OECD Environment Working Papers No. 97

Cost-Benefit Analysis and the Environment

Giles Atkinson,

Susana Mourato

https://dx.doi.org/10.1787/5jrp6w76tstg-en

OECD

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **24-Nov-2015**

English - Or. English

ENVIRONMENT DIRECTORATE

ENV/WKP(2015)18
Unclassified

COST-BENEFIT ANALYSIS AND THE ENVIRONMENT - ENVIRONMENT WORKING PAPER No. 97

by Giles Atkinson (1) and Susana Mourato (1)

(1) London School of Economics and Political Science

Authorised for publication by Simon Upton, Director, Environment Directorate.

JEL Classification: Q51, Q53, Q54, Q58, H43

Keywords: Cost-benefit analysis, policy appraisal, environmental policy

OECD Environment Working Papers are available at www.oecd.org/environment/workingpapers.htm

JT03386807

English - Or. English

OECD ENVIRONMENT WORKING PAPERS

OECD Working Papers should not be reported as representing the official views of the OECD or of its member countries. The opinions expressed and arguments employed are those of the author(s).

OECD Working Papers describe preliminary results or research in progress by the author(s) and are published to stimulate discussion on a broad range of issues on which the OECD works.

This series is designed to make available to a wider readership selected studies on environmental issues prepared for use within the OECD. Authorship is usually collective, but principal author(s) are named. The papers are generally available only in their original language -English or French- with a summary in the other language.

Comments on Working Papers are welcomed, and may be sent to:

OECD Environment Directorate
2 rue André-Pascal, 75775 Paris Cedex 16, France
or by e-mail: env.contact@oecd.org

OECD Environment Working Papers are published on
www.oecd.org/environment/workingpapers.htm

FOREWORD

Much new work has been carried out on relevant issues since OECD published *Cost-Benefit Analyses and the Environment: Recent Developments* in 2006. OECD has therefore started work on updating the book.

This paper, written by Giles Atkinson and Susana Mourato, who both were co-authors of the 2006 book,[1] presents a general review of developments in cost-benefit analysis and the environment. Together with other relevant material, this paper will be used as an input to the upcoming publication.

1 . The authors are respectively Professor of Environmental Policy and Professor of Environmental Economics at the London School of Economics and Political Science. They thank Davide Contu and Joel Atherton for valuable research assistance. Unfortunately, the lead author of the 2006 book, David Pearce, passed away before that book was published.

ABSTRACT

While the basic principles of cost-benefit analysis (CBA) are long-standing, the challenges entailed in applying these principles are constantly evolving. This paper reviews recent developments in environmental CBA since the publication of an OECD volume on this topic by Pearce et al. (2006). The character and direction of these developments also evolves over time and the current review reflects this process.

The discussion begins by considering progress in environmental valuation. A common theme here is that this sub-field shows welcome maturity through now routine use and extension to a variety of policy areas. One consequence of this maturity is arguably fewer contributions which break genuinely new ground. Of course, this situation is fluid and important areas of research remain; particularly in valuing non-use and cultural services from the environment and ecosystems. Moreover, important developments have occurred in the past decade. The use of web-based surveys has been a breakthrough, making stated preference methods more practical. This has made it possible to test a number of important innovations in discrete choice experiments, for example, far more rapidly. Valuation using subjective wellbeing approaches has also been established as a further sub-field, although it is in relatively early stages and interesting questions remain about its role in CBA.

Not all of these developments are restricted to the environmental valuation context. The continuing debate about the discount rate to apply to long-term impacts has evolved a core theme (usually entailing a declining discount rate) but embodies a number of further innovations (on the role of genuine uncertainty and so on). The paper also reviews some further topics which while not subject to the same degree of development remain important practical challenges. This includes distributional CBA, the treatment of risk and uncertainty and most importantly the way in which CBA relates to the sustainability of (social and economic) development paths and natural capital.

One question that might be asked of all this innovation is: what is it for? Of course, there is at least one easy answer to this question. It is so that actual CBA for policy decisions is carried out as well as possible. It is therefore important to assess what is known about the way in which actual appraisal is used. This is not simply a matter of documenting and reflecting on how the policy process has been a receptor of developments in CBA formulated elsewhere. Significant institutional innovations have occurred which have the potential for CBA to be used more often and more effectively too. Those institutional changes have also made clear particular analytical and information needs that may or may not be fulfilled by CBA developments to date. As such, the paper therefore seeks to take stock of all these developments in the round. What this suggests is that while it is important to update the policy community on recent advances in environmental CBA, it is also crucial to consider how these advances, as well as more routine appraisal, have been implemented in practice and what still needs to be done.

JEL Codes: Q51, Q53, Q54, Q58, H43

Keywords: Cost-benefit analysis, policy appraisal, environmental policy

RÉSUMÉ

Si les principes fondamentaux de l'analyse coûts-bénéfices (ACB) sont établis depuis longtemps, les problèmes liés à l'application de ces principes, en revanche, évoluent constamment. Ce document examine les récents développements en matière d'ACB environnementale intervenus depuis la publication par l'OCDE d'un ouvrage de Pearce *et al.* (2006) sur ce sujet. La nature et le sens de ces développements évoluent aussi dans le temps, et la présente étude prend en compte ce processus.

L'étude commence par un examen des progrès réalisés en matière d'évaluation environnementale. Une idée généralement exprimée est que ce sous-domaine présente une maturité dont il convient de se féliciter, qu'il fait maintenant l'objet d'une utilisation courante et qu'il s'est étendu à une variété de domaines d'action. Une des conséquences de cette maturité est que les contributions véritablement novatrices se font sans doute plus rares. Naturellement, cette situation est fluide et d'importants domaines de recherche restent à explorer, notamment en ce qui concerne l'évaluation du non-usage et des services culturels fournis par l'environnement et les écosystèmes. Par ailleurs, d'importantes évolutions sont intervenues au cours de la décennie écoulée. Le recours à des enquêtes en ligne a été une percée décisive, qui a rendu plus pratique la méthode des préférences déclarées. Il est ainsi devenu possible de tester bien plus rapidement un certain nombre d'innovations importantes en procédant à des expérimentations de choix discrets, par exemple. L'évaluation par les méthodes du bien-être subjectif est aussi devenue un autre sous-domaine, bien qu'elle en soit encore à un stade relativement peu avancé, et des questions intéressantes demeurent concernant son rôle dans l'ACB.

Toutes ces évolutions ne se limitent pas au contexte de l'évaluation environnementale. Le débat constant sur le taux d'actualisation à appliquer aux impacts à long terme est désormais un thème central (on retient généralement un taux d'actualisation décroissant) mais il englobe un certain nombre d'autres innovations (concernant le rôle de l'incertitude réelle, etc.). Ce document aborde également d'autres sujets qui, sans faire l'objet du même degré de développement, restent des questions pratiques importantes. Il s'agit de l'ACB tenant compte des problèmes de répartition, ou ACB distributionnelle, du traitement du risque et de l'incertitude et, surtout, de la relation entre l'ACB et la durabilité des trajectoires de développement (social et économique) et du capital naturel.

On pourrait se demander à quoi servent toutes ces innovations. Il existe bien entendu au moins une réponse facile à cette question. Elles servent à ce que les ACB sur lesquelles s'appuient les décideurs soient réalisées le mieux possible. Il importe donc de faire le point sur ce que l'on sait de l'utilisation qui est faite des évaluations effectuées. Il ne s'agit pas simplement d'entreprendre un état des lieux et une réflexion sur la manière dont le processus de l'action publique s'est approprié les développements de l'ACB formulés ailleurs. Des innovations institutionnelles significatives sont apparues, qui peuvent permettre d'utiliser l'ACB plus souvent et de façon plus efficace. Ces changements institutionnels ont aussi mis en évidence des besoins particuliers en analyse et en informations que les développements de l'ACB à ce jour peuvent éventuellement permettre de satisfaire. Ce document vise donc à faire le point de toutes ces évolutions. Il en ressort que s'il est important d'informer les responsables des politiques publiques des récentes avancées dans le domaine de l'ACB environnementale, il est également essentiel d'étudier la façon dont ces avancées, ainsi que les méthodes d'évaluation plus couramment utilisées, ont été mises en œuvre dans la pratique et ce qui reste à accomplir.

Codes JEL : Q51, Q53, Q54, Q58, H43

Mots clés : analyse coûts-avantages, évaluation des politiques, politiques environnementales.

TABLE OF CONTENTS

COST-BENEFIT ANALYSIS AND THE ENVIRONMENT

1. Introduction

Pursuing the intuition – that policy makers should go ahead with actions *only if* the benefits outweigh the costs – more rigorously in public policy formulation is the domain of cost-benefit analysis (CBA) or variants which draw on the same conceptual framework. In this review paper, the focus is on environmental CBA. That is, cost-benefit appraisals of policies and projects which have the deliberate aim of improving the provision of environmental benefits or propose actions that affect (sometimes adversely) the environment as an ancillary consequence.

