		Travel cost	A revealed preference valuation method where the marginal value of a site is identified on the basis of the expenses made by individuals to travel and visiting the site
		Hedonic pricing	A revealed preference valuation method where the marginal value of a good is identified on the basis of a regression analysis between the availability of the primary good and changes in the market price of another good with multiple attributes
		Contingent valuation	A monetarisation method where the marginal value of a good is identified on the basis of the preferences expressed in response to hypothetical trade-off questions A stated preference valuation method where the marginal value of a good is identified from the stated willingness to pay or accept compensation for a specified change in the availability of the good
Stated preferences	Determining willingness to pay in hypothetical markets or trade-off situations	Conjoint analysis: Choice experiment	A stated preference valuation method where the marginal value of a good is identified on the basis of stated choices between two or more alternative goods where at least one attribute of one good is systematically varied across respondents and at least one good has a market price or market price equivalent
Budget constraint	Determining willingness to pay for an additional Quality-Adjusted Life Year in a hypothetical situation without externalities	Budget constraint	A monetarisation method where the marginal value of a Quality-Adjusted Life Year is identified on the basis of the potential economic production per capita per year
Abatement cost¹	Determining potential cost for the marginal abatement or replacement activity	Abatement cost	A cost estimation method where the change in availability of a good is assessed in terms of the potential costs of the marginal counter-balancing change (replacement) or marginal measure that prevents the change

¹ Most often the abatement cost is determined at a specified (policy-determined) target level. Methods using mitigation, avoidance, reduction, control, restoration, or replacement costs instead of abatement cost are conceptually analogous since the same potential cost approach is applied. This is in contrast to the Averting cost method, where it is the actual preventive or offsetting expenses that are measured.

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The benchmarking encompasses the 8 monetary valuation methods and 12 applications for LCA. Each method and application was benchmarked according to 6 criteria:

- Scientific foundation
- Documentation
- Completeness
- Uncertainty
- Complexity
- LCA relevance & compatibility

with in total 50 sub-criteria, specifically developed for this purpose. Each sub-criterion was scored on a scale from 1 to 5 for compliance. Each score was documented and justified with a text description.

Each monetary valuation method was then described in terms of its application areas and the strengths and weaknesses of each method. Based on the evaluation of these features, LCA impact categories for which the method is recommendable are identified.

Five monetary valuation methods are recommended for different impact categories:

- *Market price method*: For corrosion of man-made structures; dissipation of natural abiotic resources; overexploitation of natural biotic resources; reduction in productivity from disability to work; reduction in yields in agriculture, fishery and forestry; soil erosion; and trade barriers.
- *Travel cost*: Degradation of specific local instances of cultural or natural heritage, or specific local physical degradation of natural flora or fauna.
- *Hedonic pricing*: For more directly observable impacts where there are only use values involved, such as nuisance from odour, noise, traffic, or living in a crime-prone neighbourhood, and job-related nuisances such as psychological and ergonomic stress.
- *Conjoint analysis: Choice experiment*: All midpoint impact categories not mentioned above, and ecosystem health / biodiversity endpoint.
- *Budget constraint*: Human wellbeing endpoint.

The other monetary valuation methods investigated (Averting behaviour, Contingent valuation, and Abatement costs methods) are not recommended for use in life cycle impact assessment.

In the benchmarking of LCA applications of the methods, the applications of the budget constraint and conjoint analysis received the best scores when assessed across all criteria, see Table 2. The underlying text scores are provided in an accompanying spreadsheet file. In practical LCA applications, conjoint analysis has unfortunately only been scarcely used in LCIA methods, pointing to the need for more studies to confirm the practical usability of conjoint analysis for monetary valuation in LCA. In contrast, there are many LCA applications of the abatement cost method, which is not recommended by our assessment, mainly because it does not provide valuation of damages.

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Table 2. Assessment of LCA applications of monetary valuation methods. Darker shades of green colour (and higher numbers) indicate higher compliance with the criteria, and vice versa darker shades of red colour (and lower numbers) indicate lower compliance. 1 = no compliance and 5 = full compliance. Note that numbers are for communication purposes only and not intended as additive.

