Improving Cost Benefit Analysis Guidance

A Report to the Natural Capital Committee

Summary

David Maddison (University of Birmingham)

Brett Day (University of East Anglia)

February 2015

Summary

The Green Book

The Green Book is a document published by the Treasury that provides guidance for public sector bodies on how to appraise policy, programme or project proposals. The Green Book is supported by a series of supplementary publications that focus on particular issues of project appraisal. The core methodology underpinning the guidance provided in the Green Book is that of cost benefit analysis, though other appraisal methods are occasionally referenced in the text.

As part of the ongoing refresh of the Green Book, this document, commissioned by the Natural Capital Committee, summarises a set of suggestions for improving guidance insofar as it concerns the cost benefit analysis of projects that have impacts on the natural environment. We describe such projects as environmental projects and include within that description projects whose environmental impacts are incidental to the main purpose of the project. Material relevant to this task is encountered throughout the Green Book but more specific advice is contained mainly in Annex 2 of core guidance and in supplementary guidance.

The ongoing refresh of the Green Book provides an opportunity to coordinate better the contents of core and supplementary guidance. It also provides a chance to consider what constitutes an appropriate division of material between core and supplementary guidance, and what material should be included in guidance proper rather than in the references.

Ecosystem services

One of the most important changes to occur in recent years is the widespread uptake of the *ecosystem services* paradigm and the closely related concept of *natural capital*. In essence, the paradigm seeks to characterise nature as a production system in which natural processes (ecological production functions) draw on stocks of natural capital to deliver flows of ecosystem services that in turn affect people's utility or affect production decisions.

An important insight of the paradigm is that an ecosystem service may act as an input to numerous subsequent processes. Some of those processes may be human consumptive or productive activities, in which case they constitute *final ecosystem services*. Alternatively, they may be other natural processes, in which case they are *intermediate ecosystems services*. For the purposes of project appraisal, the economic value of changes in the provision of final ecosystem services can be estimated directly using techniques of non-market valuation. In contrast, the value of changes in the provision of intermediate ecosystem services is only possible when evidence from the natural sciences can establish the resultant impact on flows of final ecosystem services.

We believe that it would be helpful for Guidance to adopt the ecosystem services framework since that framework demands a clear identification of the multiple channels by which the environmental impacts of a project affect human welfare. Likewise it provides clarity as to the division of responsibility between natural science and economics in establishing the value of those environmental impacts.

While the ecosystem services paradigm may provide a useful organising framework for the appraisal of environmental projects, we argue that some of its terminology (mostly developed outside

economics) can be confusing or overly narrow in scope. In particular, the concept of an 'ecosystem service' puts undue emphasis on services flowing from biotic systems. Indeed, the original terminology from the economics literature of *environmental goods and services* is broader insomuch as it acknowledges that natural processes may provide both services and more tangible outputs, and because it encompasses outputs from both biotic and abiotic natural systems. For similar reasons we prefer the term 'environmental production function' to the narrower 'ecological production function'. We recommend that this more inclusive (and original) terminology be adopted throughout guidance.

Many outputs from human economic activity are unwanted and unpriced and variously described as pollutants or residuals. In acknowledging the ecosystem services paradigm it is important that these environmental 'bads', which were for a long time the sole focus of environmental policy, are not now forgotten.[1]

Finally, supplementary guidance promotes the provisioning-regulating-cultural-supporting classification of ecosystem services first developed by the Millennium Assessment. There are numerous problems with that classification. One major issue is that it fails to distinguish between *final* environmental goods and services and *intermediate* environmental goods and services and hence is a potential source of confusion for cost benefit analysts. We suggest therefore that it is retired from guidance.

Natural capital

The conceptual framework described above views the stock of natural capital as an input in the production of flows of environmental goods and services. Although economists have (often implicitly) been valuing changes in natural capital current guidance does not mention natural capital at all. Taken at face value it provides no assistance in the cost benefit analysis of projects involving changes in its stock of which there must be many. This is a significant shortcoming of current guidance. Ensuring that the Green Book includes natural capital must be considered a priority.

Guidance should provide a definition so that stocks of natural capital can be recognised as such. But just as for ecosystem services it appears there is no single definition of natural capital in the wider literature. Guidance must therefore define carefully all those terms that may be understood differently by those in different disciplines or where the actual meaning is somewhat different from what a layman understanding of the issues might suggest.