In particular, the focus is on developments in environmental CBA since the publication (or completion) of the OECD book Cost-benefit Analysis and the Environment: Recent Developments (Pearce et al., 2006) in 2006. For most part, the discussion in what follows has been restricted to the past decade as much as possible. Inevitably, in a number of cases, the genesis of an important recent development may have occurred before then and so it has also been included here. The developments in environmental CBA that are documented reflect, in turn, an array of conceptual and empirical developments primarily in environmental economics; but also in other fields of economic inquiry, such as health economics.

A number of characteristics make CBA distinctive as an assessment tool. Notably it is an attempt to quantify the costs and benefits in monetary terms. That is, it is an assessment of how people whose wellbeing is affected by policy actions – either positively or negatively – value those losses and gains. Pearce et al. (2006) spent a large portion of its discussion detailing and reviewing progress in environmental valuation. This paper also reflects that emphasis, although the character of the discussion is somewhat changed. Time has moved on and with it environmental valuation has moved out of relative infancy into adulthood as a field of enquiry. Nevertheless, new developments are all the time occurring, as evidenced most prominently perhaps by valuation using subjective wellbeing approaches, as well as viewing apparent valuation anomalies through the lens of behavioural economics. The increasing use of web surveys has also brought stated preference surveys within the grasp of more routine and timely implementation.

The treatment of when costs and benefits occur in time is another distinguishing feature of CBA. The past decade has witnessed a big push in proposals about how long-term impacts of proposals should be discounted, thereby continuing earlier progress on this front which was summarised in Pearce et al. (2006). The paper also discusses separately ongoing efforts to understand how concerns about the sustainability of development and natural capital use might be incorporated in CBA. If not exactly new, the need to confront this policy agenda arguably has never been so important. Similar stories apply (but perhaps to a lesser extent) on distributional CBA and the treatment of risk and uncertainty.

The discussion also reviews evidence regarding whether CBA is *used* in actual policy formulation and whether it is *influential* in this process. Published evidence is somewhat sparse; especially in the latter dimension. By necessity this limits the discussion in what follows. However, what seems clear – at least as an interim (and so incomplete) assessment – is that policy makers cannot simply be assumed to always be choosing actions so as to achieve societal improvements as CBA practitioners might typically assume. Understanding what these decision-makers actually do (and why) is critical too from the perspective of making sense both of how the policy process actually works and how developments on the frontiers of CBA, which might enhance this process, can be more influential in future. Indeed, there are genuine signs

that this process is changing rapidly as evidenced, for example, by growing institutional infrastructure in a number of countries that not only facilitates a more prominent role for CBA in policy but also adds a further tier of scrutiny of any practical appraisals that emerge. It is important to consider, therefore, how advances in environmental CBA can enhance this process as well as reflect on what practical informational needs (perhaps arising from developments at the CBA frontier in the past) remain unmet and how these gaps can be addressed.

The rest of this paper is organised as follows. Section 2 takes stock of what has happened in the field of environmental valuation. Section 3 discusses developments in the discounting debate. Sections 4, 5 and 6 respectively cover: distributional CBA; risk & uncertainty; and, sustainability & natural capital. Some of the evidence collated about how (environmental) CBA is actually used in practice is evaluated in Section 7 and implications for recent developments drawn. Finally, Section 8 summarises the discussion and includes a final comment about the emphasis of a fuller volume on recent developments in environmental CBA.

2. Environmental valuation

For more than two decades there have been huge advances in the various methods which seek to value environmental impacts. The focus in what follows is primarily (although not exclusively) on recent advances in stated preference methods. However, it should be noted that revealed preference methods continue to be used in a number of applications and notably recently in valuing ecosystems (see, for example, NEA, 2011). In addition, there is growing recognition of the significance of approaches based on production functions, at least for particular types of environmental policy question. The emphasis reflects an objective to evaluate recent progress for a set of methods that were previously relatively experimental (in terms of use in policy) subject to debate and which were apparently general in terms of what could be valued.

Stated preference techniques are survey-based methods that seek to elicit the monetary value of non-market goods and services by directly asking people what economic value they attach to specified changes in those goods and services (Bateman et al., 2002). They offer the only way to measure non-use values for non-market changes when there are no observable markets through which preferences can be revealed. There are two main types of stated preference methods: the contingent valuation method and choice modelling techniques, such as choice experiments. The following sections review some of the latest developments in these techniques. They also report on a further development that has pushed at the frontier. This has involved valuation using subjective wellbeing approaches as well as considering the importance of behavioural insights.

2.1 Developments in contingent valuation

Contingent valuation involves asking respondents directly to value a specified policy change (Mitchell and Carson, 1989; Bateman et al., 2002). By means of an appropriately designed questionnaire, a hypothetical market is described where the outcome in question can be traded (Mitchell and Carson, 1989). This contingent market defines the policy change, the institutional context in which it would be provided, and the way it would be financed. A random sample of people is then directly asked to express their maximum willingness to pay (WTP) or minimum willingness to accept (WTA) for the hypothetical policy change. Theoretically, contingent valuation (CV) is rooted in a theory of economic behaviour of individuals or households that assume stated valuations are related, in a consistent way, to respondents' underlying preferences and correspond to monetary measures of people's welfare.[2]

2. Specifically this refers to correspondence to (Hicksian) compensating and equivalent welfare change measures discussed above (Mitchell and Carson, 1989; Freeman et al., 2014). This, in turn, is embedded in modern welfare economics, namely on the neo-classical concept of economic value, based on individual utility maximisation.

A critical assumption with the CV methodology is that respondent behaviour in a hypothetical situation will be similar to that in an equivalent real-life situation. This assumption is supported by attitude-behavioural models developed in the psychological literature, such as Fishbein and Ajzen's (1975) theory of reasoned action, which link hypothetical willingness to pay, a behavioural intention, and actual payments. The key element of a CV survey is the contingent valuation scenario. It provides respondents with information regarding the proposed policy change to be valued (including the means of provision, method of payment, timescale of payments, and extent of the market) and presents the elicitation question. In all cases, the challenge is to ensure that the scenario is comprehensible, plausible, and meaningful, such that respondents are willing and able to provide valid and reliable estimates of the values attached to the change of interest (Mitchell & Carson, 1989).

The hypothetical nature of the CV method is both an advantage and a disadvantage. On the one hand, it means that the contingent scenario is extremely flexible and need not be constrained to something that currently exists or to goods and services that people currently use. It can usefully be applied to potential future changes of a wide range of goods and services. It can also be used to uncover non-use values (or "passive-use" values) which refer to those benefits which people receive without necessarily directly experiencing the good being valued. Examples include the knowledge that the Amazonian rainforest continues to exist or the desire that biodiversity is conserved for future generations or for its own sake. (This contrasts with those benefits which are purely instrumental to use, such as recreational experiences or the benefit that biodiversity might provide for agricultural productivity.) On the other hand, the further from reality and the less familiar the scenario is, the harder it will be for respondents to act like they would in a real market situation. This is because the less experience and understanding respondents have of the goods and services they are asked to value, the more errors they are likely to incur when attempting valuation, in a one-off exercise (Bateman et al., 2011). In other words, realistic and plausible policy scenarios make it more likely that respondents either have prior preferences for such goods and services or are able to discover economically consistent preferences throughout the survey process.

Not surprisingly then measuring non-use values with reasonable accuracy, avoiding the many pitfalls associated with valuing sometimes distant, complex and unfamiliar goods and services, remains arguably one of the greatest challenges in contingent valuation. Best practice guidance on CV states that respondents should be reminded to consider substitute goods as well as their budget constraint, and information should be provided on how the policy change of interest relates to other alternative investment opportunities, in order for the contingent market to be realistic (Mitchell and Carson, 1989; Arrow et al., 1993). A key problem with non-use values is defining the relevant set of substitute goods and alternative investment opportunities which, in some cases, could be very large and difficult or impractical – if not impossible – to identify. Given the advances in contingent valuation more generally, it is surprising that so little progress has been made in developing new and robust ways of uncovering non-use values. Accurate estimation of non-use values remains to this day at the frontier of knowledge and as such it is a crucial gap in present knowledge, given the likely policy significance of such values.