LCA Application	Reference	Approach	Method	Scientific foundation	Documentation	Completeness	Uncertainty	Complexity	Relevance for LCA
STEPWISE2006	(Weidema, 2009; Weidema et al., 2007)	Budget constraint	Budget constraint	4.50	4.80	4.08	3.63	4.40	5.00
LIME 1-2	(Itsubo et al., 2012; Itsubo et al., 2004)	Stated preferences	Conjoint Analysis	4.00	4.10	3.58	4.25	3.80	5.00
ECOTAX2002	(Finnveden et al., 2006)	Revealed preferences	Averting Behavior	3.67	4.20	3.17	2.63	4.40	5.00
ECOVALUE08	(Ahlroth and Finnveden, 2011)	Mix	Contingent Valuation and market prices	3.25	3.50	3.58	2.50	4.20	4.00
MAC/RCA	(Davidson et al., 2005; Oka, 2005; Oka et al., 2005)	Abatement Cost	Abatement Cost	2.92	3.30	2.50	1.00	4.20	3.00
EPS2000	(Steen, 1999a, b)	Mix	Contingent Valuation market prices and abatement cost	3.00	4.70	3.67	3.50	4.00	5.00
EVR	(Vogtlander and Bijma, 2000; Vogtlander et al., 2001)	Abatement Cost	Abatement Cost	3.17	3.20	2.67	1.00	3.20	4.00
HEDONIC PRICING*	(Andersen et al., 2011; Riera et al., 2006; Sander and Haight, 2012)	Revealed preferences	Hedonic pricing	3.75	2.70	3.08	4.00	3.60	2.33
Travel Cost*	(Boardman et al., 2006)	Revealed preferences	Travel Cost	3.67	3.00	2.50	3.75	3.40	1.67
CV of VOLY*	(Desaigues et al., 2011; European Commission, 1999, 2004)	Stated preferences	Contingent Valuation	4.17	4.10	3.00	3.75	3.60	3.83
CV of biodiversity*	(Nunes and van den Bergh, 2001; Veisten et al., 2004)	Stated preferences	Contingent Valuation	3.83	4.10	2.83	3.75	3.60	3.00
META-ANALYSIS*	(Costanza et al., 1997; de Groot et al., 2012; Nijkamp et al., 2008)	Mix	Contingent Valuation and market prices	3.25	4.00	3.42	3.75	4.00	3.17

- A – Full compliance
- B – Compliance in all essential aspects
- C – Compliance in some aspects
- D – Little compliance
- E – No compliance

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3 SURVEY AMONG LCA PRACTITIONERS

The web-based survey among LCA practitioners shows a large interest in and support for monetarisation in LCA, but also a smaller group of respondents with legitimate objections to monetarisation.

The generally positive opinion is demonstrated by 61% disagreeing or mostly disagreeing that monetarisation is immoral. A similar proportion of the respondents agree or mostly agree that “monetarisation can be used to compare different types of impacts” (65%) and even “all impacts relevant for decision-making” (32%), and further agree or mostly agree that monetarisation “is the best way to account for peoples values” (24%), “avoids dominating influences of specific stakeholders” (35%), “generally reflects the trade-offs people are actually willing to make” (59%) and “helps deciding how to allocate resources most efficiently” (59%).

The smaller group with a strong negative opinion is demonstrated by 19% of the respondents agreeing or mostly agreeing that monetarisation is “immoral”. A similar proportion of the respondents disagree or mostly disagree that “monetarisation can be used to compare different types of impacts” and “monetarisation helps deciding how to allocate resources most efficiently”, and agree or mostly agree that monetarisation “is too uncertain to be used in LCA”, “gives more weight to rich people than to poor people” and “is only relevant for decision-makers who focus on money only”.

Some of the free-text comments in the survey responses reveal that some respondents’ objections are fundamental to the idea of social efficiency, rejecting the idea of socially-optimal decisions in itself and regarding self-interest as legitimate:

- “Preparing an environmental assessment of impact is an independent activity that should not be altered, perverted or modified by financial pressures. The decision to follow or reject an assessment is a legitimate business decision and should be made in consideration of regional economic realities. Not all pathways that show life cycle benefits should be followed”;
- “using monetization usually means to use an average structure of preferences that sometimes can be different from those of the involved stakeholders”;
- “giving weight to social and environmental impacts is very much dependent on the geographical location, the scenario where the study is being taken and the company’s views on social and environmental impacts. Therefore, the monetarisation could pass an impact result that is not truly representative of the product.”

while some respondents reject neo-classical economics as a basis:

- “Our current economic structures are one of the main reasons that we have so many environmental problems, i.e. the failure of economic systems to protect the natural environment. By tacking monetarisation onto the Impact Assessment phase of LCA, we merely support “more of the same” in decision-making.”;
- “Most of these methods are bad science based on false assumptions trying to constrain natural systems to behave like relationships between humans are supposed to be, by using the narrow approach of neo-classical economics.”

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However, the majority of objections do not fundamentally reject monetary valuation, but rather criticize bad practice in its application. Also, stakeholder involvement and acceptance is stressed as important.

