The use of economic analysis for water quality improvement investments

Rodriguez, Diego Juan

Publication date:
2009

Chapter 8:
Summary, Conclusions, and Recommendations

8.1. Summary

This study demonstrated how to conduct cost-benefit analysis of water quality investments. It attempted to clarify the range of applications of the cost-benefit idea itself, from optimizing over a complete set of possible investments, to choosing the best of a limited set of possibilities, to offering a test of the (aggregate economic efficiency) performance of a particular project proposed.

Chapter 1 provided a basic understanding of the challenge of improving water quality. Poor ambient water quality is a serious problem in developed and in most developing countries. Today approximately 85-90 of the wastewater produced in the developing countries is discharged to water bodies without receiving any kind of treatment with serious impacts on public health and ambient environmental quality. The costs of reversing the trend of ever-deteriorating water quality in rivers and estuaries near large metropolitan areas are simply enormous. Improvement in ambient water quality stems primarily from the treatment of wastewater which requires substantial financial resources and planning.

In Chapter 2 we set the stage by introducing the case study: a water quality improvement program in Brazil. Even though Brazil's water endowment represents approximately 12% of the world's total, it has very unequal distribution. In large metropolitan areas, water quality is a very serious issue. The Tietê River, which flows through the São Paulo Metropolitan Area is the most polluted river system in Brazil. The State, as early as the 1950s, embarked in an effort to clean up the river and improve its ambient environmental quality but built its first wastewater facility in the 1980s. The solution to clean up the river will require decades and significant investments.

In Part II of the study, the three chapters were devoted to present the methodological framework for cost-benefit analysis of water quality improvement projects, including the use of basinwide optimization, subset analysis, and isolated project analysis. A 'second best' type of approach is recommended: work toward requiring basinwide, vector-constrained, cost-effectiveness analysis, but subject specific projects that are identified as part of the solution to such a problem to an isolated cost-benefit analysis. Chapter 4 presents the existing nonmarket benefit estimation techniques and one in particular, the contingent valuation method, applied to the case study, was presented in detail. The principal categories of benefits are introduced. This chapter came down on the side of the so-called "direct" methods as currently and potentially most useful in developing countries, largely because of the combination of data unavailability and conceptual difficulties with obtaining all and only all the benefits via the so-called indirect methods. Chapter 5 depicts the theoretical underpinnings of parametric and non parametric approaches to contingent valuation. The use of parametric techniques forces the data to a specific distribution, constructing the contingent valuation data to a limited form of the underlying distribution function, risking misspecification errors. Non parametric approaches are easier to use (distribution free) but they allow limited exploration of the effect of the covariates.

Part III, composed of Chapter 6 and 7 presents the results of the cost-benefit analysis. Chapter 6 demonstrates that the statistical techniques for imputing benefits using referendum contingent valuation data are sensitive to the analyst's assumptions. Equally justifiable parametric and nonparametric evaluation routes to average benefits may produce very different mean estimates, estimates that are outside the 99.5 percent statistical confidence intervals generated by any given route. In short, average (and by implication, total) benefit estimates based on referendum contingent valuation data are fraught with statistical uncertainty. This source of uncertainty can be measured by the standard error of the mean, computed using any particular approach. However, the more important methodological uncertainty about which approach to extracting mean benefits is best has no such easy resolution, and both types of uncertainty about benefits matter. In addition to uncertainty about benefits, environmental investments often are accompanied by uncertainties about execution timing as a result of institutional obstacles, divergent interests of stakeholders, and the behavior of the natural world the project operates on and in, as well as the more familiar uncertainties about costs and economic prices. To reflect all of these uncertainties, the economic cost-benefit analysis demonstrated in Chapter 7 employs Monte Carlo simulation, which permits their effect on the distribution of a project's net present value to be quantified. These uncertainties are necessarily transmitted into uncertainties about the net present value of environmental investments. The NPV distribution can, and, we argue, should be quantified and evaluated during the project design and approval process. Chapter 7 argues that Monte Carlo risk analysis offers a more comprehensive and informative way to look at project risk ex ante than the traditional (and often arbitrary), one-influence-at-a-time sensitivity analysis approach customarily used analyses of economic feasibility. The case for probabilistic risk analysis is made. A number of ways to handle uncertainty about benefits are proposed, and their implications for the project acceptance decision and the consequent degree of presumed project risk are explained and illustrated. This exercise not only changes the terms of the "go or don't go" investment decision, it also identifies areas of uncertainty where it would be most valuable to improve the available information.