On a more practical note, much progress has been made in the implementation of stated preference surveys. With the development of the internet, the growth in broadband penetration and the popularity of on-line forums, there has been a strong move towards designing and implementing surveys on-line (Lindhjem and Navrud, 2010). There are now many excellent (both proprietary and open-source) software products that can be used to produce high quality web surveys (e.g. Qualtrics and Survey Monkey). Typically the implementation is carried out via a market research company that has access to an on-line panel of respondents, covering a wide range of demographics, which is paid to complete the surveys. Alternatively, there are also new crowdsourcing resources, such as Amazon's human intelligence task marketplace, Mechanical Turk. Here researchers (the 'Requesters') are able to post tasks directly (in this case surveys). Prospective respondents (the 'Turkers') then browse the existing tasks and choose to complete them for a monetary incentive set by the researchers.

Online surveys offer many advantages: they are very quick to implement (i.e. it is common to get hundreds of completed surveys back within 24 hours of launching); they are inexpensive (particularly when compared to face-to-face interviews); there is no need to input the data onto a spreadsheet as this is done automatically; the responses are immune to interviewer bias; and respondents are likely to feel more comfortable answering sensitive questions and moving through the survey at their own pace on their own and in familiar surroundings (Bateman et al., 2002; MacKerron et al., 2009). Crucially, these surveys provide a large amount of flexibility in terms of implementation. For example, the questionnaire can be tailored to the respondent, and it is easy to alter the flow of the questions depending on certain responses. Sound and images can be easily presented and it is possible to monitor the time taken on a particular page, or whether extra information was accessed.

Needless to say, there are pitfalls too. Not everyone has access to the internet (although in time this will become less of an issue as broadband reach extends, even to developing countries) and on-line surveys might not be the best option for certain groups such as the very elderly, or illiterate populations (although it is possible to design pictorial surveys to avoid this problem). Moreover, it is not possible to offer clarification if respondents get confused with certain parts of the text or the questions. A sizeable number of studies have investigated the impact of survey mode on stated values (e.g., Dickie et al., 2007; Marta-Pedroso et al., 2007).

Reassuringly, it seems that many reported problems with web-based valuation surveys can potentially be controlled for or avoided altogether. For example, respondents who speed through the survey can easily be detected and, if judged appropriate, discarded from the sample. Questions can be included to check attention and understanding. Learning mechanisms and trial questions can be added if the pilots reveal difficulties, and so on. More positively, some studies suggest that Internet panel surveys have desirable properties along several dimensions of interest (Bell et al., 2011). Importantly, Lindhjem and Navrud (2010) found no significant differences between CV values obtained between Internet and in-person administration. Within this context, these authors envisage a possible mass exodus from in-person interviews, the traditional gold standard in CV survey administration, to the much faster and cost-effective Internet surveys.

2.2 Developments in choice experiments

Choice experiments (CEs) are a multi-attribute stated preference technique initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983) in the context of transport and market research literature. Since then, CEs have become increasingly popular in the context of environmental valuation (Hanley, Mourato and Wright, 2001; Bennett and Blamey, 2001; Louviere, Hensher and Swait, 2000). They are part of the choice modelling (or conjoint analysis) approach, which also includes contingent ranking, contingent rating and paired comparisons. The choice experiment technique is, however, the only choice modelling approach which definitively meets the requirements of welfare theory (see fn. 3; Bateman *et al*., 2002). The method is derived from Lancaster's (1966) characteristics of value theory which states that any good may be described by a bundle of characteristics and the levels that these may take.

The technique is underpinned by the random utility framework and relies on the application of statistical design theory to construct choice cards in which respondents are required to choose their preferred option amongst a series of alternatives (typically two or three) which are differentiated in terms of their attributes and levels. By varying the levels the attributes take across the options and by including a monetary attribute it is possible to estimate the total value of a change in a good or service as well as the value of its component attributes, and to calculate trade-offs between attributes. A baseline or opt-out alternative must be included to make the economic choice more realistic; this avoids the problem of respondents being forced to choose options when they may not prefer this.

As stated preference techniques reach maturity, breakthrough developments become less likely. Choice modelling methods have been no exception. Most of the developments in the last decade have been small improvements in statistical design, econometric analysis and in survey implementation methods, as well as improvements in our understanding of the way individual choices are formulated in sequential choice contexts. This section provides a brief overview of some of developments in understanding respondent behaviour in choice experiment contexts.

It has been widely acknowledged that individuals might present a preference structure which is not as well-behaved as the standard discrete choice models would impose. Specifically, respondents are usually assumed to follow a fully compensatory behaviour where they trade off all the levels between alternatives, choosing the option they prefer overall. However, a number of studies have found evidence of departures from fully compensatory behaviour. This has implications in terms of the econometric models employed at the estimation phase as well as at the experimental design phase.

Respondent efficiency

It is well known that, in a choice experiment setting, respondents might adopt different "processing strategies" or "heuristics" to simplify the choice task (Heiner *et al*., 1983; Payne *et al*., 1993). Such aids to the mental thought involved in making a decision in a choice experiment might be a conscious judgement made by the respondent. For example, individuals might rationally choose to make choices considering only a sub-set of the information provided (De Palma et al., 1994). Alternatively, individuals could resort to heuristics (perhaps sub-consciously) due to limited cognitive capabilities or information overload (Simon, 1955; Miller, 1955; Lowenstein and Lerner, 2003).

In line with this, accumulating evidence has been associating different complexity of choice tasks to variations in error variance (Mazzotta and Opaluch, 1995; Dellaert et al., 1999; Swait and Adamowicz, 2001; DeShazo and Fermo, 2002; Arentze et al., 2003; Cassuade et al., 2005; Islam et al., 2007; Bech et al., 2011; Carlsson et al., 2012; Czajkowski et al., 2014; Mayerhoff et al., 2014), suggesting the importance of simultaneously taking into account statistical and respondent efficiency. In other words, respondents could experience fatigue when the choice experiment is complex and/or not engaging; similarly, the first choice sets might be used by respondents to learn the choice task and employ one, or more, decision rules.

The level of complexity of a choice experiment is defined at the experimental design stage, when the combinations that will be presented to the respondents are determined. On this note, Louviere et al. (2008) provide evidence of a negative relationship between the number of attributes and levels and choice consistency. Concerns regarding respondent efficiency have led to the common practice of dividing the total number of choice sets into smaller blocks so as to reduce the number of choice tasks presented to each respondent (as well as more economical designs to determine the number of these choice sets).[3] This reflects growing attention being given to more flexible and efficient design of these choice experiment (see, for example, Severin, 2001; Sándor and Franses, 2009; Danthurebandara et al., 2011).

3. A full factorial design consists of all the combinations possible given the number of attributes, the attributes' levels and the number of alternatives. So for the case of a choice experiment with two attributes with four levels, two attributes with six levels and two attributes with three levels, option A versus status quo; the size of the full factorial is in this case given by: $(4^2)*(6^2)*(3^2)=5184$ combinations. This typically will not be a practical path for the choice experiment. So a fractional design could be considered which refers to the selection of a subset of combinations (of the full factorial). Presenting the respondents with different blocks of choice tasks is another way of reducing the number of choice tasks each respondent has to take part in. Each block is characterised by peculiar combinations. The blocking procedure can be applied either to a full factorial or to a fractional factorial.

Non-fully compensatory decision rules

The standard interpretation of the way in which respondents choose their preferred option(s) in choice experiments is that they do so by considering (and trading off) all of the attributes comprising that choice. In practice, however, respondents may not make such trade-offs at all (i.e. they make decisions which are non-compensatory in that the value of one attribute of the choice can never compensate for the presence of an attribute that is favoured more). Or perhaps respondents make these trade-offs partially. That is, they make decisions which are semi-compensatory, in that it would take a really large amount of some less preferred attribute to compensate for less of an attribute that respondents favour more. As a result, a wide range of non-compensatory and semi-compensatory decision strategies has been put forward in the literature, particularly when estimating or analysing these choices subsequently. Since the work of Hensher et al. (2005), many studies have been focusing on modelling attribute non-attendance. *Attribute non-attendance* (ANA) refers to a situation where respondents consider only a subset of the attributes presented in each choice task (i.e. they do not fully trade-off between all the attributes present in the task before them). It has been shown that taking ANA into account might lead to significantly different monetary valuations and/or parameters' estimates (Hensher, 2006; Hensher et al., 2007; Hensher and Rose, 2009; Hess and Hensher, 2010; Hole, 2011; Scarpa et al., 2009; Scarpa et al., 2010; Campbell et al., 2010; Puckett and Hensher, 2008; Puckett and Hensher, 2009; Lagarde, 2013).

