INTEGRATING THE VALUATION OF ENVIRONMENTAL EFFECTS IN COST-BENEFIT-ANALYSIS. A REVIEW OF PUBLIC GUIDELINES

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Abstract

Cost-benefit analysis (CBA) is an important appraisal method in the context of public decision-making and planning. This paper systematically reviews 23 public CBA guidelines regarding the valuation of water and air pollution, greenhouse gas emissions, noise and effects on biodiversity and ecosystem quality. The results show that the extent to which environmental effects are integrated in the documents varies widely. Overall, the use of default values is the most preferred approach, as it allows monetary values to be obtained without complex primary valuation methods. However, the origin and scientific reasoning behind the values are often not made transparent, as highlighted in the present study. Challenges with quantification and monetarization of environmental outcomes can lead to an exclusion of these effects, as is for instance the case for biodiversity impacts, where only 6 out of 23 guidelines propose valuation procedures. Since the goal of a CBA is to capture all social costs and benefits, and the results have a direct impact on public planning decisions and policy-making, many CBA guidelines should be revised to better reflect recent developments in the field of environmental evaluation.

Key Words

Cost-benefit Analysis; CBA; Environmental Valuation; External Effects; Guidelines; Biodiversity Effects; Noise; Air Pollution; Water Pollution; Greenhouse Gases; Valuation Methods

1. INTRODUCTION: CBA IN PUBLIC POLICY AND ENVIRONMENTAL IMPACT ASSESSMENT

Cost-benefit analysis (CBA) is a commonly used economic appraisal method to rationalize decision making by comparing the costs and benefits for a given proposal (Broadman et al., 2010, p. 2). It thereby evaluates decisions in terms of their consequences, using the monetary value as a uniform scale (Layard & Glaister, 1994, p. 1).

Against the background of public policy, the purpose of a CBA is to support the efficient allocation of scarce public resources (Broadman et al., 2010 p 2f). As stated by the European Commission, it is about “demonstrating the convenience for society of a particular intervention rather than possible

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alternatives" (2014, p. 6). In many countries, CBA is not only an acknowledged method but also a mandatory requirement for regulatory proposals or infrastructure projects, policies and programs including legislation (Broadman et al., 2010, p. 21). As a tool it is applied in various ways: To assist governments and planners in decision-making processes regarding the implementation of new projects/programs, the continuation of ongoing projects or the choice of potential alternatives (Commonwealth of Australia, 2006, p. IX). As public decisions have profound consequences, it is especially important to consider all costs and benefits to society as a whole (Broadman et al., 2010, p. 3), namely the social cost and benefits, which also include environmental impacts.

Publicly funded programs and projects, especially infrastructure construction, can cause environmental harm through water, air, and noise pollution, greenhouse gas emissions, or damage biodiversity and ecosystem quality. Even though these effects lead to an impairment of human health, wellbeing, and the provision of ecosystem services (MEA, 2005), they are often referred to as external costs (INTOSAI WGEA, 2013). Contrarily, public projects and programs can also have positive effects on natural conditions. Under the precondition that a CBA aims to cover all social cost and benefits, the inclusion of environmental impacts should be self-evident[1].

However, there are many differences in the variety and extent to which environmental impacts are addressed in the evaluation of international public projects and programs using CBAs. The main challenges concern (1) the quantification of environmental outcomes regarding changes of environmental quality and (2) the monetarization of goods and services for which there is no (regular) market. First, in order to quantify an effect for a CBA, it is necessary to understand the (environmental) outcome of a certain measure, i. e., the cause-and-effect-relationship, which is especially challenging if complex natural systems are involved (Boardman et al., 2010, p. 8 f.). Second, in order to value an environmental effect or service it is necessary to understand the socio-ecologic relationship, i. e., the contribution of nature to human wellbeing (Mooney et al., 2005). This paper reviews how national guidelines for CBAs address these challenges and compares different approaches to the valuation of environmental effects.

2. RESEARCH DESIGN

In this paper, the role of environmental effects in international CBAs is systematically reviewed. To this end, official guidelines and handbooks are analyzed following these research questions: (1) How is the valuation of environmental effects integrated in CBA guidelines? and (2) What valuation methods for environmental effects do they propose?

