A review of theoretical and conceptual foundations for consolidated analysis of CVM and CBA for natural and environmental resources

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A REVIEW OF THEORETICAL AND CONCEPTUAL FOUNDATIONS FOR CONSOLIDATED ANALYSIS OF CVM AND CBA FOR NATURAL AND ENVIRONMENTAL RESOURCES

ABSTRACT

This paper outlines a theoretical framework for non-market valuation, and theoretical and conceptual foundations of cost-benefit analysis for natural and environmental resources. Despite the fact that contingent valuation estimates may contain errors, it is still recommended for policy makers to use estimated values of willingness to pay of important public goods than to ignore them. If their value is not assessed, it is simply considered a zero. Cost-benefit analysis (CBA) can apply to policies, projects, regulations, and other government interventions. It is an assessment approach that puts a monetary value on policies' consequences to justify the feasibility of a project. Building and understanding the conceptual foundations of CBA is crucial for ascertaining whether it can be used as a decision rule or not. To achieve environmentally and socially reliable management, it is recommended to involve everyone who will be affected by the policy implementation in a way that the study can reveal their interests and preferences related to a specific environmental issue or policy change. The paper points out the most relevant aspects to be taken into consideration when applying non-market valuation were generated.

Key words: *Contingent valuation method, CBA, Landfill conversion, Welfare economics.*

1. Introduction

To understand the non-market valuation (NMV) and subsequently the contingent valuation (CV), it is important to define market goods and market value, and their distinctive features from non-market goods and non-market value. Market goods and services are products (items or activities) traded on the market at a price determined by demand and supply. Their monetary values are measured by price times quantity (Samuelson & Nordhaus, 2009). Some of the examples of market goods (or items) are food, furniture, toys, and clothes. A service (or activity) infer any action done by one person for someone else. For instance, medical check-ups, haircuts, delivery, and teaching. Non-market goods and services, on the other hand, are not subject to markets, e.g. environmental services and health (J. B. Loomis, 2002). Simply, no one is charged for cleaner air. Therefore, non-market valuation refers to values for non-market resources. It is employed to assess project benefits by quantifying the economic values of goods and services that are not traded in the market (J. B. Loomis & Walsh, 1997). The concept of non-market valuation used to value non-market resources – willingness to pay (WTP) – is the same concept used to value market goods and services. Price in the market is simply WTP for the good, or it represents trade-offs that people make. NMV considerably resembles detective work in estimating the monetary WTP for natural and environmental resources from transactions such as higher level of environmental quality, distances traveled

for recreation, jobs accepted, or home purchases. A summary of the fundamental reasons for NMV is as follows:

- Conservation of natural and environmental resources (Pearce, 2013),
- Resource conservation policies support (Hanley et al., 2001),
- Comparison of the benefits assessed for natural and environmental resources and alternative resource use options (Nunes & van den Bergh, 2001),
- Application of the obtained valuations in cost-benefit analyses of public projects (Lipton et al., 1995).

As the need for a cleaner and safer environment was developing, obvious questions started to emerge. How clean should the air be? What is the level of impurity that we should tolerate in the drinking water? What is the acceptable level of national park system expansion for the public? What is the value that public healthcare recipients put on access to their traditional doctor instead of being registered in a health preservation organization? How much do people care about a specific public good? What is a dollar value for keeping the option of swimming in a lake inside of a national park? The demand for answers was increasing and consequently, economists started to develop economic models that can address these questions. Policy makers were particularly interested in non-market valuations because it gave them information about the potential benefits of public goods[1] that they could balance against their costs and arrive at more rational choices.

The contingent valuation represents one of the most guaranteed approaches to measure non-use values in monetary terms, which makes its major advantage. The CVM is a survey technique that composes "*a hypothetical market to measure willingness to pay or accept compensation for different levels of non-marketed natural and environmental resources"* (J. Loomis & Helfand, 2003, p. 184). It can measure both passive use values (e.g. benefits for a society from the existence of a natural environment) and the value of outdoor recreation at the alternative attribute level (e.g. crowding and wildlife abundance). In environmental valuation, passive use values play a significant role because many respondents are showing positive WTP values for changes in environmental quality, that are not reflected in observable behavior (Hoyos & Mariel, 2013).

The main idea of CVM is to assess an individual's WTP for "buying" use or preservation of a non-marketed natural resource by using hypothetical situations (J. Loomis & Helfand, 2003). According to Loomis & Helfand (2003), there are three key features of the market: (1) description of the change in environmental quality being valued, (2) payment vehicle, and (3) WTP or WTA question. The responds can be obtained in-person, through telephone interviews or mail questionnaires. The CVM is a direct form of the stated preference methods, as the obtained value estimates are dependent on the specifics presented to respondents in a survey. It is seriously underpinned in welfare economics and the neoclassical concept under the individual utility maximization framework.