ANA is usually identified either by directly asking respondents to state whether and which of the attributes they have not considered or, alternatively, inferring this information by means of an appropriate econometric model. *Stated* ANA was firstly introduced by Hensher et al. (2005); however, it has been questioned as the information obtained poses concerns in terms of its reliability (Campbell and Lorimer, 2009; Carlsson et al., 2010; Hess and Hensher, 2010; Hess, 2012; Hess et al., 2013; Kaye-Blake et al., 2009; Kragt, 2013), with some authors putting forward the opposite argument (Hole et al., 2013). As it seems unsatisfactory to simply discriminate between fully attending respondents and not, authors have suggested gathering a more thorough and nuanced information on attribute attendance (Alemu et al., 2013; Colombo et al., 2013; Scarpa et al., 2013). In turn, the inferred ANA literature has proposed that it may be more appropriate to reduce the magnitude of a parameter when there are indications of non-attendance for the corresponding attribute, rather than setting its magnitude equal to zero altogether. (Balcombe et al., 2011; Cameron and DeShazo, 2010; Kehlbecher et al., 2013).

Outside of the debate concerning *stated* ANA versus *inferred* ANA, other streams of research have been exploring other avenues. One example is *stated attribute importance* (SAI), where respondents are asked to rank the choice experiment attributes in order of importance for their choices (see, for example, Balcombe et al., 2014). Some of this research on modelling choice has also considered the way in which behavioural science might inform how respondent choices are understood. For example, the typical assumption is that a respondent processes choice situations according to a "Random Utility Model", where the respondent chooses (or ranks) combinations of attributes within a choice set according to which option provides him or her with highest utility (wellbeing). However, a respondent's choice might plausibly reflect other decision procedures such as a "Random Regret Model", in which a respondent chooses a preferred option in order to minimise his or her chances of experiencing regret about that choice (Boeri et al., 2012; Chorus et al., 2008, 2014).

Further possibilities exist. A respondent may behave according to lexicographic preferences, where his or her choice is made according to a strict order based on perhaps choosing the option which contains the highest value of a favoured attribute while ignoring other dimensions of that option (Sælensminde, 2001; Scott, 2002; Rosenberger et al., 2003; Gelso and Peterson, 2005; Campbell et al., 2006; Lancsar and Louviere, 2006; Hess et al., 2010); while others may use other criteria, such as "Elimination by Aspect" (Cantillo and Ortúzar, 2005; Swait, 2009) or reference points (Hess et al., 2012). Finally, the same

individual may on some occasions behave according to a full compensatory model, and on other occasions adopt a simplifying strategy (Araña et al., 2008; Leong and Hensher, 2012).

Whether respondents adopt a single or a mixture of decision-making rules depends on the specific case study. What is relevant for the practitioner is that, if heterogeneity in the decision rules used by respondents is present, it should be detected and taken into account when analysing choices in a statistical model. Failure to do so may lead to biased coefficient estimates and, crucially from a policy perspective, monetary valuations. Research is needed so as to identify a set of decision rules which are deemed to best represent decision process heterogeneity whilst still allowing for preference heterogeneity (Hess et al. 2012; Araña et al., 2008; Boeri et al. 2012). Finally, future research still needs to investigate how to interpret or estimate monetary valuations from respondents who exhibit this decisional diversity.

2.3 Insights from behavioural economics

The last decade has witnessed a huge increase in popularity of behavioural economics (BE) (see Camerer et al., 2011, for a review) and, in turn, of its influences in environmental economics (e.g. Horowitz et al., 2008; Shogren and Taylor, 2008; Brown and Hagen, 2010). Experimental research in this area has repeatedly identified empirical phenomena that are not adequately explained by traditional neo-classical economic analysis. Rabin (1998) talks about three waves in the development of behavioural economics, from the initial focus on the identification of behavioural anomalies, to formalising alternative theoretical conceptualisations in precise models, to fully integrating these alternatives into economic analysis, thereby improving and reshaping economic principles.

With the growth of behavioural economics, some of the known issues of stated preference methods have started to be recast in the light of these alternative theories of behaviour. In reality, most of the biases had been identified before behavioural economics came into vogue as a way of summarising such findings (Mitchell and Carson, 1989; Kahneman, 1986). For example, what used to be called simply information effects is now often referred to as framing or priming effects as a result of this general behavioural turn in economics.

According to Shogren and Taylor (2004, p.29) "Behavioural economics has probably had the biggest impact on environmental economics through research on the nonmarket valuation for environmental goods". Of note, two special editions of the journal Environmental and Resources Economics (Volume 32(1) in September 2005; Volume 46(2) in June 2010) were dedicated to behavioural economics and the environment and to methods that have been developed to deal with preference anomalies in stated preference valuation studies. Moreover, the relationship between environmental valuation and behavioural economics goes both ways: Carlsson (2010) asserts that the marriage of behavioural economics with non-market valuation techniques was inspired by anomalies that appeared in applied stated preference studies; and, as Horowitz et al. (2008, p.4) puts it, "Valuation is a form of experimentation and this experimentation has played a large role in learning about preferences and by extension, behavioural economics".

"Anomalies" in stated preference data often emerge where bounded rationality exists (typically for complex and ill-understood changes) and can take many forms. This includes preferences which are imprecise or are only learned and constructed during the administration of the survey itself (and so likely to remain incomplete). It also includes factors which should be superfluous to determining respondent preferences but might not be in practice (e.g. context, such as current personal mood or immediate environment) or the benefit being valued commanding greater importance for respondents at the time of the survey but this is not a true reflection of how they would otherwise view its significance (so-called "focussing illusion"). A range of issues related to the complexity of valuation tasks may also be viewed in this way, including choice under risk and uncertainty (Sugden, 2005; Swait and Adamowicz, 2001;

Horowitz et al., 2008; Shogren and Taylor, 2008; DellaVigna, 2009; Brown and Hagen, 2010; Carlsson, 2010; Gsottbauer and van den Bergh, 2011; Bosworth and Taylor, 2012).

Sugden (2005, p.7) states that when trying to comprehend the anomalies found in even the best designed stated preference studies, "we need to take account of evidence from the widest range of related judgement and decision-making tasks". These include assessing laboratory experiments of psychologists, behavioural economists and economic behaviour observed outside of stated preference studies. Gaining a better understanding from the behavioural economics literature of the source of the problems in stated preferences will make it possible to design better solutions to minimise them, as discussed further below.

Various studies have shown that the *Homo economicus* view of behaviour concerning self-interest consistently deviates from real-life actions of people, in that individuals typically care about reciprocity and equality (Fehr and Gächter, 2000; Camerer et al., 2011). Individuals have been found to punish others who operate in an uncooperative manner, whilst rewarding those who act in the communal interest. Cai et al. (2010) found that respondents in an internet-based hypothetical CV valuation study (measuring WTP for climate change mitigation strategies) exhibited increased WTP values when they believed that the negative effects of climate change would fall disproportionately on the world's poorest people and when larger cost shares were paid by those deemed to shoulder greater responsibility for mitigation. Moreover, the social context in which the valuation takes place also matters, as people care about others and about their approval. Alpizar *et al*. (2008) found that contributions to a public good stated in public were 25% greater than contributions stated in private.

There is a well-documented difference in derived values between WTP and WTA studies (Horowitz and McConnell, 2002). Knetsch (2010) focuses on which of these two elicitation methods to choose, depending on the case in question, highlighting that an understanding of reference states will help to avoid under-valuation of non-market environmental goods. Taking insights from behavioural economics, Bateman et al. (2009) found that by increasing the simplicity of tasks faced by respondents, the difference between WTP and WTA values regarding land use changes was reduced. Horowitz et al. (2008, p.3) also discuss the divergence of WTP and WTA values in some detail, showing that behavioural knowledge of survey design and context dependence can help to understand the WTP-WTA gap: "making sense of the gaps is an essential component of sustaining the validity of this valuation method."

The results from the meta-analysis of CV studies by Brander and Koetse (2011) highlighted the effect of study design on value estimates and the authors discussed the need to recognise and accommodate this when using CV results (see also OECD, 2012). They found that the methodological design of a CV study had a sizable influence on results and that values derived using payment vehicles such as donations or taxes tended to be significantly lower than other payment scenarios. As with many other studies, the authors found that the use of dichotomous choice or payment card methods produced significantly reduced values compared with open-ended methods. Brown and Hagen (2010) considered that differences in behaviour might be mitigated by using survey devices such as budget constraint reminders and 'time-to-think' procedures.

Looking at seven empirical studies, in which WTP value estimates were adjusted with preference uncertainty scores which quantify on a numerical scale how uncertain respondents stated they were about their WTP (e.g. from 0 to 10 where 0 might be wholly uncertain and 10 might be extremely certain). This is then compared with conventional (i.e. unadjusted) double-bounded CV WTP estimates, Akter et al. (2008) discussed whether or not respondent uncertainty could be measured accurately. Contrary to the NOAA Panel (Arrow et al., 1993) advice, the empirical evidence explored in this study suggested that incorporating information on uncertainty led to largely inconsistent (and less efficient) welfare estimates. That said, an awareness of respondents' valuation confidence can be helpful in understanding survey results. Conversely, Morrison and Brown (2009) investigated techniques for reducing hypothetical bias,

such as certainty scales, cheap talk and dissonance minimisation (where respondents are allowed to express support for a programme without having to pay for it). They found that certainty scales and dissonance minimisation were the most effective in reducing the bias.