In order to narrow the analysis, the paper focuses on five different environmental issues: (a) water quality, (b) air quality, (c) noise, (d) greenhouse

1 CBA is certainly not the only appraisal method used to evaluate the effects of public programs and projects. When it comes to the protection of environmental resources, for instance, national and international procedures and methods are used, such as the Strategic Environmental Assessment and the Environmental Impact Assessment, which are legally required in the European Union. However, this paper focuses on CBA and its claim to analyze social cost and benefits comprehensively.

gas (GHG) emissions and (e) impacts on habitats and biodiversity[2]. Moreover, it introduces a simple but straightforward system for classifying the extent to which the guidelines and handbooks consider these environmental topics within the CBA, using the following categories:

- x The environmental topic is not discussed at all, there is no reference to the topic.
- a The topic is mentioned as important but not monetizable, as external effect that is not considered in the CBA or as background information.
- b The CBA guideline/handbook proposes default values to integrate the environmental issue based on an input unit such as tons of pollutant or vehicle kilometres.
- c The guideline/handbook underlines the importance of valuing the environmental effect and suggests quantification and monetarization methods.

While categories one (x) and two (a) refer to guidelines/handbooks that refrain from operationalizing specific environmental effects in CBAs, the other two categories (b and c) represent different approaches to the integration of monetary values.

The paper is structured as follows. In Section 3, the guidelines and handbooks analyzed are presented with respect to their main characteristics and differences. The results summarized in Section 4 consist of three parts, starting with a matrix that gives an overview of the analysis and is elaborated on the following two different levels: First, the environmental effects are discussed individually, focusing on national differences and interesting examples. Second, the question of valuation methods is further examined, distinguishing between default values, primary valuation techniques and valuation outside of CBA. Section 5 summarizes and discusses the results and is followed by the conclusions (Section 6).

3. OVERVIEW OF OFFICIAL CBA GUIDELINES

To analyze the role of environmental effects in CBA, the present study reviews official guidelines and handbooks on CBA. The publications were issued by national governments and governmental organizations of ten different countries: Austria, Australia, Canada, Germany, France, Ireland, New Zealand, Switzerland, United Kingdom and United States. Moreover, three documents by the European Commission were included.

All the guidelines and handbooks used are also described in a database of official CBA documents, collated by the Department of Public Finance and Infrastructure Policy at the Vienna University of Technology, which has not been published. Although the database does not claim to be comprehensive, it aims to include the most relevant guidelines for European as well as

2 For a more detailed description of the environmental effects see Annex 1.

international English-speaking countries, which makes it a valuable point of departure for further analysis.[3]

Publications by non-governmental institutions as well as regional governments were excluded. Additionally, some documents were ruled out as they do not cover environmental issues at all, e.g., guidelines from the public health sector. Table 1 gives an overview of the final selection of guidelines and handbooks.

TABLE 1 Overview of official CBA guidelines and handbooks (own compilation)

Country	Year	Title	Issued by	Topic
AT	2009	Richtlinie für Kosten-Nutzen-Untersuchungen im Schutzwasserbau	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW)	Water Management
AT	2010	RVS 02.01.22 Nutzen-Kosten-Untersuchungen im Verkehrswesen	Österreichische Forschungsgesellschaft Straße-Schiene-Verkehr (FSV)	Transport
AU	2006	Handbook of Cost-Benefit Analysis	Department of Finance and Administration	General
AU	2015	Green Infrastructure. Economic Framework	Victoria Institute of Strategic Economic Studies (VISES)	City Planning
AU	2018	Australian Transport Assessment and Planning Guide	Commonwealth of Australia, Australian Transport Assessment and Planning	Transport
AU	2018	Assessment Framework for initiatives and projects to be included in the Infrastructure Priority List	Infrastructure Australia	Infrastructure
CA	2007	Canadian Cost-Benefit Analysis Guide: Regulatory Proposals	Treasury Board of Canada Secretariat	General
EU	2003	Anleitung zur Kosten-Nutzen-Analyse von Investitionsprojekten	European Commission	Cohesion Policy (Transport, Infrastructure, Energy, R&D)

3 As the selection of the CBA guidelines and handbooks was conducted in 2020, it is possible that by now (Spring 2024) newer versions of the documents have been issued.

Country	Year	Title	Issued by	Topic
EU	2014	Guide to Cost-benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014–2020	European Commission	Cohesion Policy (Transport, Infrastructure, Energy, R&D)
EU	2018	2nd ENTSO-E Guideline for Cost Benefit Analysis of Grid Development Projects	ENTSO-E European Network of Transmission System Operators for Electricity	Energy
FR	2017	Guide de l'évaluation socioéconomique des investissements publics	France Stratégie	General
FR	2019	Référentiel méthodologique pour l'évaluation des projets de transport	Direction générale des Infrastructures, des Transports et de la Mer	Transport
GE	2016	Methodenhandbuch zum Bundesverkehrswegeplan 2030	Bundesministerium für Verkehr und digitale Infrastruktur	Transport
IR	2016	Project Appraisal Guidelines for National Roads Unit 6.1 - Guidance on conducting CBA	Transport Infrastructure Ireland	Transport
IR	2019	Public Spending Code: A Guide to Economic Appraisal: Carrying Out a Cost Benefit Analysis	Department of Public Expenditure and Reform	General
NZ	2015	Guide to Social Cost Benefit Analysis	New Zealand Treasury	General
NZ	2018	Economic Valuation Manuel	NZ Transport Agency	Transport
SW	2009	SN 641 820: Kosten-Nutzen-Analysen (KNA) im Straßenverkehr	Schweizerischen Verbandes der Straßen- und Verkehrsfachleute (VSS)	Transport
UK	2018	The Green Book - Central Government Guidance on Appraisal and Evaluation & Supplementary material	HM Treasury	General