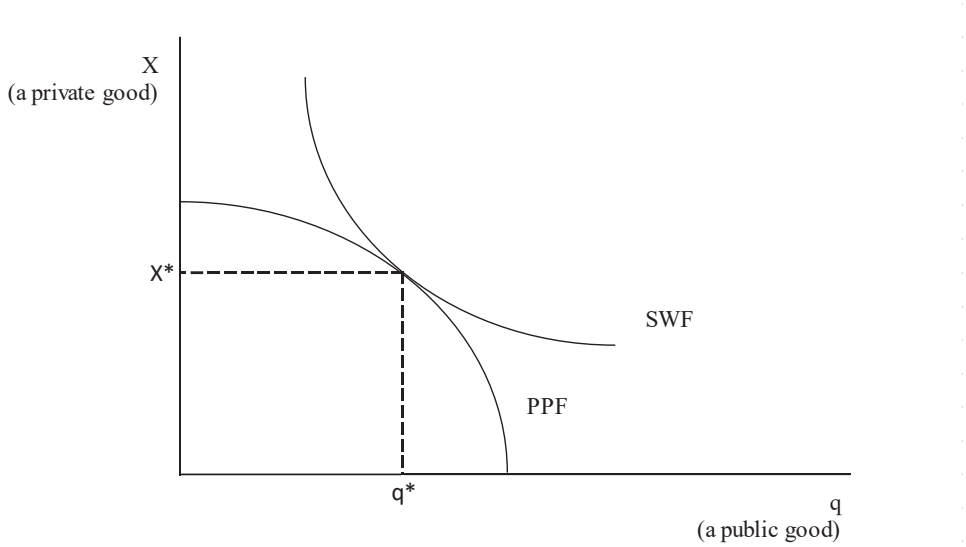
2. The Basis of Welfare Economics

Economists differentiate two branches of modern economics, positive and normative (Stiglitz, 1986). The positive economics relies on verifiable statements about the world whereas the

[1] A pure public good is perfectly non-excludable and non-rivalrous between the individuals who wish to use the good (Cornes & Sandler, 1996). There are few public goods that in reality meet these conditions, for instance air and national defense.

normative or welfare economics seeks to evaluate the effects of economic policies on the well-being of the community based on opinions or judgements. Throughout history, the concept of a social welfare function (SWF) was essential for welfare economics, and the level of optimal production was defined as the tangent between production possibility frontier (PPF) and SWF (Figure 1). By the late 1930s, the idea of measuring individuals' satisfaction in quantitative terms was almost completely abandoned, and experts replaced cardinal utility for an ordinal, which has severely compromised the theoretical basis of the SWF. In 1951, Arrow's Impossibility Theorem showed that it is impossible to aggregate preference into an SWF without violating a few premises of behavior and choice. Due to these events, the SWF does not play an important role in applied economics, but it remains used in economics texts for explanatory purposes. Instead, a Pareto-improving[2] criterion is used by welfare economics to judge on a certain policy.

Figure 1: Point of Optimal Production



Source: According to Rosser (1988), p. 280.

In applied modern welfare economics, a cost-benefit analysis attempts to monetize the gains and losses to economic agents (individuals, consumers, households, or firms) affected by alternative levels[3] of supply of a public good (Mitchell & Carson, 1989). In practice, that would allow the gainers (form a policy change) to offset the losers. Consequently, if an economic agent is better off while not making another worse off, the Pareto criterion is met. One of the advantages of CV is its capability of providing the information necessary to evaluate benefits by different criteria, including potential Pareto-improvement criterion.

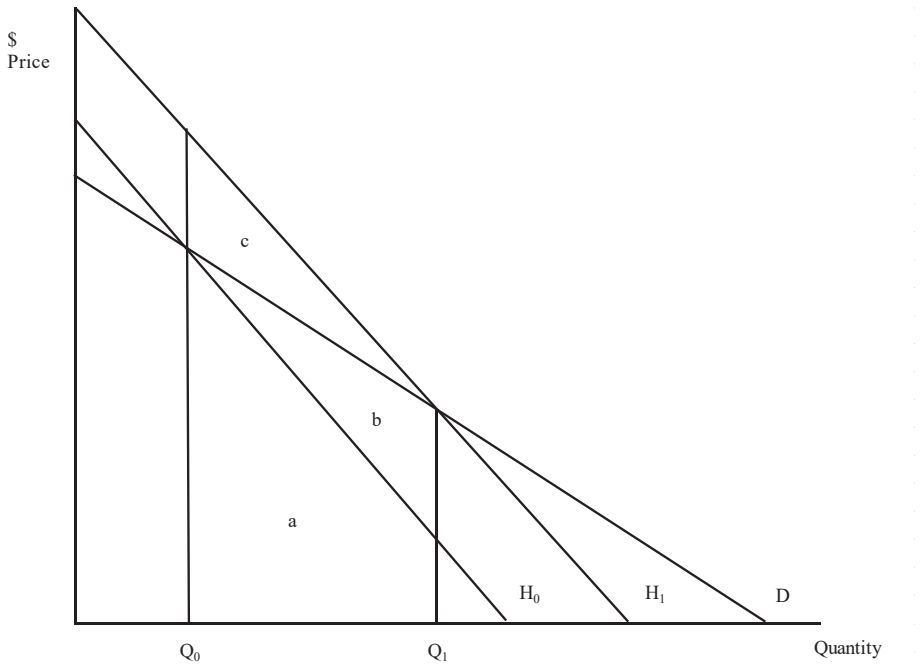
2.1. Choice of Benefit Measure

Traditionally, consumer surplus (CS) is the measure of consumer benefit (Ward & Beal, 2000). The idea itself was created by a French engineer, Jules Dupuit, in 1844, but rediscovered and renamed by a British economist, Alfred Marshall (Houghton, 1958). The area under the Marshallian demand curve and above the price line depicts CS. In figure 2, the