Finally, in a seminal paper, Bateman et al. (2008) argue that a key mechanism for anomaly reduction in CV studies lies in providing respondents with opportunities for learning by repetition and experience. The authors test three alternative conceptualisations of individual preferences: (i) *a-priori* well-formed preferences, that are capable of being elicited via a single dichotomous choice question, as recommended by the NOAA guidelines (Arrow et al., 1993); (ii) learned or 'discovered' preferences through a process of repetition and experience, based on Plott's (1996) "discovered preference hypothesis", where stable and consistent preferences are argued to be not pre-existent, but the product of experience gained through repetition; and (iii) internally coherent preferences but strongly influenced by arbitrary anchors, inspired by the work of Ariely *et al.* (2003).The latter argued that, even when individual choices are internally coherent, they can still be strongly anchored to some arbitrary starting point, and by altering this starting point, values can be arbitrarily manipulated (a type of behaviour coined as 'coherent arbitrariness').

In order to test these alternatives, Bateman *et al.* (2008) develop the so called 'learning design contingent valuation' method, which is essentially a double-bound dichotomous choice payment format[4] (Hanemann, 1991), applied repeatedly to mutually exclusive goods, to allow for learning and experience in the valuation tasks and for the opportunity to 'discover' preferences within the duration of the survey. Their findings support a model in which preferences converge towards standard expectations through a process of repetition and learning, i.e. the discovered preferences hypothesis (Plott, 1996). Knowledge of the operating rules of the contingent market was also found to be a prerequisite for producing reliable and accurate values.

Bateman et al. (2008) results suggest a number of practical empirical fixes for common CV issues. First, it supports the use of double-bounded dichotomous choice formats rather than one-shot single-bounded designs. Double-bounded designs have the added advantage of also permitting a substantial improvement in the statistical results of a given sample relative to that provided by applying a single-bounded format (because it contains more information about respondents' preferences). As a result double-bounded CV formats have risen in popularity in recent years and have arguably become one of the most prevalent CV designs. Second, it indicates that it is the last response in a series of valuations which should be attended to rather than the first. Third, it supports the use of 'practice' questions (such as those described by Plott and Zeiler, 2005), which could then be followed by a single, incentive-compatible,[5] contingent valuation question. Finally, it also highlights the advantage of the increasingly common choice experiment method, discussed in the following sections, as a means of developing institutional and value learning. The idea of preference learning during repeated choices has also been observed by researchers using choice experiments. Several studies have shown that estimates of both preferences and variance obtained from the initial choices are often out of line with those obtained from subsequent choices (Carlsson et al., 2012; Hess et al., 2012; Czajkowski et al., 2014).

It is hoped that wider adoption of elicitation approaches that provide opportunities for learning might lead to a reduction in issues in stated preference studies which have previously been regarded as insoluble anomalies. Particularly, it appears to be a promising avenue for exploring potentially more accurate estimates of non-use values, where unfamiliar goods and ill-formed preferences are particularly prone to a range of heuristics and framing effects.

4. In this format respondents are asked two WTP questions in succession. For example, if a person has stated they would not be willing to pay the initial amount offered in question 1 then that respondent is offered a second lower amount in question 2.

5. That is, respondents state truthful answers based on what they are willing to pay.

2.4 Selected empirical applications

Culture

Cultural heritage is the legacy of physical artefacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations (UNESCO website). Cultural heritage assets refer to physical or tangible heritage, such historic monuments, ruins and buildings, historic urban and rural centres, historic gardens, archaeological sites, industrial sites, architectural monuments, scientific or technological assets, artefacts, and collections, and to non-physical or intangible heritage, which includes but is not limited to traditional festivals, oral traditions, customs, ways of life and traditional crafts (Yahaya, 2006). An additional distinction can be made between moveable assets – such a paintings and sculptures – and immoveable heritage assets, such as castles and historic buildings.

Cultural heritage assets are different from goods exchanged in regular markets. Their supply is fixed in the short run, and they are usually publicly owned and freely accessible. Even when visitors are charged for entrance and for the use of these sites, the access fees are usually nominal and not related to the true cost of providing and maintaining them. This means that nonmarket (valuation) methods must be used to determine the value that people place on visiting these sites, using them and conserving them (Ready and Navrud 2002). The importance of heritage assets in terms of their aesthetic, archaeological, educational, intellectual, collective identity, artistic and of course economic contribution (in terms of the revenue raised by the services they provide) has hence motivated an ever-increasing application of valuation methods with the aim of deriving estimates of monetary values for the protection of heritage from a society point of view, which in turn could be used in heritage project appraisal and decision making.

Empirical research eliciting economic values associated with access and/or conservation of cultural goods and services dates back to the 1980s when the first valuation studies in the field were conducted, focusing on the arts, theatre, historical sites, museums, libraries and broadcasting (Noonan 2003). Since then, the literature has steadily grown, and many studies have been conducted worldwide investigating a variety of culture-related benefits. For comprehensive reviews see Pearce *et al.* (2002), Noonan (2003), and Provins et al. (2010). Here it is attempted to highlight some of the main trends of the last decade or so, both in the valuation of built heritage and of the more intangible elements of culture.

Inspection of the literature on built heritage shows that studies on European heritage are the most frequent (e.g. Armenia, Bulgaria, Denmark, Greece, Ireland, Italy, Lithuania, Netherlands, Norway, Portugal, Spain, Switzerland and United Kingdom). There is great diversity in terms of the types of heritage assets valued, with studies on historic built heritage, i.e. immoveable heritage assets such as churches, cathedrals, temples or monasteries, castles and palaces, historic houses and monuments being the most popular.

Interestingly, most studies focus on the exterior conditions of the built assets, such as restoration, maintenance or cleaning of facades or materials (early examples are Morey et al., 1997; Pollicino and Maddison, 1999; Garrod and Willis, 2002; Navrud and Strand, 2002). One study even focused on preservation of submerged heritage assets, non-visible to visitors and public (Hasler et al., 2006). In contrast, very few studies have valued indoor conditions and they mostly refer to visitor comfort in the form of avoiding congestion at the site (e.g. Maddison and Foster, 2003; Brown, 2004; Salazar Borda, 2007), preserving access, or maintaining current conditions and specific visitor services at museums, galleries or archaeological sites (Bravi et al., 2002; Santagata and Signorello, 2002; Mazzanti, 2003; Sanz et al., 2003; Apostolakis and Shabbar, 2005).

Until very recently, only two studies considered the benefits associated with the conservation of in-house collections, i.e. moveable heritage (Brown, 2004; Mourato et al., 2002). In 2014, a large EU-funded project, Climate for Culture (2014), embarked on a major multi-country valuation exercise, the most comprehensive and in-depth analysis ever undertaken of the economic benefits associated with reducing climate change damages to the interiors of built heritage in Europe (Mourato et al., 2014). Comparable CV studies were conducted in five European countries – Germany, Italy, Romania, Sweden and the United Kingdom – with a total of ten case study sites within these countries (including palaces or manor houses, churches and museums). Focusing on non-iconic heritage and, specifically, the indoor contents of heritage buildings, which are arguably largely common across regions (e.g. collections such as paintings, wooden objects, textiles etc.), the authors investigated the reliability of value transfers both within national boundaries (i.e. within same country case studies) and across national boundaries (i.e. different case studies in Europe). Importantly, they found that heritage conservation values can successfully be predicted via value transfer approaches, with moderate transfer errors. Much more empirical work is needed in this area to test the transferability of values associated with cultural goods and services.

The valuation scenario of the majority of previous studies concerns the degradation of heritage goods, in terms of changes in appearance, authenticity or accessibility, as a result of natural weathering (e.g. Seenprachawong, 2005); insufficient conservation work (e.g. Carson et al., 2002; Del Saz Salazar and Mantagud Marques, 2005; Baez and Herrero, 2012); both external conditions and lack of conservation (e.g. Willis, 1994, Garrod et al., 1996; Garrod and Willis, 2002; Alberini and Longo, 2009); and visitors' presence (e.g. Brown, 2004; Tuan and Navrud, 2008). A number of studies concentrate specifically on the effects of air pollution or environmental degradation on historic assets (e.g Morey et al., 1997; Pollicino and Maddison, 1999; Groslaude and Soguel, 1994; Navrud and Strand, 2002; Alberini et al., 2004) and, more recently, climate change (Mourato et al., 2014).