Country	Year	Title	Issued by	Topic
UK	2018	Transport Analysis Guidance (TAG) UNIT A1 Cost-Benefit Analysis	Department for Transport	Transport
US	2014	Guidelines for Preparing Economic Analyses	U.S. Environmental Protection Agency (EPA)	Environmental Protection
US	2015	A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction	National Oceanic and Atmospheric Administration (NOAA)	Environmental Protection
US	2020	Transportation Benefit-Cost Analysis	Transportation Economics Committee	Transport

As can be seen in the table, the guidelines and handbooks cover different topics: the analysis of regulatory proposals and public investments in general, transport projects or more specific fields such as the valuation on energy networks, flood control measurements or green infrastructure. The variety of these topics also leads to different areas of focus concerning environmental issues.

Another difference concerns the target audiences for the particular publications. While some of the handbooks are intended to guide professionals through the analysis, e.g., by including checklists (for instance New Zealand Transport Agency 2018) others resemble more general textbooks on the theory, use, and challenges of CBA, with the aim of informing the interested public (like EPA 2010).

In some cases, e.g., where there are new scientific findings, the guidelines and handbooks were refined and updated in external documents, data tables or online. If publicly available, these documents were also taken into consideration. Each document is given an abbreviation referring to the country and main topic of the document. This abbreviation is later used in the results table below.

4. RESULTS

4.1. Overview

Table 2 gives an overview of the environmental topics discussed in the CBA guidelines and handbooks.

TABLE 2 Categorization of the integration of environmental topics in CBA guidelines and handbooks (own compilation)

Guideline Short	Air	GHG	Noise	Water	Biodiv.
AT - Water Management	x	x	x	x	x
AT - Transport	b	b	b	a	a
AU - General	a	x	a	a	a
AU - City Planning	c	b	x	c	c
AU - Transport	b	b	b	b	b
AU - Infrastructure	a	a	a	a	a
CA - General	a	x	a	a	x
EU - Cohesion Policy	b	b	b	a	a
EU - Cohesion Policy	b	b	c	b	c
EU - Energy	x	c	x	x	a
FR - General	b	b	b	a	a
FR - Transport	b	b	b	x	a
GE - Transport	b	b	b	x	a
IR - Transport	a	b	a	a	a
IR - General	b	b	a	a	x
NZ - General	b	a	a	a	x
NZ - Transport	b	b	b	a	a
SW - Transport	c	b	c	a	c
UK - General	c	b	b	b	c
UK - Transport	b	b	b	a	a
US - Environmental Protection	a	a	a	a	a
US - Environmental Protection	a	x	x	x	a
US - Transport	b	b	c	c	c

x	The environmental topic is not discussed
a	The topic is mentioned but no valuation is proposed
b	The CBA guideline/handbook proposes default values to integrate the environmental issue
c	The guideline/handbook proposes quantification and monetarization methods

The way in which the five environmental topics are discussed through the documents is categorized in four groups, ranging from not mentioned (x) and only theoretically mentioned (a), to the use of default values (b) and primary valuation methods (c). The shading of the cells in the table allows an overview of how the environmental issues are addressed across the documents. For instance, water pollution and biodiversity impacts are less often valued, as indicated by the dominance of darker shades. The results are also summarized in Table 3.

TABLE 3 Sum of the different approaches applied to address selected environmental topics in CBA guidelines (own compilation)

		Air	GHG	Noise	Water	Biodiv.
x	The environmental topic is not discussed	2	4	4	5	4
a	The topic is mentioned but no valuation is proposed	6	3	7	13	13
b	The CBA guideline proposes default values to integrate the environmental issue	12	15	9	3	1
c	The guideline proposes quantification and monetarization methods	3	1	3	2	5

In the following section, the five environmental topics are discussed individually, then different valuation approaches are highlighted.

4.2. Addressing environmental effects in CBA guidelines

The following section briefly summarizes how CBA guidelines and handbooks address five environmental topics: water and air pollution, noise, greenhouse gas emissions and the destruction of habitats and biodiversity. Different valuation approaches are presented and consolidated using examples.