[2] A Pareto-improving policy change is a change in relative efficiency, or a change which moves an economy from a less preferred (Pareto-inferior) position to a preferred (Pareto-superior) position.
[3] The terms level, quality, and quantity of a public good are used interchangeably, depending on the nature of a good.

ordinary demand curve is the line marked D and price is assumed to be zero, as it is an example of a pure public good. The area a+*b* represents the change in consumer surplus resulting from an increase in supply of the public good from Q_0 to Q_1. As a measure of benefits resulting from quantity or price changes, the concept of CS has showed numerous problems. They are mostly related to the fact that the ordinary demand curve holds income constant, rather than the level of utility (or satisfaction). A British economist, John Richard Hicks, suggested different CS measures, known as the Hicksian consumer surplus measures (HCS) (Blackorby et al., 2008), which was considered Marshallian CS measures calculated from demand curves, holding total utility constant at certain levels. Based on how an economic good is used and owned, the four measures can involve either compensation or payment to maintain utility at the specified level (Table 1). According to Randall & Stoll (1980), the Hicksian variation measures are used when the consumer can alter the level of the good and the CS measures when the levels of the good to purchase are fixed. The compensating surplus measure can be explained as the consumer's WTP for an increase in quantity such as the level of air visibility. For a decrease in visibility, on the other hand, the compensating surplus measure can be interpreted as the minimum damage that the consumer is willing to accept in return for receiving the decreased level of a good.

Figure 2: Surplus Measures for a Change in Quality



D Ordinary Marshallian demand curve
H(U_0): Hicksian demand curve for utility level U_0
H(U_1): Hicksian demand curve for utility level U_1
a+b equals ordinary consumer surplus
a equals compensating surplus
a+b+c equals equivalence surplus

Source: According to Silberberg (2016)

Table 1: Hicksian Welfare Measures for CV Surveys

	WTP	WTA
Quantity increase	CS	ES
Price decrease	CS; CV	ES; EV
Quantity decrease	ES	CS
Price increase	ES; EV	CS; CV

Definitions:

WTP-willingness to pay

WTA-willingness to accept

CS-compensating surplus

CV-compensating variation

ES-equivalence surplus

EV-equivalence variation

WTP is the amount of money an agent would be willing to give up to obtain a change and still be as well off as with his previous entitlement.

WTA is the amount of money that would have to be given to an agent, with a specified entitlement, to forgo a change and still be as well off as if the change had occurred.

Compensating measures assume that the agent is entitled to his current level of utility, or, alternatively, his status quo endowment of property rights.

Equivalence measures assume that the agent is entitled to some alternative level of utility, or, alternatively, to a set of property rights different from those currently held.

Surplus measures constrain the quantity of the good being considered at the quantity, which would be purchased at the new (old) price in the absence of compensation for the compensating (equivalence) surplus.

Variation measures do not constrain the quantity of the good the agent would purchase.

Source: Mitchell, R.C. and Carson, R.T. (1989) Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington DC, p. 25.

Based on data needs and assumptions about physical environments and economics agents, different methods of measuring benefits can be used for public goods. They can be divided into two major categories, behavioral linkage methods and physical linkage methods. Table 2 summarizes the first measurement technique.

Table 2: Behavior-Based Methods of Valuing Public Goods

	Direct	Indirect
Observed market behavior	**OBSERVED/DIRECT**	**OBSERVED/INDIRECT**
	Referenda	Household production
	Simulated markets	Hedonic pricing
	Parallel private markets	Actions of bureaucrats or politicians
Responses to hypothetical markets	**HYPOTHETICAL/DIRECT**	**HYPOTHETICAL/INDIRECT**
	Contingent valuation	Contingent ranking
	Allocation game with a tax refund	Willingness-to-(behavior)
	Spend more-same-less survey question	Allocation games
		Priority evaluation technique
		Conjoint analysis
		Indifference curve mapping

Source: Mitchell, R.C. and Carson, R.T. (1989) Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington DC, p. 75.