An interesting related development has been the recent focus on the so-called 'cultural services' provided by ecosystems. Some ecosystems may have historical and cultural interest and therefore benefit from special cultural heritage designations. Of note, there are 194 natural sites on the UNESCO list of World Heritage sites (UNESCO 2015), including the Great Barrier Reef in Australia, the Grand Canyon National Park in the USA, the Brazilian Atlantic Forest Reserve, the Serengeti National Park in Tanzania, Mount Etna in Italy, and the Dorset and East Devon Coast in the UK. These sites and many others provide a range of outdoor services that fall into the category of cultural ecosystem services. Cultural services is an umbrella term that includes a range of benefits experienced from contact with natural (including natural heritage) sites such as: outdoor leisure and recreation, spiritual benefits, physical and mental health, neighbourhood development, education and knowledge and inspiration. Non-use values associated with the existence of these sites are also included within the scope of cultural services. Early valuation studies of such services include Lockwood et al. (1996), Alberini et al. (2004), Dutta et al. (2007) and Martin-Lopez et al. (2009).

Of note, considerable progress has been made recently in the UK National Ecosystem Assessment (NEA, 2015; Bateman et al., 2011; Church et al., 2011), that provided an overview of current knowledge on the value of UK cultural ecosystem services, in terms of what they are, how they have changed over time, what is known about their value and the gaps that still exist in understanding their contribution to human wellbeing. While the value of recreation and leisure was found to be well understood and documented, the report found considerable gaps in our understanding and measurement of other types of cultural ecosystem services, such as spiritual benefits, mental health, neighbourhood development, education and knowledge, inspiration and non-use values. This seems to be an area ripe for further research.

Overall, existing valuation work considers a variety of tangible and intangible heritage goods of local and international importance, with the majority of studies investigating preferences for immoveable assets

(single assets mostly but also in groups). Recent developments include the significant research carried out on the value of preserving moveable assets through the Climate for Culture (2014) project, and on the area of cultural ecosystem services, following on from the UK National Ecosystem Assessment (NEA, 2015). In most cases, positive values are attributed to access to, and conservation or restoration of heritage goods, which in turn suggests that degradation of or lack of access to heritage reduces individual and society's wellbeing.

Finally, there is also a growing literature in economics on the value of the arts and other similar cultural services. For example, a small but growing number of studies has focused on services provided by libraries and archives (e.g. Morris et al., 2002; Pung et al., 2004; Jura Consultants, 2005; Aabø 2005; Hájek and Stejskal, 2014; Fujiwara, Lawson and Mourato, 2015). According to Aabø (2009) and Kim (2011), who provide recent reviews of libraries valuation studies, the net benefits provided by libraries seem to be broadly positive although the values vary widely. Other studies aimed to elicit benefit values for the preservation, increase or improvement of the arts in general (e.g. Thompson et al., 1983; Morrison and West, 1986; Glass et al., 1999; Thompson et al., 2002), festivals (Bedate, Herrero and Sanz, 2004), publicly provided TV programmes (e.g. Finn et al., 2003), and provision of performances such as theatre plays (e.g. Forrest et al., 2000; Bille, 2002).

Health

Contingent valuation methods have been widely applied in the health literature. Von Stackelberg and Hammitt (2009) conducted a stated preference study to derive a monetary value for increased IQ points, in the context of low-level lead exposure reductions. They used a similar method to Dockins et al. (2002), adopting a parental method of valuation through an intra-household model, relying on respondents making judgements regarding the health of their (hypothetical) 10 year-old child. Their double-bound dichotomous choice (DBDC) CV study found a WTP per IQ point (of USD 466) and this value was distinctly lower than that found in a study by Lutter (2000) which translated the revealed preference findings from Agee and Crocker (1996) in to a parental WTP per IQ point gained of USD_{1997} 1 100 - 1 900. This downward bias is not an unusual finding in the CV literature (Carson and Groves, 2007).

A meta-analysis of over 60 health WTP studies, by Lin et al. (2013), suggests that variations in risk perception/tolerance and personal/family familiarity may lead to higher WTP values from some individuals to identify whether they have a disease (or risk factor). More severe health impacts and diseases that lack controllable risk factors (e.g. some cancers or congenital abnormalities) were found to be associated with higher WTP estimates. Various issues exist which limit comparability between different studies, thus inhibiting the effectiveness of insight gained from analysing health WTP studies at the macro level. To this end, Sach et al. (2007) recommend a checklist, or "minimum reporting set of information", as a first step towards increasing the consistency of methods used and therefore the values obtained across the field (see Smith and Sach, 2010).

OECD (2012) reviews the extensive evidence on the value of statistical mortality (based on stated preference studies) which could be used in economic appraisal around the world. The results of this review are striking, indicating both good progress in this work as well as a range of practice. Synthesising this work in a database therefore has a number of important functions. First, it allows the analysis and understanding of differences across values in the database. Second, it allows a more informed judgement to be made (perhaps via meta-analysis) about appropriate statistical values to apply in particular geographical and policy contexts. For example, the report provides a series of recommendations based on population and risk characteristics as well as a range of other factors. Third, a database[6] acts as a useful 'one-stop shop' and as such quite possibly increases possible uptake of valuation in actual policy applications. Such data

6. See *www.oecd.org/env/tools-evaluation/valuingmortalityimpacts.htm.*

are also being used to address larger-scale questions about the burden of environmental pollution. An example of this can be found in the use of valuation to estimate health costs of air pollution (e.g. OECD, 2014; WHO, 2015) and the modelling of the large-scale impacts arising from possible policy actions to reduce these burdens (e.g. Vrontisi et al., 2014).

2.5 Developments in subjective wellbeing valuation

The last decade has witnessed a significant increase in research on subjective wellbeing (also referred to as happiness) (see MacKerron, 2012, for a review) and more specifically on subjective wellbeing valuation (Welsch and Kuhling, 2009; Ferreira and Moro, 2010). In parallel, using subjective wellbeing measures to appraise policies, inform policy design and monitoring progress has become increasingly popular in the public policy sphere (Fujiwara and Campbell, 2011; Dolan et al., 2011).

Subjective wellbeing

Subjective wellbeing (SWB) refers to self-reported measures of personal wellbeing, usually collected via surveys. There are three key dimensions of SWB:

- *Life satisfaction* (or evaluative SWB). This dimension is a self-evaluation of one's life according to some positive criterion (Kahneman et al., 1999). It can be measured on an aggregate level as a single-item (life as a whole) or instead split into distinct life domains in a multiple-item scale (Cummings, 1996, proposed seven domains of life satisfaction: material well-being, health, productivity, intimacy, safety, community, and emotional well-being). For example: 'All things considered, how satisfied are you with your life as a whole?' with responses being measured on numeric scales, such as, for example, 0 to 10.

- *Eudaimonic subjective wellbeing.* This dimension refers to the process of achieving a flourishing and worthwhile life where one's true potential is realised (Waterman, 1993; Ryan & Deci, 2001). It relates to intrinsic aspirations, self-realisation, personal growth, and sense of purpose and meaning in life. For example: 'Overall, to what extent do you feel that the things you do in your life are worthwhile?' or 'Does your life have meaning and purpose?'

- *Momentary subjective wellbeing* (or experience SWB). This dimension measures feelings, affect or mood at a particular point in time (MacKerron and Mourato, 2013). It is highly influenced by recent events or news and can change quickly. For example: 'How happy are you right now?'

Most existing research has focused on the measurement and determinants of life satisfaction (see Dolan et al., 2008 for a review). In contrast, substantially less is known about eudaimonic wellbeing (Skianis, 2012). Inclusion of a stronger eudaimonic dimension in research and policy making would be beneficial: many behaviours and policies are arguably aimed at enhancing opportunities for people to flourish, to be fulfilled and to achieve a sense of meaning and purpose in life, rather than pursuing pleasure per se. Meanwhile, there is an incipient but growing body of research on momentary wellbeing, fuelled by technological developments that facilitate the collection of instant SWB data, via apps and mobile devices (e.g. MacKerron and Mourato, 2013).

The influential Stiglitz Commission (Stiglitz et al., 2009) argued that all measures of SWB are useful for policy and should therefore be regularly and separately measured, via large-scale surveys undertaken by official statistical offices. In line with this recommendation, in 2011, the UK Office for National Statistics started to collect data on all three key dimensions of personal SWB.[7] In the same year, the HM

7. See also *www.oecdbetterlifeindex.org/*.

Treasury published supplementary Green Book guidance on using the subjective wellbeing for valuing non-market goods in CBA (Fujiwara and Campbell, 2011).