4.2.1. Air pollution

Only two of the analysed CBA guidelines and handbooks do not refer to air pollution or air quality. Transport-related CBA guidelines in particular propose standardized integration of the monetary value of air pollutants and small particulate matter. A distinction can be made between guidelines that propose air pollution default values for units such as vehicle-kilometres travelled or per net ton-kilometre (MTES, 2019; Commonwealth of Australia, 2018), and those that include direct quantification of the amount of air pollutants emitted by a transportation project or program (FSV, 2010; European Commission, 2014; BMVI, 2016; New Zealand Transport Agency, 2018; Department for Transport 2016). Often the default values are further distinguished based on spatial criteria, considering, for instance, varying impacts in urban and rural areas. Although air pollution valuation is included in most CBA guidelines and

handbooks, the monetization approaches and environmental outcomes considered vary widely across the documents. For instance, the value of a ton of air pollutants (PM10, NOx, CO and HC) applied in the Economic Valuation Manual of New Zealand's Transport Agency represents a damage cost approach, reflecting harmful effects on ecosystems and the population. Regarding health cost, this handbook refers to the value of statistical life of NZD 4.1 million (2016, approximately EUR 2.3 million) (New Zealand Transport Agency, 2018, p. 386). In the Swiss Transport valuation, air pollution effects consist of three parts: health cost, considering additional illnesses and deaths of the exposed population (76 %), damage to buildings leading to shorter renovation cycles (12 %) and effects on soils, leading to agricultural yield reductions and forest destruction, which are calculated using a reparation cost approach (12 %) (VSS, 2007, p. 35–44). The Australian economic framework for green infrastructure recommends valuing the benefits of urban trees by estimating savings for other pollution control measures (avoided cost approach) (VISES, 2015, p. 33).

4.2.2. Greenhouse gas emissions

The valuation of greenhouse gas emissions (GHG) incorporates an effect in CBAs that is per definition non-local but of global relevance. GHG emissions are a topic of many international agreements and national program responses, which require a quantification of emissions, for instance, the annual greenhouse gas inventories submitted to the United Nations Framework Convention on Climate Change (UNFCC, 2020).

As knowledge about the quantification of GHG emissions as well as substantial scientific literature on the valuation of CO_2 exists, it is not surprising that the issue is covered by most CBA guidelines and handbooks. In this regard, 15 out of 23 documents propose default values for the valuation of GHG emissions; no other environmental effect is integrated in a more standardized way. Most of the guidelines and handbooks recommend or prescribe a cost per unit approach. Similar to air pollution, a distinction can be made between the assigning of values directly to tons of CO_2(-equivalent) and the use of proxies, like vehicle kilometres or kilowatt hours. In only four documents the importance of the integration of GHG emissions in public valuation is not mentioned, of which three were published before 2010.

There are different approaches to determining the cost of GHG emissions. ENTSO-E states that it "should reflect the (avoided) cost of mitigating the harmful effects that CO_2 emissions pose for society (2018, p. 32). Similarly, the UK Green Book refers to the "economic cost of mitigating a unit of carbon" (HM Treasury, 2018, p. 70) and the Irish Public Spending Code calculates the "cost to Ireland of removing these emissions from the atmosphere" (Department of Public Expenditure and Reform, 2019b, p. 20). The German guideline, on the other hand, uses a GHG value, estimated by the Umweltbundesamt, of EUR 145 per ton which takes account of abatement and damage cost of climate change (BMVI, 2016, p. 111).

As climate change and its effects relate to large uncertainty and risk, some guidelines apply CO_2 values that increase with time. The European Guide to Cost-benefit Analysis of Investment Projects proposes, for instance,

a central estimate of EUR 25 per ton CO_2 Equivalent in 2010 with an annual addition of EUR 1 until 2030 (European Commission, 2014, p. 52).[4]

Some jurisdictions differentiate between CO_2 that is covered by an Emission Trading System (ETS) and non-traded CO_2. The European ETS includes only CO_2 emissions from power and heat generation, commercial aviation and energy-intensive industry sectors like steel or paper production (European Commission, 2020). While the price of traded CO_2(-equivalents) is set at the market value of emission allowances, GHG emissions from other sources, especially the transport sector, are valued differently. This combined approach leads to different prices for this environmental externality, despite the fact that any ton of CO_2 (regardless of the source) has the same effect on the global climate (for further discussion of this topic see Mandell, 2010). The Irish handbook, for instance, uses a value of EUR 32 per ton for non-traded CO_2 and EUR 23.6 for traded CO_2 for 2020, and the difference is even more distinct in the future (2050): EUR 265 for non-traded and EUR 88 for traded CO_2 (Department of Public Expenditure and Reform, 2019a, 23).