The damage function approach (or physical linkage method) uses marketplace prices to value the estimated effects. It is based on the presumption that there is a technical relationship, a biological or an engineering, between the consumer and the public good in question. For instance, temperature as a specific water characteristic is related to trout fishing, rather than the behavioral motivation of economic agents (e.g. fishermen). These methods cannot be used in existence or indirect-use benefit valuations. Contingent valuation is based on behavioral linkage between changes in amenities and their effects. Depending on the type of behavioral linkage and how preferences are revealed, four classes of behavior-based methods of the public good valuations can be distinguished: observed/direct, observed/indirect, hypothetical/direct, and hypothetical/indirect. Key properties of these benefit measurement methods and advantages of the CVM, especially hypothetical/direct methods, are described in the Theoretical Foundations section.

2.2. Willingness to Pay versus Willingness to Accept Measures

Formulating an elicitation question as WTP or WTA depends on which HCS measure the researcher wants to use for a given welfare change. The choice is a matter of property rights; whether the agent has to buy the good concerned if he wants to enjoy it, or he has the right to sell it (Cornes & Sandler, 1996; Faure, 1992). Concerning the public goods, it is not always easy to answer this question, mainly because the rights are collective. Unlike HCS, the Marshallian CS manages to avoid the problem of deciding on the appropriate property right, but on the other hand, it is not a true measure of the agent's welfare change. In case the researcher wants to measure both WTP and WTA for the same amenity (a change in a public good), he can rely on the CVM as the only direct measure of the two. The readers are encouraged to read more on the WTP-WTA dilemma in extensive literature (Arrow & Fisher, 1974; Bishop & Heberlein, 1979; Cummings et al., 1986; Randall & Stoll, 1980). For public goods that require annual or periodic payments to maintain the same level of the good, like air quality, neither use nor ownership can capture the pertinent relationship between a change in a public good valued and the consumer. Table 3 presents the summary of implications for Hicksian surplus measures for private and public goods, and their property rights.

Table 3: Hicksian Surplus Measures for Private and Public Goods

	Private goods		Public goods[a]		
	Own	Not own		Individually held	Collectively held
Use	CS_{WTA} (decrease)[b]	ES_{WTP}	Level currently accessible	CS_{WTA}	CS_{WTP} (decrease)[b]
Do not use	ES_{WTA}	CS_{WTP} (increase)[b]	Level not currently accessible	CS_{WTP}	CS_{WTP} (increase)[b]

[a] For public goods that require annual payments (or their equivalents) to maintain a given level of the good.

[b] Indicated measure for a decrease (increase) in the amenity from the status quo.

Source: Mitchell, R.C. and Carson, R.T. (1989) Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington DC, p. 39.

2.3. Aggregation Issues

Once WTP amount estimations have been obtained for individuals by a CV survey, the researcher has to see if it is possible to translate the estimates on the relevant population and to obtain the total benefit.

1) Aggregation of individual benefits – it is necessary to make a few assumptions to make sure that the findings of a CV study can be used to obtain the accurate estimate of aggregate individual WTP for a specific quantity: (i) a weighting scheme has to be chosen because a dollar of a person's WTP has an equal weight in an SWF. Other weighting schemes are possible to use, because WTP involves an income constraint; (ii) a design of payment structure has to be made to accumulate all the revenues that the respondents revealed they are willing to pay in a CV survey.
2) Subcomponent aggregation – this includes combining separately measured components of benefits in a CV study for: (i) different geographical locations; (ii) different types of benefits as parts of a bigger program, e.g. the air and water quality of a larger national environmental program.
3) Distribution of individual WTP or distribution of benefits from a policy change – policy makers may more desire this kind of information than the aggregate comparison of benefits and costs if it is considerably clear that the policy change debated would be Pareto-improving and the distributional information is available from a CV survey.

3. A Review of the Contingent Valuation Method

If we compare four different classes of benefit measurement methods based on five criteria–ability to measure option price, ability to value good not previously available, ability to estimate all existence-class benefits, ability to directly estimate the relevant ordinary and Hicksian inverse demand curves–the advantages of hypothetical methods are noticeable, particularly the flexibility of hypothetical/direct methods (Table 4). This is the method to directly measure people's valuation of specific hypothetical changes in quality and quantity of public goods. These methods, including contingent valuation, put forward institutional links between amenity levels and individual behavior (Smith & Krutilla, 1982). The institutional assumption implies that a respondent's answer to hypothetical markets is perfectly comparable to existing markets. If this premise is established, methods unique in simplicity, the ability to assess different benefit categories, and theoretical justification become available (Mitchell & Carson, 1989). Unlike observed methods (e.g. Travel Cost Method), hypothetical methods (e.g. CVM) are able to obtain WTP amounts of respondents that include both use and existence value. In addition, the hypothetical characteristic of CV allows the respondent to make his own tradeoffs in terms of money, as it has the ability to directly measure concrete points on an individual's compensated demand curve.

Table 4: Key Properties of the Benefit Measurement Methods

Desirable properties	Method			
	Observed/ Direct[a]	Observed/ Indirect	Hypothetical/ Indirect	**Hypothetical/ Direct**
Able to obtain option price estimates in the presence of uncertainty	No	No	Yes	**Yes**
Able to value goods not previously available	Yes	No	Yes	**Yes**
Able to estimate all existence class benefits	Yes	No	Yes	**Yes**
Relevant ordinary (or inverse) demand curve is directly estimable	Yes	No	No	**Yes**
Relevant Hicksian compensated demand (or inverse demand) curve is directly estimable	No	No	No	**Yes**

[a] In some cases, only referenda have the desired property.