To put this into a broader conceptual context, subjective wellbeing is one of three possible accounts of wellbeing (Parfit, 1984; Dolan et al., 2011): objective lists, preference satisfaction and mental states.

- *Objective lists* refer to the fulfilment of basic material, psychological and social human needs and rights. Typically these are identified "exogenously"; that is, proposed by experts or the logical extension of a theory of, or body of ideas about, wellbeing. Sen's (1999) capability approach[8] in an example of this account and expresses wellbeing as ultimately determined by the capability of people to enjoy opportunities afforded by freedom from e.g. political oppression, malnutrition and illiteracy;

- *Preference satisfaction* is the wellbeing account associated with neo-classical economic theory. It is based on the premise that we can infer wellbeing (or its close relative, utility) from people's preferences and choices (Parfit, 1984). As such, the preference satisfaction account is widely used and is behind economic appraisal techniques, such as CBA;

- *Mental states* correspond to people's self-reports about their own wellbeing and is therefore what was called subjective wellbeing above. It is popular not just in social sciences such as psychology but also, increasingly, in economics.

The links between these various accounts of wellbeing are not easy to map out as they ultimately refer to different constructs. Peasgood (2008) measured the three types of wellbeing for the same population and noted that that, for some people, there were large differences between the various accounts. In terms of SWB and preference satisfaction, the two accounts that is of the most interest here, SWB is often described as an 'experienced utility' measure, which is related to how people feel about their life and circumstances, in contrast with the traditional, preference-based concept of 'decision or expected' utility, which is based on what people want (Kahneman et al., 1997; Kahneman and Sugden, 2005). MacKerron (2011) argues, however, that the differences between the two approaches are deeper than simply being prospective and retrospective versions of the same equivalent metric. In many instances, the two conceptualisations may coincide, when the things people want are also the ones that make them happy, but this is not always the case. For a review of the similarities and differences between the subjective wellbeing and the preference satisfaction approach, see MacKerron (2012).

Subjective wellbeing valuation

Subjective wellbeing data provides a new and alternative way to value non-market changes. That is, one can estimate monetary welfare measures based on people's self-reported wellbeing. This has become known as the Subjective Wellbeing Valuation approach (Frey et al., 2004a; Frey et al., 2009; Welsch, 2009; Fujiwara and Campbell, 2011). Given a change in the determinant of interest, say environmental quality, the approach works by calculating the change in income that would produce a SWB impact of equivalent size.

This new method of monetary valuation could potentially be a useful complement to revealed and stated preference methods, since it does not require assumptions about rationality, is not subject to the

8. See also Nussbaum (1992) for further discussion of the conceptual foundations of this approach. A volume by Gough and McGregor (2007) discusses how objective and subjective approaches might be combined both in theory and in practice, to provide fuller accounts of peoples' wellbeing, particularly in the developing world.

same types of bias affecting those techniques (for example, hypothetical bias), and does not require individuals to be conscious of the levels or effects of the parameters being valued (Welsch & Kuhling, 2009).

One key assumption is required in order to use SWB data for non-market valuation: that SWB is a direct measure of individual welfare. Hence, by observing SWB one can estimate direct monetary measures of welfare change associated with a non-market change using a direct utility (as measured by SWB) function, as long as income is one of the determinants included. Following Fujiwara and Campbell (2011), consider the following direct SWB function:

$$SWB(Q, M, X) \qquad (1)$$

where Q = the non-market good (e.g. air quality), M = income and X = other determinants of SWB. The value associated with a welfare-increasing change in the provision of the non-market good from Q^0 to Q^1 is estimated as:

$$SWB(Q^0, M^0, X) = SWB(Q^1, M^1 - CS, X) \qquad (2)$$

where CS is the Hicksian compensating surplus measure of welfare associated with the change. Empirically, the SWB function can be estimated as:

$$SWB_i = \alpha + \beta_M M_i + \beta_Q Q_i + \beta_X X_i + \varepsilon_i \qquad (3)$$

where α is a constant, β_M, $\beta_Q$and β_X are the coefficients associated with the determinants of SWB, ε is the error term and the i represents the individual. The SWB function can be estimated with either cross-sectional data or panel data, using a range of multivariate statistical methods. Some authors treat the SWB data as being cardinal, while others relax this assumption and use statistical models[9] to analyse the ordered data.[10] A critical assumption is that there is a causal link between the independent variables and SWB (Dolan et al., 2008).

Measures of welfare change can then be uncovered from the marginal rates of substitution between the non-market good and income, specifically using the ratio of the non-market good and the income coefficients from model (3):

$$CS = {\beta_Q}/{\beta_M} \qquad (4)$$

Equation (4) can be interpreted as the amount of money that would be required to keep SWB constant in absence of the non-market good (for goods that provide positive wellbeing). The income term is typically modelled in log form, $\ln(M_i)$, in order to account for the diminishing marginal utility of income. In this case, the welfare value measure is calculated as:

9. These might be either ordered logit or ordered probit models with the practical distinction between the two usually assumed to be minimal.

10. For example, if person 1's stated SWB is 6 and person 2's SWB is 3, the cardinal approach asserts that person 1 is twice as "happy" as person 2. The ordinal approach by contrast simply asserts that person 1 is "happier". Of course, this still assumes that SWB between people is comparable (i.e. people interpret the scale in the same way).

$$CS = M^0 - exp^{\left[\ln(M^0) - \frac{\beta_Q}{\beta_M}\right]} \quad (5)$$

The SWV method has been used most frequently in the valuation of environmental changes to do, for example, with air quality, noise, climate change or droughts (van Praag and Baarsma, 2005; Carroll et al., 2009; MacKerron and Mourato, 2009; Rehdanz and Maddison, 2008; Welsch, 2002, 2006, 2007). Review of environmental valuation applications, see Welsch and Kuhling (2009) and Ferreira and Moro (2010) but given this remains work-in-progress more up-to-date reviews are clearly needed. But there are growing examples in other areas as well: for example, employment (Clark and Oswald, 2002); terrorist attacks (Frey et al., 2004a); health (Ferrer-i-Carbonell and Van Praag, 2002; Groot and van den Brink, 2006); macroeconomic events (Blanchflower and Oswald, 2004); corruption (Welsch, 2008); crime (Cohen, 2008); social relationships (Powdthavee, 2008); adult learning (Dolan and Fujiwara, 2012); housing quality (Fujiwara, 2013); and cultural activities and events (Fujiwara, 2013a; Fujiwara et al., 2014).

The values obtained using the SWB approach have been widely criticised for being unrealistically large. For example, MacKerron and Mourato (2009) found that a small 1% increase in NO_2 levels was equivalent to a 5.3% drop in income; Frey et al. (2007) found that the value of reducing terrorist activity in Northern Ireland to the same level as in the Republic of Ireland was equivalent to 41% of personal income; Clark and Oswald (2002) estimated the value of employment to be an implausibly high GBP 276 000 per year to an individual, in addition to their wage income; Frey and Stutzer (2005) estimated that Paris residents valued reducing terrorism levels to the level experienced elsewhere in France at 14% of their income; and Powdthavee (2008) found that an increase in the level of interactions with friends and relatives from 'less than once a month' to 'most days' was worth GBP 85 000 a year.

The root of the overestimation problem lies with the difficulty in estimating the marginal utility of income: because of the many channels by which income affects subjective wellbeing, the income coefficient is usually under-determined in SWB models. This result in an overestimation of welfare values, as the income coefficient appears in the denominator of the valuation equation ratio (see equation 4). This issue is discussed in more detail in the following section.

Moreover, it should be emphasised that the values obtained using the SWB approach do not have to necessarily coincide to those obtained using the traditional preference-based valuation approaches. As explained above, both valuations are derived from a different theoretical measure of wellbeing: preference-based methods are based on decision utility, used in purchasing decisions, i.e. what people would be prepared to pay for an improvement; while subjective wellbeing valuation is based on experienced utility, i.e. people's actual experiences. For example, Fujiwara (2014) shows that while 'lack of space' is often cited as a key factor behind the decision to move house, it does not however, seem to affect life satisfaction, i.e. the actual life experience of living in a particular dwelling. People's preferences and experiences can diverge, and it is an empirical matter which is most relevant for a particular policy.

Advantages and limitations of the subjective wellbeing valuation approach

Subjective wellbeing valuation has a number of limitations but also some advantages when compared to traditional preference-based non-market valuation approaches. Here the most important pros and cons are being mentioned.

As noted above, perhaps the largest problem associated with using the SWB valuation method is the inability of SWB models to *accurately estimate the income coefficient* because of measurement error, endogeneity, reverse causality and parametric restrictions (Fujiwara and Campbell, 2011) which has been found to be substantially biased downward. Undervaluation of the income coefficient leads, in turn to an overestimation of economic values (see equation 4). In an early attempt at comparing preference-based CV and subjective wellbeing valuation, Dolan and Metcalfe (2008) found large differences between the two

methods with the SWB valuation approach producing significantly larger values (GBP 19 000 vs GBP 245), on a study of the value of an urban regeneration project.