The valuation of GHG emissions can be also understood as a reflection of political preferences. An interesting example are the French guidelines which were developed by France Stratégie (2017), an autonomous institution under the authority of the Prime Minister. In the 2017 Guide to Socio-Economic Assessment of Public Investments the cost per ton of was set on EUR 32/t in 2010, increasing by +5.9% per year until 2030, and up to EUR 100/t for 2030, increasing by +4.5% per year afterwards. In 2019 the values were revised to underline the importance of reaching carbon neutrality. A ton of CO_2-equivalent is now valued at EUR 90 in 2019, EUR 250 in 2030 and EUR 500 in 2040. As stated by the commission under Alain Quinet, the higher value has the effect to widen the scope of sectoral actions and relevant public investments in the fight against climate change (France Stratégie, 2019, p. 25f.).

4.2.3. Noise

Noise is an external effect, for which 12 out of 23 guidelines and handbooks propose valuation methods. Similar to air pollution, most of them (8) are transport-connected CBAs. Usually, marginal values per decibel are applied. Some guidelines and handbooks apply different values regarding the degree of urbanization and the source of the noise (e.g., road and rail traffic) (France Stratégie, 2017; MTES, 2019), while others require the estimation of population affected by certain levels of noise (FSV, 2010; BMVI, 2016; New Zealand Transport Agency, 2018; Department for Transport, 2019).

The US Transportation Benefit-Cost Analysis states that if a project leads to noise above a certain threshold, noise abatement measures will be undertaken, and the cost included in the project's overall costs. For very large projects and projects aiming at reducing noise, primary valuation methods like hedonic pricing or CVM are proposed (Transportation Economics Committee, 2020). The European Commission also encourages the application of primary surveys using CVM or hedonic pricing (2014, p. 87).

4 Due to growing European awareness of the extent and dangers of the climate crisis, the European Investment Bank to which the aforementioned guideline refers, now used shadow cost of carbon of EUR 250 per ton instead of EUR 45. Until 2050 the cost trajectory will lead to EUR 800 per ton CO_2-Equivalents (EIB, 2023).

4.2.4. Water pollution

The influence of projects and programs on water quality is regularly mentioned as important, though most guidelines and handbooks refrain from introducing concrete valuation approaches. This is the case for more than half of the documents (13 out of 23); another five do not refer to the topic at all. The Swiss CBA Guideline for transport projects acknowledges that water pollution can be an important external effect, but as no monetary values are available, they are valued outside of the CBA (VSS, 2007, p. 9).

Nevertheless, some publications offer valuation methods or default values to integrate the issue of water pollution into the CBA. The Australian Transport Assessment and Planning Guide uses default values to account for the fact that traffic pollution leads to a deterioration of water resources. They calculate cents per vehicle kilometres travelled, distinguishing between types of vehicles and the degree of urbanization (Commonwealth of Australia, 2018). The European Commission proposes replacement cost methods, such as valuation using the avoided cost of purchasing water on the market or operating domestic filtering systems (European Commission, 2014, p. 142f.).

An interesting example is the UK Green Book, which introduces values for the improvement of water quality in waterbodies using the categories of the European Water Framework Directive. The values are based on the National Water Environment Benefits Survey, which assessed the willingness to pay for recreational services, such as fishing, aesthetic services, and existence values using contingent valuation and a choice experiment (Environment Agency, 2013; for methodological details see Metcalfe, 2012). For instance, an improvement from poor to moderate was valued at GBP 20,100 per kilometre and year (HM Treasury, 2018, p. 66).

4.2.5. Effects on biodiversity and ecosystem quality

Effects on biodiversity and ecosystem quality are generally non-monetized in CBAs. These effects are not easily quantified as they are characterized by high complexity and multiple interconnections with issues like ecosystem functioning or the resilience of ecological systems (Provins et al., 2015; Pascual et al., 2010, p. 40). Not only is the impact of measures on biodiversity and ecosystem quality often unclear, but the estimation of biodiversity's value to society is connected with conceptual and practical challenges (Boardman et al., 2010, p. 432f.).

Therefore, most guidelines and handbooks state that these impacts that are "currently not feasible or practical to monetise" (Department for Transport, 2018, p. 2) or can "not be quantified objectively and clearly via an indicator or through monetisation" (ENTSO-E, 2018, p. 68). As elaborated in Section 4.3.3, some CBA guidelines and handbooks prefer to deal with this environmental issue through qualitative descriptions while others refer to separate evaluation methods, like multi-criteria analysis (e.g., European Commission, 2014, p. 331).