8.2. Recommendations

This thesis is on the application of economics to complex water infrastructure projects. It is not a theoretical piece, but rather an attempt to provide the analyst a good understanding on how we, project economists, apply the existing theory into practice and what are the limitations that we face in the process. Let's not fool ourselves: economic analysis is an uncertain exercise that ultimately requires good judgment from the analyst. Even if we had access to the most complete data sets, and we had a thorough understanding of economic theory, we need to apply judgment and experience. In developing countries, we face serious constraints in terms of technical capacities and lack of accurate data. The analyst faces increase uncertainty and also must apply much more intuition and creativity. Hence, the following recommendations are to the project economists that need to appraise complex water infrastructure investments in developing countries.

Let us begin with a simple question: How valuable is economic valuation? In this case that million dollar question has a half billion dollar answer. A cost benefit analysis for the full project was not performed at the onset. If it had been, the project may not have ever been undertaken and the borrower could have avoided a potentially large social loss. Even in the face of severe uncertainty about benefits, in hindsight its costs appear too great to make it economically attractive: it's NPV is unambiguously negative under almost all conceivable circumstances.

However, the prospect of a major water borne disease outbreak if nothing were done to correct the pollution situation was not reflected in the original analysis or explicitly emphasized in the CV exercise done to estimate benefits for Stages II and III, assuming Stage I benefits were nil. The likelihood of such an event is not known, nor is the extent to which CV respondents considered health issues in formulating their answers. Finally there may have been non economic reasons for trying to reduce pollution in this major metropolitan area which influenced the decision to go ahead. The project was approved around the time of the heavily publicized United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992, an event which raised expectations and encouraged countries to pursue sustainable development following the principles of Agenda 21.

Whatever the pressures surrounding the project were, cost effectiveness analysis was used to justify going ahead with the first stage of investment, on the unproven assumption that the entire project was economically viable. This decision locked the borrower into contractual obligations for operation of the first stage facilities, repayment of the first stage loan, and continuance of the pollution control program. Now, paradoxically, if the entire effort cannot be abandoned the next best thing to do is to go ahead and complete the program. The first recommendation is that when millions of dollars are at stake in water pollution control program investments, even though the benefits of water quality improvement are hard to specify precisely cost benefit analysis is definitely worth the effort, even though the benefits of water quality improvement are hard to pin down. In a recent study analyzing the impact of public investment on private investment in infrastructure, Cavallo and Daude (2008) conclude that "the most important concern when it comes to infrastructure investment, for example, is project selection. Selecting projects with the greatest impact is critical; thus, it is crucial that countries set up institutions capable of doing adequate planning, cost-benefit analysis and ongoing monitoring and evaluation." (page 27). Additonaly, it is important to stress that uncertainties are inherent in any type of investments or policies we undertake. These uncertainties are further exacerbated in the context of complex environmental projects in developing countries. Cost-benefit analysis is a tool that when properly applied, provide the decision maker with a clear framework where all assumptions and uncertainties are made explicit. Furthermore, it identifies the information and data gaps.

The second question we need to ask is on which type of cost-benefit analysis we should apply (its scope): basinwide optimization, subset analysis, or the isolated project or policy justification. In Annex 3, Table 3A these three options are presented. Unfortunately, there is no basis for making judgments about the relative values of the advantages and disadvantages of an isolated project analysis, or a subset analysis as opposed to basinwide optimization; i.e., the cost of extra data gathering, estimation, and model construction vs. the gain in efficiency net benefits from the way water quality is eventually managed. Such a basis will depend on research that contrasts the implications of the broader and narrower approaches for costs and benefits and keeps track of the costs of the approaches themselves. In the absence of any agency's willingness to fund such studies, it is fair to say that there will be no way to settle the disagreement between those who want to push toward basinwide optimization and those who think too little will be gained to justify what they expect will be vast expense and years (or decades) of frustrating research. The recommendation is an intermediate-term compromise: Work toward requiring basinwide, vector-constrained, cost-effectiveness analysis, but subject specific projects that are identified as part of the solution to such a problem to an isolated cost-benefit analysis. This is not too far from what is already common, the difference being the basinwide character of the cost-effectiveness model. An important point to keep in mind, is that when we are looking at large investments, there is an inherent need to initiate the analysis by looking carefully at the alternatives available. These alternatives should be carefully evaluated. Such analysis will also allow the determination of the investment priorities. Once these investments are identified, we can proceed by subjecting projects to isolated economic analysis.