Source: Mitchell, R.C. and Carson, R.T. (1989) Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington DC, p. 88.

3.1. Validation and Reliability of WTP

The validity of the CVM has been disputed as unreliable and biased as it uses hypothetical data that affects the veracity of estimated values (Ajzen et al., 2007; Bengochea-Morancho et al., 2005; Bennett et al., 2013; Collins & Vossler, 2009; Hausman, 2012). In fact, it is reasonable for people to question if respondents would really pay the amount they stated. The empirical evidence indicates that, when the question is referred to as WTP rather than WTA, the respondents would pay as much as stated if they have consumed the good before (J. Loomis & Helfand, 2003).

To use WTP estimates for policy analysis, a certain degree of accuracy and credibility of environmental valuation has to be proved (Bateman et al., 2004). Several validity checks have emerged and widely used: content, construct, criterion and convergent validities (Mitchell & Carson, 1989). Content validity evaluates how appropriate the questions were for obtaining credible estimates of WTP, and whether the questions were asked in a clear, neutral, understandable and meaningful manner. Essentially, content validity assessments are subjective.

Construct or theoretical validity test evaluates the consistency of the CVM results with other studies (convergent validity) and with economic theory, intuition and prior expectation (expectation-based validity) (Pearce, 2013). Criterion validity in CV is a measure of validity or degree of a survey to estimate true WTP. It should be able to assess if the respondents understand the CV questions or they are responsive to the crucial parts of the hypothetical scenario, and whether the elicited WTP reveals the actual amount the respondent is willing to pay if a hypothetical market existed. Convergent validity tests if the WTP estimates for a good would turn out to be the same regardless of the valuation approach used. The convergent validity test is generally evaluated by comparing actual behavior-based methods with

hypothetical markets used in CVM (J. Loomis & Helfand, 2003). It is important to say that both measures may be equally valid as well as invalid. In case of dealing with non-market impacts, where observable market data to verify the reliability of the WTP estimates does not exist, the results can be compared with those of similar studies (Pearce, 2013).

The other aspect of accuracy is reliability, which is related to consistency between true variation and measurement error. Based on J. B. Loomis (1993), one can be certain that the statement of WTP elicited in CV surveys resembles the behavior that would be captured if the situation would be real and not hypothetical. Despite the fact that CVM estimates may contain errors, many economists still prefer to use estimated values of WTP of important public goods than to ignore such values in policy analysis (J. Loomis & Helfand, 2003). The error in CVM estimates for passive incuse values is comparatively less relevant than the error of implying a zero value. Public good that have not been quantified would simply seem to be less relevant and their costs would not be as comparable.

To assess reliability in CVM, the test-retest reliability, the split-half, or the alternate form is employed. The test-retest is a measure of stability and reliability of a survey instrument over time. The instrument and the participants to be tested are identical. The split-half validity test involves dividing the sample into two equal parts, e.g. geographical areas (Bennett et al., 1998), and the respondent's WTP response for both halves of the test is compared. The correlation between the two halves provide the split-half reliability (Kline, 2005). The alternate form reliability refers to the consistency of test results between two different forms of a test. The two forms should be equivalent in all aspects, but administered at different times or in succession.

4. The Foundations of Cost-Benefit Analysis for Non-Market Valuations

The evidence of the use of CBA in practice can be found in American legislation in the 1930s when an investigation that endorsed social accounting prevailed on the Flood control Act of 1936. That Act (United States of America, 1936) authorized the United States Army Corps of Engineers to construct projects, such as dams, levees and flood gates, to provide flood protection if "the benefits to whomsoever they may accrue are in excess of the estimated costs...". This became a requirement to estimate all potential values a policy could generate. About 15 years later, the first CBA manual was published, the so-called "Green Book", and the first non-market valuation methods were suggested. In 1965, the former president Lyndon Johnson ordered all federal authorities to apply Program Planning and Budgeting (PBB), which became basically CBA. Scientific research on non-market valuation methods increased during this period not only in the US but also in Europe (e.g. the Amsterdam Treaty). Nevertheless, not many countries use CBA regularly.