There are, however, some exceptions. The United Kingdom puts an emphasis on biodiversity valuation. The Green Book recommends using survey-based stated preference methods to obtain monetary values for biodiversity where it directly impacts human wellbeing. These values are typically

estimated per hectare or per household (HM Treasury, 2018, p. 67). Moreover, they reference to Defra's Environmental Valuation Look-up Tool, which is an Excel based tool providing a collection of environmental valuation evidence (accessible online at Defra, 2020). The Swiss guideline calculates the value of lost habitats due to sealing based on a replacement cost approach, which considers the cost of recreating a valuable habitat elsewhere, including land purchase, development and monitoring (VSS, 2007, p. 85). On average, a hectare of destroyed habitat is valued with CHF 2,800 per hectare and year (VSS, 2007, p. 85).

4.3. Valuation approaches

This section summarizes three approaches used to integrate environmental effects in CBA guidelines and handbooks: (1) the use of default values, (2) the application of primary valuation methods and (3) the reference to qualitative assessments, which also means excluding the monetary value of environmental effects from the CBA. This classification is also consistent with categories 2 to 4 from the systematization used in Section 4.1.

4.3.1. Default values, plug-ins and benefit transfer

As it can be time consuming and resource intensive to use primary methods to derive shadow prices for environmental effects (Atkinson & Mourato, 2008, p. 326), many guidelines and handbooks prescribe fixed values. These values are mostly presented as marginal values: e.g., estimates of the marginal social cost of one decibel of noise increase or one extra ton of particulate matter. Broadman et al. refer to these values as "plug-ins", as they are taken from another valuation study, or a meta-analysis, and are plugged into the CBA (2010, p. 407).

The use of such default values is especially common in transport-related CBAs, applying standard valuation of at least GHG emissions, air pollution and noise. The quantification relies either on estimates of changes in the amount of emitted pollution in tons and decibels (e.g., FSV, 2010) or is based on projected increases in transport vehicle kilometres (e.g., MTES, 2019). There is often some differentiation in values depending on specific characteristics, e.g., noise during daytime is considered less harmful (and therefore costly) than noise during the night (HM Treasury, 2018, p. 63f.), and there is a difference between air pollution emitted in cities and rural areas (e.g., France Stratégie, 2017). It is, however, a weakness of the approach that it does not take into account real context-specific features (Markandya, 2016, p. 17). Moreover, it is not always clear how default values were calculated and which effects they actually cover.

Default values offer a rather simplistic approach with the advantage of avoiding complex and time-consuming primary evaluation methods and facilitating the comparison between use cases. However, as regional, temporal and policy specific differences are not (fully) captured by using default values, they only allow for an approximation of environmental costs and benefits. The CBA used within Australian Transport Assessment and Planning differentiates between rapid CBAs that apply plug-ins for projects "where externality costs are not critical", and detailed CBAs, "where externalities make a significant

difference", that require site-specific research (Commonwealth of Australia, 2018, p. 51 f.).

4.3.2. Primary valuation methods

There are well-established methods available for estimating monetary values of environmental effects and non-market goods, which are consolidated in both theory and practice of CBA (European Commission, 2014, p. 311). Following Pascual et al. (2010), there are three main groups of valuation methods:

1. Direct market valuation methods, which use data from actual markets, consisting of market price-based methods (MP), production function approaches (PF) as well as cost-based approaches (CB), like the calculation of damage costs or averting expenditures/replacement costs.
2. Revealed preference methods, which use observation of individual choices in existing markets; the methods include the hedonic pricing method (HPM) and the travel cost method (TCM).
3. Stated preference methods, which are survey-based methods investigating the willingness to pay for changes in a hypothetical market. Contingent valuation (CVM) and choice experiments (CE) are most frequently used.

To assess the importance of primary methods in CBA guidelines, a simple keyword search[5] was conducted within the selected CBA document sample[6] (see Table 1). Figure 1 shows how many CBA guidelines and handbooks mention these different types of valuation methods. It should be noted that 10 out of 23 documents do not refer to any primary valuation method at all; this is, for instance, the case for the transport valuation guidelines and handbooks of Austria, Ireland, New Zealand or the United Kingdom, as well as the French publications and the European Guideline for Energy.

As can be seen in Figure 1, HPM as well as CVM are each mentioned in 11 documents. Another commonly mentioned valuation technique is the calculation of cost connected to environmental effects, whether to measure damage or the cost connected to averting damage or replacing an environmental service. TCM and choice experiments are also regularily mentioned, emphasizing that stated and revealed preference methods are both considered valuable approaches for determining the cost of an environmental effect

Obviously, this kind of analysis does not consider the extent to which the valuation methods are discussed. While some publications only mention that specific methods exist, others present advantages and challenges, provide guidance for the application of methods in the field and the appropriate choice of method for the estimation of different environmental effects (for in-

5 Different formulations and names for the primary methods were used.

6 It should be mentioned that this kind of analysis does not provide information on the extent to which the methods are dealt with in the CBA guidelines and handbooks. While some guidelines mention methods in the case of concrete applications, others include a section or appendix on the variety of valuation methods available. It nevertheless provides interesting insight if the use of primary methods is discussed in general.

stance HM Treasury, 2018). This is usually done using examples; most guidelines refrain from prescribing the application of primary valuation methods.