Chapter 4 was devoted to presenting the different valuation techniques, their advantages and disadvantages and the difficulties in applying the methods. The evaluation of policy and investment decisions requires reliable data that allows the analysts to perform cost-benefit analysis. In many cases, particularly in developing countries, secondary sources of information are missing, justifying the use of hypothetical methods. But in the case of water quality improvement investments, it is necessary to capture use and non use values. Since values can only be captured by Contingent Valuation (CV) and Conjoint Analysis (CA). CA is beginning to see more use in the developing countries but none (so far) in the context of project analysis. CV has been widely applied, particularly since the NOAA Blue Ribbon Panel Report in 1993 (NOAA, 1993) recommended the use of the referendum form of CV. Hence, until we see more rigorous applications of CA for project analysis in developing countries, the recommendation is to continue the use of Contingent Valuation Method, in particular the referendum format, for water quality improvement investments. The use of contingent valuation (CV) methods, to estimate benefits has become increasingly common in project analysis.

The use of referendum-type of instrument has a major downside: econometric techniques must be applied to the referendum data in order to infer the mean or media willingness to pay (WTP) of the sample and, thus, of the population of potential beneficiaries. This is not a trivial issue. The results depicted in Chapter 6 show the wide range of central tendency estimates of WTP and the variation effects in the cost-benefit analysis results. Before becoming completely and inextricably caught up in the fine points of econometric estimation of parametric choice models, it is worth pausing to consider the options available and the point of the exercise. If the primary goal is to explain and understand respondent behavior, verify whether CV survey responses are consistent with economic theory, or estimate WTP for a population other than the one sampled, parametric choice models must be estimated. If all one needs is a benefit measure for cost-benefit analysis, on the other hand, nonparametric estimates of mean WTP have an advantage, which is why we recommend them. Practical recommendations:

- Do an open-ended survey at the pretest stage to get an idea of the bid range that should be used in the full-blown referendum survey and produce a tentative benchmark WTP from the open-ended data for comparison.

- Design the referendum survey to cover the bid range so nonparametric means and medians can be computed reliably. Make sure the sample is representative of the population and does not involve oversampling of selected socioeconomic groups or geographical areas. Monitor the survey results, perhaps executing it in phases, so adjustments in the bid range can be made if coverage deficiencies become apparent.

- Run a battery of central tendency measures, definitely including a nonparametric measure and perhaps including the bounded probit median, rather than arbitrarily picking one or two of the more familiar parametric measures.

- Explore the influence of the several WTP measures on the cost-benefit analysis outcome, looking for the existence or absence of an uncertain gray area.

One final recommendation: average (and by implication, total) benefit estimates based on referendum contingent valuation data are fraught with statistical uncertainty. This source of uncertainty can be measured by the standard error of the mean, computed using any particular approach. However, the more important methodological uncertainty about which approach to extracting mean benefits is best has no such easy resolution, and both types of uncertainty about benefits matter. In addition to uncertainty about benefits, environmental investments often are accompanied by uncertainties about execution timing as a result of institutional obstacles, divergent interests of stakeholders, and the behavior of the natural world the project operates on and in, as well as the more familiar uncertainties about costs and economic prices. To reflect all of these uncertainties, the economic cost-benefit analysis demonstrated in Chapter 7 employs Monte Carlo simulation, which permits their effect on the distribution of a project's net present value to be quantified. Monte Carlo risk analysis offers a more comprehensive and informative way to look at project risk ex ante than the traditional (and often arbitrary), one-influence-at-a-time sensitivity analysis approach customarily used. We recommend the use of Quantitative Risk Analysis (QRA) for large, complex, water infrastructure projects. QRA should be rule rather than the exception in Cost-Benefit Analysis.

8.3. Further Research

Based on this study, two areas that would benefit from future research are presented. The first one is on the controversial issue of discount rates in cost-benefit analysis. The second area is the combination of the contingent valuation method (CVM) with participatory techniques widely used in other social sciences.

The controversies surrounding the discount rates are not new to the reader and it is widely accepted the notion that this concept is central to economic analysis. The absurdity of the use by most multilateral development banks, bilateral agencies, and developing countries of a 12 percent discount rate reflecting primarily the opportunity cost of capital, stemming from studies undertaken in the 1970s by development economists should be revisited, particularly in light of the type of investments currently undertaken in the environment field, where projects are required to implement for decades or hundreds of years. Our discounting is affecting the future generations and equity concerns should be internalized in investment decisions. By attaching little weight to future welfare, conventional discounting appears to ignore any notion of intergenerational equity (Groom et al. 2005). Furthermore, in many type of investments, particularly long-term environment projects, the expected net present value is highly sensitive to the selection of the discount rate. Current literature suggests three different approaches to select a social discount rate: a) marginal public investments should have the same return as the private one (public projects can crowd out private investments), b) derive the discount rate from the predicted long-term growth in the economy (social time preference approach), and c) the most recent approach based on the application of variable discount rates over time which involves decreasing (marginal) discount rates (DDRs) (European Commission 2008).