4.1. Theoretical Foundations

When evaluating different investment alternatives, a company or an individual tends to consider only the costs and benefits that incurred to it. In a very similar way, we tend to consider all of the costs and benefits to society as a whole, that is why CBA is frequently regarded as social cost-benefit analysis (Boardman et al., 2007). CBA can apply to policies, projects, regulations, and other government interventions. It is an assessment approach that monetizes all consequences of a policy to all members of society to justify the feasibility of a project. The total value of a policy is defined by its net social benefits (NSB) that equal the social benefits (B) minus the social costs (C):

$$NSB = B - C \quad (1)$$

The main two types of CBA include *ex ante* and *ex pos*t. The standard CBA is referred as ex ante, and is conducted before the project is implemented. Ex post analyses are conducted at the end of a project and they provide information about the class of an intervention, and consequently whether particular classes of projects/policies are feasible. The third type of CBA, *in medias res*, is performed during the project and it can influence a decision on continuing with the project or ceasing it. The fourth type compares an ex ante with an ex post or in medias res of the same project. Whereas the comparative type of CBA is significantly useful to policy makers, it is the least implemented among the four. The summary of values of the four types of CBA for government decision making is presented in table 5.

Table 5: Value of Different Classes of CBA

	Class of Analysis			
Value	**Ex Ante**	**In Medias Res**	**Ex Post**	**Ex Ante/Ex Post or Ex Ante/In Medias Res Comparison**
Resource allocation decision for this project.	Yes—helps to select the best project or make "go" versus "no-go" decisions, if accurate.	If low sunk costs, can still shift resources. If high sunk costs, usually recommends continuation.	Too late—the project is over.	Same as *in medias res* or *ex post* analysis.
Learning about actual value of specific project.	Poor estimate—high uncertainty about future benefits and costs.	Better—reduced uncertainty.	Excellent—although some errors may remain. May have to wait long for study.	Same as *in medias res* or *ex post* analysis.
Contributing to learning about actual value or similar projects.	Unlikely to add much.	Good—contribution increases as performed later. Need to adjust for uniqueness.	Very useful—although may be some errors and need to adjust for uniqueness. May have to wait long for project completion.	Same as *in medias res* or *ex post* analysis.
Learning about omission, forecasting, measurement and evaluation errors in CBA.	No	No	No	Yes, provides information about these errors and about the accuracy of CBA for similar projects.

Source: Boardman A, Greenberg D., Vining A., Weimer D. Cost-Benefit Analysis: Concepts and Practice. 4th ed. Pearson series in economics; 2007. 61–95, p. 4.

One way of determining whether a project is worthwhile is by comparing a project's inputs and outputs (benefits). In other words, by using the total of the present values of its benefits minus the total of the present values of its costs, i.e. net present value (NPV). If the NPV is greater than zero (NPV>0), the project is worth doing. In the case of several alternatives, the rational criterion implies choosing the project which maximizes the NPV in the search for the

efficiency of resource allocation. Two of the most common alternatives to NPV are the benefit-cost ratio (B/C) and the internal rate of return (IRR). The project should be done if the B/C is greater than one (B/C>1). In addition, the higher the B/C ratio, the more efficient is the resource allocation (Stewart & Possingham, 2005). The IRR is the interest rate that sets the NPV of a project to zero. The general decision rule says that if the IRR for a project is greater than a target value, the project is desirable.

The NPV of a project equals the sum of the present values of its benefits (B_t) minus the sum of the present values of its costs (C_t) incurred in period t (for t=0,1,…,T) (Zerbe Jr. & Bellas, 2006).

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+i)^t} \quad (2)$$

where:
B_t = benefits in period t;
C_t = costs in period t;
i = interest rate for period t; and
T = number of periods the project will last.

The B/C ratio is equal to the present value (PV) of a project's benefits divided by the PV of its costs. In an equation this is:

$$B/C\ ratio = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+i)^t}} \quad (3)$$

where:
i = the discount factor for period t; and
T = the total number of periods under consideration.

The IRR of a project is the interest rate that will generate an NPV of zero, that is:

$$\sum_{t=0}^{T} \frac{B_t - C_t}{(1+i_{IRR})^t} = 0 \quad (4)$$

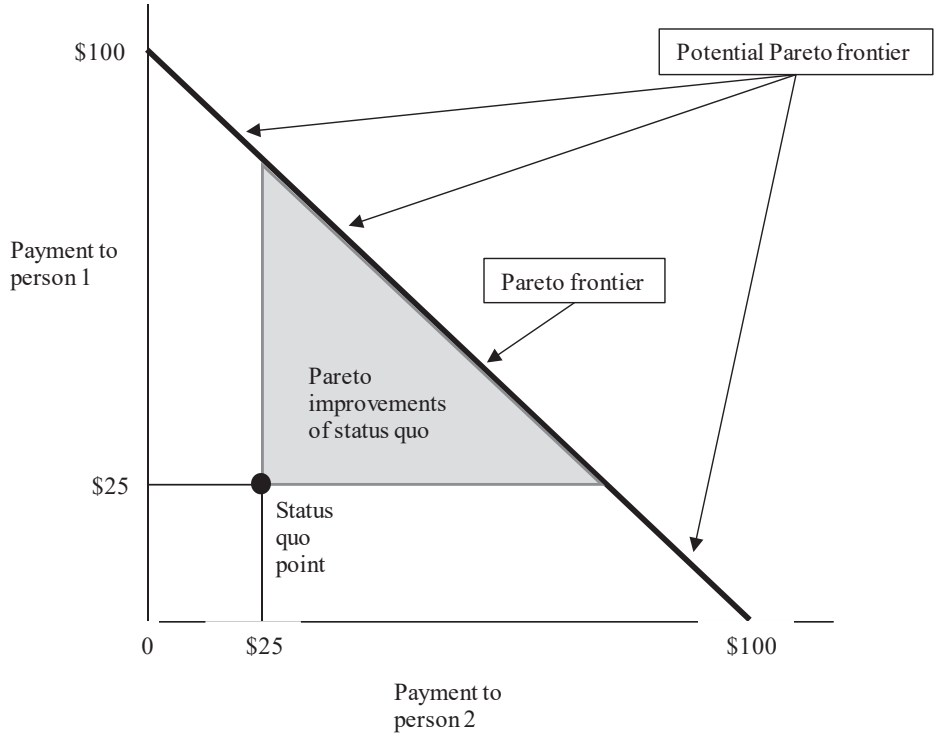
where:
B_t = benefits in period t;
C_t = costs in period t; and
i_{IRR} = the internal rate of return.