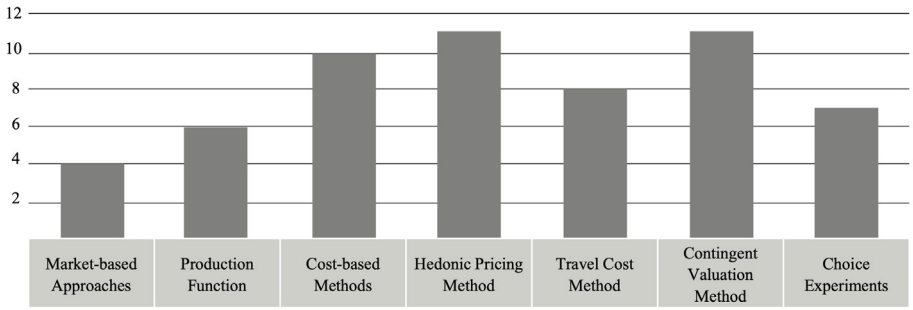

FIGURE 1 Number of CBA guidelines that mention specific primary valuation methods. (Graph: Antonia E. Schneider, CC BY-SA)

The Australian Economic Framework for the valuation of green infrastructure provides detailed examples of how to value positive environmental effects along with quantification and monetarization approaches, like calculating replacement costs (VISES, 2015). The Swiss guideline for the valuation of transport projects states that the use of market prices is the preferred valuation method. However, if this is not possible, one should apply the HPM, the CVM or the mitigation/damage cost method, whereby the methods should be considered in this order (VSS, 2007, p. 10). If a significant impact is expected, the US Transportation Benefit-Cost Analysis handbook calls for the use of HPM or CVM in connection with hydrological impact and land use models in order to monetize effects on water quality and habitats (Transportation Economics Committee, 2020).

4.3.3. Non-monetary valuation methods and other evaluation types

The majority of guidelines and handbooks state that some environmental outcomes are non-monetizable or too uncertain to be given a monetary value. In particular, effects on biodiversity as well as water quality are often excluded from monetarization as they "cannot be robustly expressed in monetary units" (Infrastructure Australia, 2018, p. 32) since the complexity of environmental systems leads to uncertainty (Australian Government, 2020, p. 3). Another reason not to monetize certain effects is given by the Irish guideline, which uses the principle of proportionality in order to decide if a certain environmental effect is quantified and monetized or not: "If the amount of efforts and resources required to quantify a particular benefit outweighs the advantages of including it, it should not be quantified but a qualitative assessment should be clearly made" (Department of Public Expenditure and Reform, 2019a, p. 16).

While some guidelines and handbooks simply exclude effects without monetary value, like the Austrian directive for the evaluation of flood protection infrastructure (BMLFUW, 2009), others propose different valuation methods using quantification and qualitative descriptions. A differentiation can be made between guidelines and handbooks that include a qualitative assessment in

the CBA and those which refer to other methods that should be additionally conducted, in a combined-methods approach.

Group one consists mostly of English-speaking countries. For example, Infrastructure Australia requires that effects which cannot fully be quantified are "discussed qualitatively and/or supported by available quantitative data" (2018, p. 100) and the NZ Transport Agency provides detailed information on how to quantify and report effects on water quality and biodiversity within the framework of CBA (Appendix 8).

The combined-methods approach is, for instance, applied by the German framework for the evaluation of national traffic routes (BMVI, 2016), which consists of different modules. The first module is the CBA, in which environmental effects concerning air pollution, GHG and noise are monetized. Other effects, like the destruction of habitats, are covered by module two, the Nature conservation assessment (Umwelt- und Naturschutzrechtliche Beurteilung). Other examples are the Swiss VSS, which states that the mere existence of non-monetizable effects, which are therefore valued with CHF 0, is the main reason why it is not sufficient to use a CBA to evaluate a project. In order to include these effects, one should apply an additional utility analysis (Nutzwertanalyse) (2007, p. 19). The European Commission, on the other hand, proposes the use of multi-criteria-analysis for benefits that are "not just non-monetary, but also physically not measurable" (2014, p. 331).