We define natural capital as a stock capable of being measured at the beginning and the end of the accounting period and which serves as an input to some production function or household utility function and which would exist even in the absence of humankind. It should be noted however that stocks of residuals arising out of economic activity would be excluded from this definition of natural capital. Despite this changes in the stocks of residuals do have welfare implications and probably ought to be included in assessments of the stock of natural capital.

[1] A semantic issue arises as to whether one describes these flows of residuals as outputs of human activity that constitute an environmental bad (e.g. generating pollution) or whether one thinks about that human activity as using as an input quantities of an environmental good (e.g. using up clean air). Both descriptions are equally valid.

Knowing the value of goods and services produced using natural capital is necessary but not sufficient to value changes in the stock. This knowledge must be supplemented by scientific information regarding the role natural capital plays in the production of goods and services and how the stock changes as a result of dynamic processes both in natural and human systems which, to make things that bit more difficult, may exhibit nonlinearities and discontinuities. Accordingly, valuing changes in natural capital stocks may often be complicated and is likely to be an interdisciplinary undertaking.

Under certain circumstances, the value of marginal changes in the stock of natural capital can be calculated with relative ease. Indeed, those marginal values fall out naturally from the set of models developed by natural resource economists to examine economic systems that depend on natural capital. Applications include the study of fish stocks, timber stocks, deposits of mineral and energy resources and stocks of pollutants in water and air. The simplifying assumption underpinning these models is that human behaviour can be approximated by a dynamic optimisation model often seeking to maximise social value from the use of a natural capital stock, an assumption that will often be indefensible. Encouragingly recent contributions to the economics literature have highlighted methods for estimating the value of marginal changes in natural capital stocks that do not rely on assumptions of optimising behaviour.

We recommend that new supplementary guidance be developed to support practitioners in appraising impacts on natural capital. That guidance could contain a list of some of the most important stocks of natural capital and the environmental goods and services they support as well as the roles that they play in the economy. It should outline the principles for valuing changes in natural capital stocks, describe the various methods available for obtaining those values and make recommendations about the accuracy of approximations that might be made if an exercise in exact valuation is not possible.

Sustainability

A project's impact on natural capital stocks is also a key consideration in assessing issues of sustainability. It would be useful if new supplementary guidance on natural capital directed practitioners in providing a sustainability analysis of their projects. That analysis would entail documenting and attempting to value all impacts on natural capital. It should also identify how those impacts are distributed over different forms of stock and over different periods of time. As with standard distributional analysis in cost benefit analysis, such information will allow decision makers to better understand the sustainability implications of a project and consider the case for implementing compensating investments (perhaps in establishing new stocks of natural capital).

A taxonomy of values

Apart from proposing a classification of environmental goods and services supplementary guidance also spends time describing the concept of total economic value. Total economic value represents all the different sorts of value that households can derive from the environment. The major division of total economic value is traditionally into use and non-use values with further subdivisions identifying additional sorts of values. Historically this has been used to illustrate the diverse ways in which households benefit from the environment. But despite its enduring popularity this classification has several well-known shortcomings.

In particular it seems doubtful that option value constitutes a separate sort of value. And it is similarly unclear in precisely which out of several competing senses indirect values for environmental goods and services should be considered indirect. Furthermore the different sorts of values normally said to comprise non-use values cannot be separately estimated. Most importantly, the problem with the total economic value classification is that it examines value from the point of view of household and not the cost benefit analyst. That perspective may be useful for conveying the fact that individuals gain value from environmental goods and services in a variety of ways, but it fails to provide the essential information that cost benefit analysts require in making decisions about how to estimate the value of environmental goods and services. Because of these and other problems the Green Book might wish to consider retiring the concept of total economic value.

We suggest an alternative framework that is based on establishing the fundamental economic characteristics of the environmental good or service and then defining precisely how that good or service enters the household's choice problem. The express purpose of this framework is to guide analysts to appropriate methods of environmental valuation. For example, we maintain that the division of values into use and non-use continues to be critically important since it determines which nonmarket valuation technique is appropriate.

Apart from dividing values for environmental goods and services into use and non-use values we also suggest classifying environmental goods and services according to whether they enter household utility functions or production functions. This distinction is important because households do not possess values for intermediate goods and services i.e. those which do not enter household utility functions. Guidance should note that there is no purpose in asking households about their willingness to pay for intermediate goods and services. Environmental goods and services that enter production functions possess value only insofar as they affect the production of final goods and services.