4.2. Conceptual Foundations

If we think about our daily actions, we realize that we somehow face their benefits and costs, and it seems natural to think in the same way about public policy alternatives evaluation. We want to measure and directly compare the efficiency of different alternatives. In that sense, building and understanding the conceptual foundations of CBA is crucial for ascertaining whether it can be used as a decision rule or not. In modern welfare economics and CBA, efficiency is referred to as allocative or Pareto efficiency. That means that a distribution of goods is Pareto efficient if there is no alternative to it that can make at least one person better off without making somebody else worse off (Boardman et al., 2007). Therefore, as long as an

alternative allocation that would make at least one person better off without making the other worse off exists, it is not Pareto efficient. This concept is graphically explained in figure 3 in a very simple situation that involves the allocation of $100 between two persons.

Figure 3: Pareto Efficiency



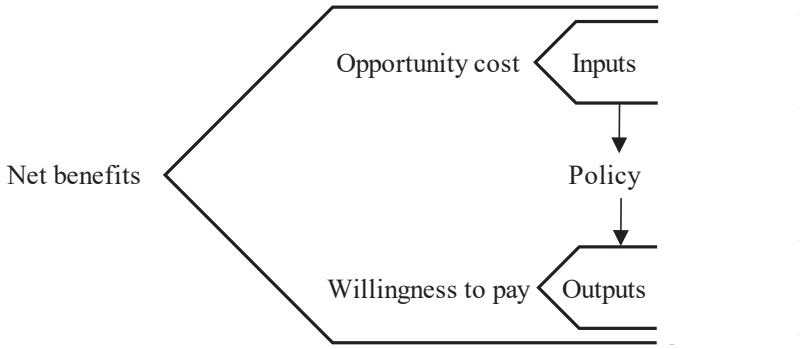
Source: Boardman, A. E. (2001). Cost-benefit analysis: Concepts and practice. Upper Saddle River, NJ: Prentice Hall, p. 28.

The horizontal axis represents the amount of money received by person 2, and the vertical axis represents the amount of money received by person 1. The maximum amount that each can receive is $100, and this is labeled as $100 on the two axes. The line that connects these two points is called the potential Pareto frontier. If the two persons agree on how to divide the total amount between themselves, they will receive any amount of money of up to $100. On the other hand, if they do not agree, then they will receive only $25 each (the status quo point). The Pareto frontier is the segment of the potential Pareto frontier that gives each person at least as much as the status quo. The shaded triangle that goes through the status quo point and the Pareto frontier represents all the possible alternative distributions that would make at least one them better off than the status quo without making the other person worse off. This implies that the status quo is not Pareto efficient, and moving to any of these points represents Pareto improvement (until reaching the potential Pareto frontier). In the concept of Pareto efficiency, implicit are the initial starting positions of the society members.

When it comes to net (social) benefits and Pareto efficiency, the connection is clear: "*if a policy has positive net benefits, then it is possible to find a set of transfers, or "side payments", that makes at least one person better off without making anyone else worse off"* (Boardman et al., 2007, p. 27). To fully grasp this link, it is important to indicate how benefits and costs in CBA are measured. Specifically, it is required to regard WTP as the policy outputs valuation method and opportunity costs (OC) as the policy inputs (or resources)

valuation method (Figure 4). Only if the total net benefits of the policy in question measured by the WTP are positive, then there are sets of payments and contributions that would make this policy a Pareto improvement over the status quo. In CBA, the OC is used in order to monetize the inputs for a policy implementation. "*The opportunity cost of using inputs to implement a policy is its value in its best alternative use"* (Boardman et al., 2007, p. 31). In other words, OC measures the value that society must forgo to use the input to implement a specific policy. The policy is Pareto efficient if it produces enough benefits that allows everyone who bears costs to be completely compensated. Generally speaking, a policy is potentially Pareto improving if the net benefits to society are positive.

Figure 4: Categorization of Net Benefits of Projects



Source: Boardman, A. E. (2001). Cost-benefit analysis: Concepts and practice. Upper Saddle River, NJ: Prentice Hall, p. 29.