5. DISCUSSION AND CONCLUSION

The objective of a CBA is the rationalization of decisions in order to maximize general welfare (Dreze & Stern, 1987, p. 911). The right to live and work in a sound environment, which provides reliable ecosystem services and natural goods, is clearly a social priority. Therefore, the evaluation of public projects and programs obviously should include relevant issues. This paper has provided a systematic overview of national CBA guidelines and handbooks, discussing if and how five selected environmental concerns were addressed, and which monetarization methods were proposed. The comparison of 23 different documents shows considerable differences in the way and extent to which environmental effects are integrated in the public evaluation of projects and policies. Certain patterns nevertheless emerge.

Only a minority of guidelines and handbooks provide concrete instructions on how and which primary valuation methods should be used to estimate environmental impact. Rather they present a variety of methods, often in a textbook-like manner and sometimes accompanied by case studies. As shown, biodiversity and habitat effects and issues connected with water pollution are less often valued than other environmental effects. This can partly be explained by a lack of understanding regarding the impacts to be measured. As ecosystems are very complex, scientific evidence about causal relationships is not always available, which impedes the quantitative expression of certain phenomena (Romijn & Rene, 2013, p. 72).

In recent years, large contributions to the debate of environmental valuation in the context of CBA were made (Guijarro & Tsinaslanidis, 2020; Markandya, 2016; OECD, 2018). However, it is clear, that the CBA guidelines and handbooks in this analysis represent very different stages of this

discussion. While some use the ecosystem service framework and formulate detailed valuation approaches, like the UK Greenbook (HM Treasury, 2018), others still argue that no suitable valuation methods exist (BMLFUW, 2009, p. 22). Therefore, a revision of some CBA guidelines and handbooks with respect to theoretical and practical improvements in the field of environmental valuation is recommended.

The preferred approach is the use of default values, which is particularly the case for noise, air pollution and greenhouse gas emissions. In particular, transport-related CBA guidelines propose standardized values for the valuation of environmental outcomes. This approach enables a quick and inexpensive integration of environmental effects in CBAs, which can provide a useful complement to cost and benefits. Nevertheless, the estimation of these values should be critically examined. It is especially important to consider which valuation approach and scientific reasoning lies behind the value and which effects were included, something that is often not made transparent in the CBA guidelines and handbooks. As an example, different effects can be taken into account when valuing the cost of air pollution: increased illnesses and mortality, damage to buildings, agricultural yield reductions or disturbances in ecosystems as well as any combination of effects. Consequently, differences in the quantification and monetarization of these effects can lead to very different monetary values, for instance, health costs can be estimated using the value of statistical life or increased expenditures in the health sector. Using default values in CBA means that the challenges of valuing (non-market goods) are not circumvented but rather outsourced. CBA practitioners need to be aware of and openly communicate the background and limitations of the values they use.

There is an important limitation to the present study regarding the use of CBA guidelines and handbooks as proxies for international CBAs. As the legal obligation of the documents also used in planning varies strongly, from obligatory requirements to mere theoretical inputs and assistance for practitioners, the impact of the analyzed documents on the actual CBAs will vary as well. Thus, in order to determine how environmental effects are valued in practice, further research on CBAs should be conducted. Nevertheless, the analysis of the guiding documents enables an overview of how different countries and agencies approach environmental effects resulting from public projects and programs.

Finally, it is impossible to write about environmental valuation without acknowledging that it is not possible to capture the full value of nature. Valuation is always an anthropocentric approach, highlighting effects relevant for public wellbeing based on social preferences (Pascual et al., 2010, p. 5). Emphasizing the valuation of environmental effects in the framework of CBAs does not imply to neglect other perspectives and methods for managing environmental resources (Ninan & Inoue, 2014, p. 189). Rather it is about ensuring that environmental externalities are internalized, and important social costs and benefits connected to nature are not simply omitted from decision-making and planning processes.

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ANNEX: DESCRIPTION OF ENVIRONMENTAL EFFECTS

Noise pollution – harmful impact on human health and ecosystems, for instance, disturbances of wild animals related to noise pollution.

Air pollution – emissions of localized air pollutants such as sulphur dioxide, nitrous oxide or small particulate matter (PM). Negative effects on air quality lead to the impairment of ecosystems and adverse effects on human health.

Greenhouse gas emissions – emissions of air pollutants which contribute to the greenhouse effect. Such gases are carbon dioxide, chlorofluorocarbons, water vapor, methane, and nitrous oxide. These gases have different global warming potential and are often summarized in CO_2 equivalents.

Water pollution – contamination of water bodies, surface water as well as ground water. Effects on water quality affect aquatic wildlife as well as humans, for instance, by degrading drinking water quality.

Effects on biodiversity and ecosystem quality – the loss of habitats and species caused by soiling, deforestation, habitat fragmentation and other human intervention.

BIOGRAPHY

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