The choice of an appropriate discount rate is one of the most critical problems in all economics and yet it is still un unresolved issue (Weitzman 2001). The array of different approaches (as abovementioned) and the lack of consensus on the topic leave the analyst believing that almost any discount rate can be justified. However, the is wide agreement that discounting at a constant positive rate for environmental problems such as climate change, biodiversity loss and nuclear waste, with water pollution contributing highly to the first two issues, is problematic, irrespective of the rate used (Groom et al. 2005).

Weitzman (2001) conducts a survey of 2,160 economists and derives a probability distribution of the various responses. His main finding is that even if every individual believes in a constant discount rate, the wide spread of opinion on what this rate should be, makes the effective discount rate decline significantly over time. The author concludes by proposing a 'gamma discounting' method under which the discount rate should be declining from a mean of around 4 percent per year for the near future down to around zero for the far-distant future[169]. Gollier (2002) proves that under various conditions on preferences, uncertain growth reduces the efficient discount rate at any horizon and this rate should be smaller for more distant futures. The use of DDRs implies that the policy maker will put relatively more effort to improve social welfare in the far distant future that in the shorter term (Gollier, Koundouri, and Pantelidis 2008). The longer the horizon is, the larger is the uncertainty on future wealth, hence the smaller the rate should be. The author recommends using a risk free rate observable in financial markets for short time horizons; a rate no larger than 5% is recommended for medium term investments (between 50 and 100 years) and a decreasing rate down to around 1.5% for benefits and costs occurring in the very long run (more than 200 years). Newell and Pizer (2003) find that the certainty equivalent rate falls continuously from 4% to 2% after 100 years, 1% after 200 years, and 0.5% after 300 years, suggesting that the distant future should be discounted at significantly lower rates than suggested by the current rates. Even though their findings are for fairly long environmental programs, the authors also argue their validity in long lived infrastructure projects (the case of long-term programs in water quality could be included). The UK also recommends nowadays the use of declining rates when appraising public investments (HM Treasury 2003).

Even though we are seeing more research on this topic, the case for DDRs is still not proven beyond doubt, particularly in light of recent critiques of the fact that these rates introduce time-inconsistency to the decision making process (Rambaud and Torrecillas 2006). Future research is required to strive to achieve consensus on the appropriate discount rate, but most importantly, to begin applying these new approaches in any serious cost-benefit analysis of long-term investments.

169 Weitzman defines the periods in: a) Immediate Future (1 to 5 years hence), the Near Future (6 to 25 years hence), the Medium Future (26 to 75 years hence), the Distant Future (76 to 300 years hence) and the Far-Distant Future (more than 300 years hence).

The second area suggested for future research is the combination of CVM with participatory techniques widely used in other social sciences. One strong critique by non-economists of cost-benefit analysis (CBA) is the fact that community, public interest, and other democratic processes are not inherently captured by the method. Public interest, it is argued, is reduced to the sum of private interests. This is not new. Bryne (1987) stated that:

> *...Cost-benefit rule imputes little value to democratic processes of decision making, preferring calculation to consent as the basis of public choice. It ascribes no special importance to the ideals of democratic freedom and justice, reserving ideal status instead for the purportedly objective and efficient decision. Ultimately it is right reason, not democratic participation or values that is cherished and nourished under cost-benefit government. (p. 82).*

Critics of stated-preference approaches stress that these techniques attempt to value unfamiliar goods, thus basing policy on 'uninformed preferences' (Alvarez-Farizo and Hanley 2006). The typical survey instrument and process provides limited time for conveying information to individuals on complex environmental issues. Critics argue that the standard one-on-one interview is not adequate since it does not provide enough information and time to elicit informed responses. The respondent cannot query for additional information, resulting in an imperfect response and willingness to pay results not reflecting proper values and preferences. Furthermore, individuals may not have pre-existing preferences for all environmental goods; instead they construct their preferences during the course of a contingent valuation survey (Alvarez-Farizo and Hanley 2006). Also, when making purchasing decisions or voting over environmental issues, individuals gather information and consult with other members of society (friends, family, etc) to make informed decisions. Sagoff (1988) argues that society bases decisions on environmental, health, and safety issues on community preferences rather than on the aggregation of individual preferences. Spash (2007) states that selecting people randomly, as done with CV surveys, to obtain their preferences is very different from selecting people to act as representatives of social groups who are empowered to make judgments of what is best for society.