4 EDUCATIONAL NEEDS

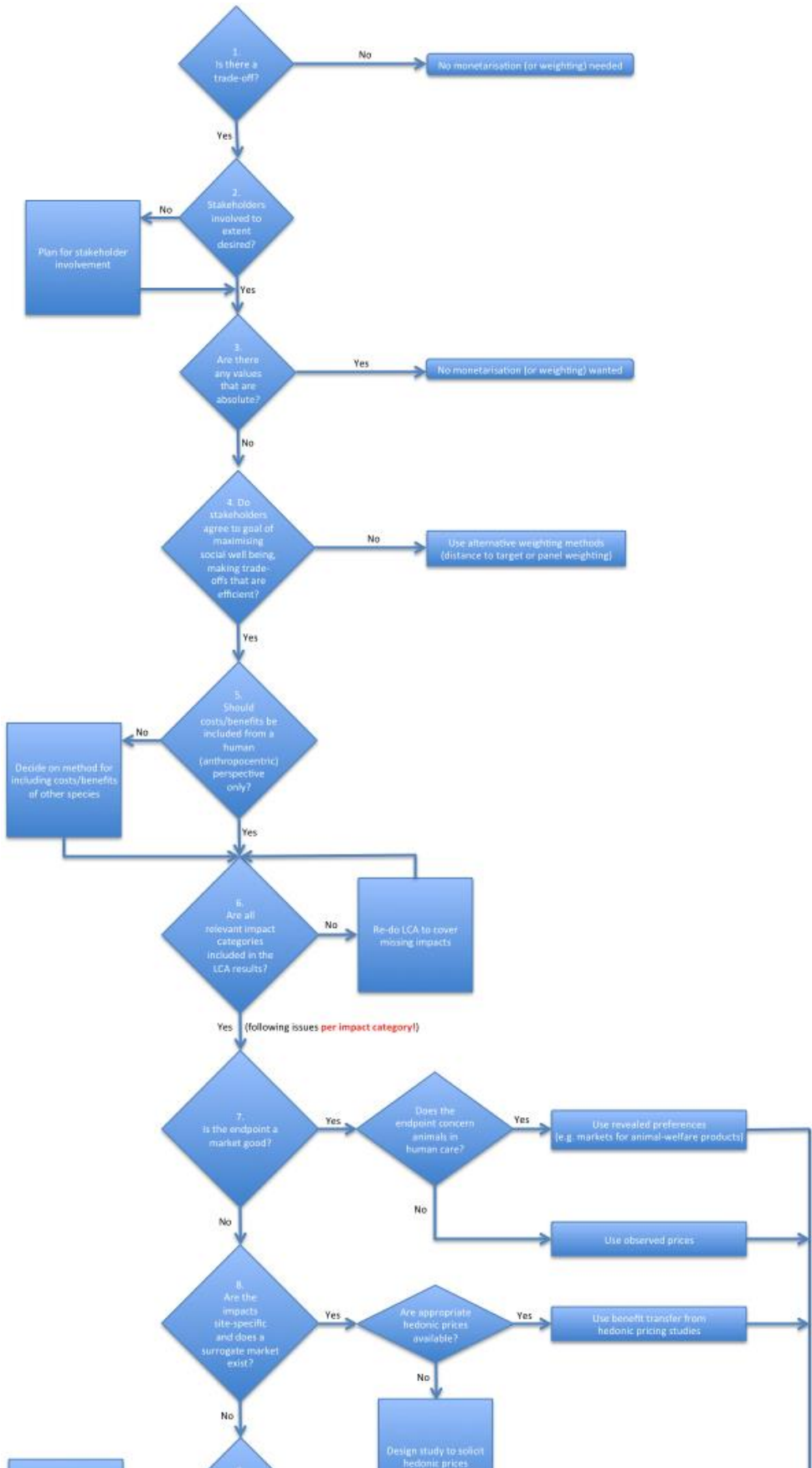
The surveys reveal a need for education and information to correct some misunderstandings about what monetarisation is and does:

- How monetary valuation is distinct from other economic tools, such as Life Cycle Costing, Material Flow Cost Accounting, Ecoefficiency, etc., and how these tools relate to each other.
- How abatement cost methods are different from monetary valuation methods seeking to assess utility losses, and clarifying their application fields and relations to Life Cycle Inventory.
- The relative merits of monetary valuation in relation to other methods to weight or compare different impacts.
- The monetary valuation methods available, their applicability and recommendations on their use. Some modern and new approaches to monetarisation (Conjoint analysis and the budget constraint) are still not well-known among practitioners.
- The good practice and limitations of monetary valuation.

5 GOOD PRACTICE RECOMMENDATIONS

The different points of criticism identified in the surveys are addressed in the “Good practice recommendations” from the study. The decision tree on the following pages is suggested, which takes into account both the scientific and procedural aspects identified as important in the surveys and in the literature review. Each of the points in the decision tree are described in more detail in the “Good practice recommendations”.

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