5. Consolidated Analysis of CVM and CBA

The CBA is a broadly used and accepted framework for supporting social decision-making and making it more rational (Boardman et al., 2007). It is an analytical tool used to analyze the efficiency of a government project by deriving the present value of the net benefits (PVNB) of a policy,

$$PVNB = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \quad (5)$$

where B_t represents the social benefits of the policy in time t, C_t represents the social costs of the policy in time t, r is the discount rate and T is the number of time periods that define the life of the policy (Alberini & Kahn, 2006, p. 92). The CBA estimates and aggregates the monetary value of projects' advantages (benefits) and disadvantages (costs) to a society to establish whether they are effective, which implies that the CBA is based on welfare theory. To estimate the costs of a public project as precisely as possible, it is recommended to refer to the existing examples. Here, landfill conversions and restorations are used as examples of environmental improvement projects (tables 6 and 7).

Table 6: General Information about Converted Landfills in Hong Kong

Landfill Site	Location	Area (ha)	Total Waste Received (Mt)	Landfill Closed (Year)
Jordan Valley	New Clear Water Bay Road, Jordan Valley	11	1.5	1990
Ma Yau Tong Central	Lin Tak Road, Lam Tin	11	1	1986
Ma Yau Tong West	Tseung Kwan O Road, Lam Tin	6	0.6	1981
Sai Tso Wan	Sin Fat Road, Lam Tin	9	1.6	1981
Ngau Chi Wan	Fung Shing Street, Ngau Chi Wan	8	0.7	1977
Siu Lang Shui	Tuen Mun	12	1.2	1983
Ma Tso Lung	Pak Shek Au	2	0.2	1979
Ngau Tam Mei	Yuen Long	2	0.15	1975
Gin Drinkers Bay	Kwai Chung	29	3.5	1979
Tseung Kwan O Stage I	TKO development area 77	68	15.2	1995
Tseung Kwan O Stage II/III	TKO development area 105	42	12.6	1994
Shuen Wan	Ting Kok Road, Tai Po	55	15	1995
Pillar Point Valley	Part within Tuen Mun Area 46 and part within Castle Peak Firing Range	65	11	1996

Source: www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_si_lra.html

Table 7: Landfill Restorations in Hong Kong

Landfill Site	Period of Restoration Works	Capital Cost* ($M)	Commissioning of Restoration Facilities	Estimated Operation Cost* ($M/yr)
Jordan Valley Ma Yau Tong Central Ma Yau Tong West Sai Tso Wan Ngau Chi Wan**	1997-1998	249	1998	9
Siu Lang Shui Ma Tso Lung Ngau Tam Mei	1999-2000	332	2000	21
Gin Drinkers Bay Tseung Kwan O Stage I Tseung Kwan O Stage II/III	1997-1999	369	1999	21
Shuen Wan	1996-1997	168	1997	5
Pillar Point Valley	2004-2006	199	2006	15

Note:
* All capital cost shown are actual costs; all operation costs are estimated at 2014/15 level.
** The restoration work for Ngau Chi Wan Landfill was carried out from 1998-2000 and the restoration facility was fully commissioned in 2000.
Source: www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_si_lra.html

Essentially, if the discounted PV of the benefits are greater the discounted PV of the costs, then the project is feasible. A CBA includes various types of limitations, such as distributional issues, choosing a discount rate, excluding environmental issues, etc. Economists tend to combine WTP with CBA to add the social element into it as the valuation method based on CBA is often considered too simple to address environmental values properly (Verlicchi et al., 2012) or healthcare problems (Haefeli et al., 2008; Koopmanschap et al., 2008). To achieve environmentally and socially reliable management, it is recommended to involve local residents (or others who will be influenced by the policy implementation) in a way that the study can reveal their interests and preferences related to a specific environmental issue or policy change.

6. Conclusion

Many researchers use the CVM to estimate economic benefits with respect to changes in the landscape. In the present paper a review of theoretical and conceptual foundations for consolidated analysis of CVM and CBA for landfill-to-park conversions is given. The following aspects as the most relevant to be taken into consideration when applying non-market valuation were generated:

- The money should be used as announced to respondents during an examination procedure;
- Nature protection and conservation and environmental improvement (water, landscape, air, etc.) should be involved;
- Different scenarios should be involved;
- The effects of landscape changes on the benefits of visitors;
- The prevention of further degradation of the ecological quality should be ascertained;
- A combination of WTP and CBA approaches should be applied to properly measure the environmental values as the estimations of social preferences;
- The management that will use the estimations should use the increased capital in part to compensate the population, not only for environmental purposes. In that case, the WTP should be measured before the compensation methods are applied and after the respondents are informed on spending plans.

CBA is a broadly used and accepted framework for supporting social decision-making. It can be applied to policies, projects, regulations, and other government interventions. As an assessment approach that monetizes consequences of a policy to a society, it is essential for identifying whether a government project is efficient.

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