These classifications are fundamental to cost benefit analysis of environmental projects they help to ensure that there are no overlooked ways in which environmental change might impact welfare. This classification also makes it clear when particular nonmarket valuation techniques are required.

Techniques of nonmarket valuation

One very surprising omission from the Green Book is a clear statement of the normative basis of cost benefit analysis. This weakness is most keenly felt in the sections dealing with non-market valuation where the theoretical case for deriving measures of willingness to pay (WTP) and willingness to accept (WTA) is not made. Without a clear explanation of the justification for using those measures in project appraisal it is difficult for analysts to understand why methods that derive other measures of value are not compatible with cost benefit analysis. We strongly recommend that guidance be updated to provide an account of the normative foundations of cost benefit analysis.

Both core and supplementary guidance describe a variety of nonmarket valuation techniques. In core guidance the various techniques are illustrated by means of examples. It is not clear whether these examples have any special status but the refresh provides an opportunity to consider whether these need to be updated or perhaps even replaced with descriptions of the sorts of situations in which particular nonmarket valuation techniques might prove useful.

The refresh also needs to consider the adequacy of the explanations that accompany the different techniques and whether it would be helpful to identify instances when particular techniques are actually variants of some more general technique.

It is our opinion that there would be considerable advantage in expanding the supplementary guidance to provide a comprehensive overview of the range of techniques for environmental valuation with as much emphasis given to the production side of the economy as is currently afforded the consumption side. Moreover, we believe that the guidance should provide much more practical advice regarding the circumstances in which the different methods might usefully be employed, their data requirements and their key advantages and limitations.

The treatment of risk

In addition to the issues identified above which are largely specific to the cost benefit analysis of environmental projects we now go on to consider a range of other matters. Some of these are relevant to the appraisal of environmental projects (where appraisal refers to a body of techniques of which cost benefit analysis is simply one approach). Other issues of particular relevance to environmental projects such as uncertainty and irreversibility have a bearing even on the cost benefit analysis of non-environmental projects and are therefore arguably matters for core rather than supplementary guidance.

Projects whose main objective is to reduce risk should employ as a measure of benefits option values rather than expected damage if these risks are both large and uninsurable. Option values are defined as the maximum payment that the household would make across all possible states of the world rather than face the certain prospect of damage. Guidance might also wish to include a definition of option values as well as option price and outline a methodology for calculating these values. It would be desirable for guidance to include a description of the circumstances under which risks are uninsurable.

The cost benefit analysis of irreversible projects needs to be approached carefully when there is uncertainty which is likely to be resolved at some point in the future. In such circumstances the consequence is a reduction in the value of any irreversible decision for example to develop (destroy) a natural area. Project appraisal involving irreversible decisions is often best approached by constructing a decision tree with decision nodes and probabilistic outcomes. Guidance should continue to encourage a mode of thought that sees the value in postponing decisions and in building flexibility into environmental projects.

Closely related to the problem of uncertainty is the concept of the (quasi-option) value of information. Uncertainty serves like a constraint essentially forcing policymakers to adopt the same policy across all possible states of the world. The effect of information regarding the true state of the world is effectively to remove this constraint and the value of information represents the cost of this constraint.

Implementing the value of information concept might save money by preventing the commissioning of research which would have no possible impact on the optimal decision (and which is therefore worthless) or by supporting the case for commissioning research which increases the expected net benefits of a project by an amount greater than the cost of the research. Whilst supplementary

guidance contains statements about the need to ensure that information gathering exercises are proportionate this message could be much strengthened by explicitly appealing to the value of information concept.

The distribution of environmental outcomes

Another issue of growing importance is the distribution of the costs and benefits of environmental outcomes. Guidance describes analysing the distributional outcome of projects having an impact on household income as an important adjunct to cost benefit analysis. Given that DEFRA has commissioned several pieces of work on distributional issues it seems appropriate that guidance should now refer to the distributional impact of environmental projects on the environmental outcomes experienced by households. This should be distinguished from the wider task of determining the distributional outcomes of environmental projects per se which would include consideration of both the distribution of the costs and the benefits rather than one particular outcome.

Existing techniques of analysing distributional outcomes are readily extended to environmental outcomes. These include techniques for merely describing changes in the distribution of environmental outcomes as well as for describing changes in the equality of environmental outcomes. Techniques also exist for exploring changes in the environmental outcomes across groups of interest e.g. different income categories. Guidance might refer to some of the studies that DEFRA has commissioned. At the same time it should be acknowledged that not every environmental project will have distributional consequences worth bothering about and even for those that do it might be impossible to model them.