At the same time, the quantification of environmental values in monetary terms is still demanded by policy-makers so researchers have began to incorporate elements of participatory approaches and combine them with contingent valuation exercises (Alvarez-Farizo and Hanley 2006). Two such methods have been recently incorporated to the environmental valuation literature: citizens' juries and market stall[170].

170 These two approaches are also known in the literature as Deliberative Monetary Valuation (DMV).

In the citizens' juries (CJ) approach, small groups of citizens (around 12 individuals) are drawn from the relevant population to discuss a particular issue over two or three days (Coote and Lenaghan 1997). These jury members hear witnesses present evidence on the issue; they question the witnesses and decide on an agreed, preferred course of action (Alvarez-Farizo and Hanley 2006). No monetary values are customary in these exercises. However, Alvarez-Farizo and Hanley (2006) combine this method with choice modeling (similar approach as CVM) by conducting what the authors labeled a 'valuation workshop', to analyze the local consequences of implementing the European Union's Water Framework Directive. The authors' findings were that preferences change significantly when people were provided with additional information and time to think and discuss, compared to individuals participating in conventional survey exercises. Moving from individual to collective views produced changes in values and preferences. The authors conclude that when "[P]lacing respondents in a valuation workshop context is perhaps more appropriate for assigning values to complex environmental goods such as is implied by integrated catchment management, relative to the way in which data is normally gathered, while the search for collective, agreed values amongst stakeholders is more in line with the ethos of the water framework directive." (p. 476).

The market stall (MS) approach evolves from the citizens' juries' method and is beginning to be applied in environmental decision-making. The MS method attempts to combine the features of group techniques with the particular requirements of economic valuation and cost-benefit analysis (Macmillan et al. 2002). The MS approach differs from the CJ method in that its primary objective is the production of WTP estimates. Between 5 and 10 participants attend two group meetings spaced approximately one week apart. In the first meeting, participants are presented with the relevant information of the project/policy in question and with a detailed explanation of the contingent market and payment vehicle (Macmillan et al. 2002). Participants have the opportunity, in this initial meeting, to discuss any aspects of the project. At the conclusion of the group meeting, the WTP question is presented and each participant responds confidentially and in writing. During the week-long interval, participants keep a daily diary in which they record any questions and comments that they may have related to the project/policy. In the second meeting, participants are provided with another opportunity to raise questions and issues and the WTP question is re-administered.

The first application of combined MS and CVM for an environmental program can be found in Macmillan et al. (2002). The authors combine these two methods to establish whether government compensation in Scotland being made to farmers, represent 'value for money' by estimating the value placed on goose conservation by the general public. They conclude that the MS estimates were consistently lower (3.5 times lower) than equivalent WTP measures for the interviewed sample but the drivers for this discrepancy could not be clearly identified. Philip and Macmillan (2005), apply the combined MS-CVM approach in a project to investigate public perceptions of, and attitudes towards, the control of wild animal species in Scotland. In this application, most participants took the opportunity to revise their WTP suggesting that the additional information and time was valuable. Similar conclusion was reached in a recent study by Lienhoop and Macmillan (2007) to estimate the environmental costs and benefits of hydro-scheme developments in an Icelandic wilderness area. In this particular case, over 40% of participants changed their value during the week-long interval (Lienhoop and Macmillan 2007).

The limited application of CVM combined with CJ or MS is providing incipient but interesting conclusions. First, the combined approach may assist policy makers by providing a more detailed comprehension of public preferences, including a thorough understanding of the pros and cons of different actions, and helps to understand the decision making process associated with the recording of WTP (Philip and Macmillan 2005). Second, there are possibilities for making qualified decisions within a group setting while producing aggregated social values (Spash 2007). Third, the additional time and information seems to have an effect on willingness to pay (WTP) values. Some disadvantages have also been identified in these studies: (i) sample sizes are typically small which may impact its usefulness in CBA where population means are necessary, (ii) less well educated or very busy individuals may be difficult to recruit, and (iii) the main factors for the differences in WTP are difficult to identify.

The use of these approaches should be seriously taken into consideration. Philp and Macmillan (2005) state that "[T]he CV Market Stall approach throws up new and interesting possibilities for research into monetary valuation of environmental management projects generally, including, for example, wildlife and habitat management, landscape preservation, pollution control mechanisms, and water quality." (p 272). For future research it would be interesting to compare group and individual approaches, by providing individuals the same amount of time and information as the groups. The ballot effect also seems to be relevant; in CVM individuals elicit WTP values by responding to the interviewer but in MS, the WTP response is done secretly. Also, the provision of additional information and time seems to motivate individuals to offer more enthusiasm and effort when responding. The potential benefits of these approaches, particularly as tools to address some of the weaknesses of traditional methods, should be further explored.