Modelling approaches

Particularly for those environmental projects implemented specifically to address distributional concerns it is important to be aware that the outcome will ultimately depend on behavioural response. For example, the implementation of a project to improve environmental quality in an area may alter rents and wage rates and therefore the demographic composition of the area. Sophisticated equilibrium sorting models are required in order to anticipate these responses.

Guidance might care to acknowledge the fact that unless behavioural responses are accounted for environmental projects intending to address distributional concerns might be frustrated. Guidance should identify the circumstances under which the significant additional effort involved in properly addressing these issues is likely to be justified e.g. when addressing distributional concerns is an environmental project's sole purpose.

In equilibrium sorting models the focus is on simultaneous equilibrium across different locations and different markets. In general equilibrium models by contrast the focus is on simultaneous equilibrium only across different markets. The strength of general equilibrium models is that they are a numerical implementation of a theoretical model whose properties are well understood. Such models however focus on longer run outcomes and not the transition between equilibria. Despite this they have nevertheless found widespread application in the evaluation of policies to investigate the costs of restricting GHGs and in many other areas unrelated to environmental economics.

Although current guidance is quite rightly focussed on a partial rather than a general equilibrium approach general equilibrium models may occasionally be required particularly when an environmental project significantly changes the current distribution of income or alters the market prices upon which the partial equilibrium approach to cost benefit analysis is based.

Whilst the appraisal of environmental projects is often an interdisciplinary endeavour many appraisals adopt a single-disciplinary perspective. What this means is that although several disciplines are involved information might be shared between them in a way that does not always guarantee consistency. In integrated assessment modelling by contrast information from different disciplines is combined in a coherent manner thereby producing insights not separately available from each discipline on its own.

Integrated assessment models have an important role to play in the appraisal of environmental projects. Their most obvious but not only role is in capturing important feedback effects thereby yielding more accurate appraisals.

An important distinction exists between integrated assessment models in which interventions are user-specified and those that may be termed policy optimisation models. In policy optimisation models policy variables are chosen in order to maximise the objective function subject to constraints. When the objective function is specified in terms of economic benefits variables associated with the optimal solution often possess interesting economic interpretations. As explained integrated assessment modelling – or as it is more often referred to in that context bio-economic modelling – may have an important role to play in the valuation of natural capital.

Guidance recommends being alert to the possibility of altering the specification of the project e.g. its scale or timing in order to increase further its net benefits. Normal practice here is to evaluate a small number of alternatives for the project and to select the best. It is nevertheless hard to be certain that such a process actually results in a project specification which is really the best out of all those that could be implemented. Although seldom attempted approaching the problem with a model capable of policy optimisation would make it much easier to find the unique best project specification.

Temporal issues

It is common to encounter projects whose environmental impacts are spread over future time periods. The costs and benefits of such impacts are customarily converted into their present value counterparts. This however assumes that the future value of these impacts is known. An alternative procedure is to discount the impacts themselves using a special ecological discount rate in order to convert future impacts into present impacts which may then be valued. This assumes that the ecological discount rate is known. The informational requirements in order to implement either approach are identical but typically exceed what is available.

Whilst there is currently no satisfactory solution to the problem of discounting future environmental impacts guidance should point out the wholly unsatisfactory nature of any approach which relies upon the values of environmental goods and services remaining constant especially in a situation where consumption is increasing and the quantity of environmental goods and services decreasing.

Spatial issues

The location of an environmental project will often have significant implications for its costs and benefits. Different locations may be endowed with different quantities of environmental goods and services. Furthermore environmental goods and services cannot often be transported from one site to another. The question of space and location is touched on several times in core guidance but not mentioned at all in supplementary guidance.

The importance of geographical location is most obviously apparent in the appraisal of projects that require an environmental good or service as an essential input. Likewise the value of environmental goods and services often depends on their proximity to centres of population. Spatial heterogeneity also ensures that the distribution of substitutes and complements varies across space. Finally the spatial interconnectedness of environmental systems means that a project could change the flow of environmental goods and services in other locations.

Over recent years it has been increasingly common for researchers to use Geographical Information Systems to aid decisions regarding the location of environmental projects. The most sophisticated analyses involve value surfaces seeking to identify the location where a project would provide the best benefit cost ratio.