However, in the last few years the methodology for wellbeing valuation has evolved and there appear to be some promising solutions to account for these problems. One such development is the three-stage SWB valuation procedure proposed by Fujiwara (2013b): (i) in the first stage a SWB model is estimated; (ii) in the second stage a separate income regression model is estimated using data on lottery wins (an exogenous income change, see Gardner and Oswald, 2007) as an instrumental variable in a two stage least squares model framework to derive a robust causal estimate of the impact of income on SWB; (iii) and in the final stage the results from the two models are used to derive unbiased monetary values. Other suggested ways to improve the estimation of income effects involve including relative income in the SWB equation, as well as controlling for other factors that are related to income, such as hours of work and commuting time (Fujiwara and Campbell, 2011).

Another key issue is that of *causality*. It is typical to assume that statistical models of the determinants of SWB identify causal relationships; that is, for example, the finding that income is a significant explanatory variable in a SWB regression is taken as evidence that income increases wellbeing. However, in many studies, the associations estimated between the explanatory regressors and the wellbeing variable cannot be interpreted as causal effects. This is because SWB may itself determine some of the explanatory variables. For example, there is some evidence to suggest that happier people may be healthier, earn more money and be more likely to get married (Fujiwara and Campbell, 2011). Moreover, there may be omitted variables in the model that affect both the dependent and the independent variables. In order to be able to make causal inferences from SWB models, more sophisticated statistical or other research design methods are needed.[11]

It is not clear how to use the SWB valuation approach to measure *non-use values*. As such the approach, as things stand, does not offer any obvious advantages in what is arguably the most difficult area in non-market valuation. It is of course conceptually feasible that one could use subjective wellbeing to capture non-use values. If it were possible to identify behaviours/experiences that reflect non-use values, one could try to measure the subjective wellbeing associated with these behaviours and in turn, calculate monetary value equivalents. Examples of such behaviours include donations to good causes that one is not likely to benefit from directly. But clearly, where related behaviours exist one does not need SWB valuation as one can simply observe the behaviours. And in most policy-relevant cases, there are no observable behaviours for non-use values.

There is a potentially promising way in which SWB valuation could be used to measure non-use values. Through the use of a so called 'anchoring vignette' study, respondents are presented with a hypothetical life or event and asked questions about how this event might affect SWB. This could involve a short scenario describing a hypothetical individual donating money to a non-use policy, say the conservation of the rare Iberian lynx. The respondent is then asked to imagine what impact this policy might have on life satisfaction. While this approach presents a potential way of dealing with non-use values, it also brings the SWB approach into the realms of hypothetical scenarios and so risks facing the same sorts of problems as stated preference methods. Vignettes are increasingly being used in wellbeing and health research (e.g. Kapteyn et al., 2011).

Because SWB is based on experienced utility, it also poses limitations when attempting to estimate the *impact of future policy changes*. It relies on observing similar changes that might have already occurred

11. For example, key explanatory variables such as income should be either instrumented with a variable that is truly exogenous (such as perhaps the lottery wins mentioned in paragraph 73) or determined through a random control trial.

at some point in the past, or using the vignette approach described above. In this approach, respondents are presented with a scenario which reflects some future change. As such this is not dissimilar say from the valuation scenario in a stated preference survey which describes some policy change of interest.

SWB is arguably better suited to measure large changes that clearly impact on subjective wellbeing than *marginal changes*, whose impact might be impossible to detect due to the bounded nature of the SWB scales (e.g. 0-10) (Fujiwara and Campbell, 2011). Researchers have experimented with wider scales, say from 0-100, but this raises the issue of whether respondents can accurately pinpoint their level of SWB in such detailed scales.

While stated and revealed preference methods typically use money as a measuring unit, there is more than one subjective wellbeing measure that can be used (life satisfaction, eudemonic wellbeing and momentary wellbeing) and it is *not clear which measure should be used for which purpose* (Dolan et al., 2011). Different types of SW will have different determinants. For example, life satisfaction might be more strongly correlated with income than momentary happiness, that might be more correlated with the type of activity being undertaken or the company one is with. So it is conceivable that some policies may affect one type of wellbeing more than another.

For example, MacKerron and Mourato (2013) show that momentary wellbeing is significantly higher in natural environments. They found that the predicted happiness of a person who is outdoors, birdwatching, with friends, in heathland, on a hot and sunny Sunday early afternoon is approximately 26 scale points (on a 0-100 scale) higher than that of someone who is commuting, on his own, in a city, in a vehicle, on a cold, grey, early weekday morning. However, it is unlikely that eudemonic wellbeing for example would increase so substantially because of such an experience. So a decision needs to be made as to what measure of wellbeing is relevant to what type of policy. Typically, life satisfaction has been used in monetary valuation but that might not always be the best measure.

Moreover, it may be impossible to fully separate out the three key dimensions of wellbeing identified above: Seligman (2011) finds that mood determines around 70% of the life satisfaction reported on average, with less than 30% being determined by how well people judge their life to be going.

Finally, SWB metrics also have their own *measurement challenges*. For example, measures such as life satisfaction involve a retrospective judgement of one's life and it is well known that people have imperfect recollection of past experiences (Kahneman and Krueger, 2006). The SWB scores may also be influenced by arbitrary contextual factors like the weather or the performance of football teams (Schwarz and Strack, 1999). SWB responses may also be influenced by the order in which they appear in a survey. The commonly used single-item measures of SWB (e.g. to measure overall life satisfaction) are opaque and do not allow the researcher to investigate if and how the various dimensions of life were accounted for and aggregated by respondents.

To compound the problems, narrow scales (e.g. 1-5) may not be broad enough to be able to reflect all that is important to our lives (Loewenstein and Ubel, 2008). Moreover, evidence shows that people adapt relatively quickly to change, both positive and negative (e.g. unemployment, disability, pay rise, marriage) in what was called the phenomenon of 'hedonic adaptation'. Therefore, changes in policy may not be reflected in the level of SWB (Loewenstein and Ubel, 2008).

But not all is gloom. The SWB approach is based on actual rather than hypothetical experiences, which is an attractive feature for policy makers (although how to consider non-use in this framework remains a challenge). It can potentially capture the effect of changes that people may either not be consciously aware of, or fail to attribute to particular causes/policies. It avoids the strict set of rationality assumptions needed in preference-based methods. And importantly, the SWB approach might be useful to

estimate values for non-market changes that may be particularly difficult to be directly valued with willingness to pay approaches, such as those involving community benefits, spiritual benefits, equality and distributional issues and so on.

It is also thought to avoid problems related to protest values, strategic bias and hypothetical bias and be less sensitive to contextual influences such as priming effects, because WTP is not elicited (Fujiwara and Campbell, 2011). Importantly, SWB valuation also eliminates 'focussing illusion' issues (Schkade and Kahneman, 1998), since respondents *typically* are not asked about the value of a particular policy change the 'importance' of which then dominates their thinking during the survey process, but that value is instead inferred ex post from the econometric analysis. But it should be noted that these are assumed advantages rather than proven ones as research is scarce in these topics.

Fundamentally, much less is known about the limitations and bias of this nascent SWB valuation approach. Revealed and stated preference methods have a much longer history of research and applications in economics. But overall, the SWB approach offers a promising new way of valuing non-market goods. Future research and applications will tell if this promise holds.

3. Discounting and the future

While pre-2006 debates about environmental CBA were dominated by monetisation, and specifically valuation based on stated preference methods, in the past decade, the overriding controversy has surrounded the discount rate. On the one hand, this is nothing new and goes back to debates of the 1980s (and earlier) about the 'tyranny of discounting'. On the other hand, the more recent debate has been fuelled by substantive contributions, beginning notably with the findings of the Stern Review (Stern, 2007) (as well as earlier research by e.g. Weitzman, 1998, and Gollier, 2002). This, in turn, has prompted serious reflection on discounting the (far-off) future with the appraisal of actions to mitigate climate change being the exemplar.

Hepburn and Gosnell (2014) provide an authoritative and relatively up-to-date review of a number of significant developments. Those authors identify several key themes in this work. Amongst these is the way in which debate has coalesced around the distinction between descriptive and prescriptive approaches to discounting. Clearly, this is in itself was not novel as a way of understanding these debates. Arrow et al. (1996), for example, provides a critical assessment of these issues too. Nevertheless, the distinction has once more proved useful, in particular in assessments of proposals for the social discount rate, r, based on the Ramsey equation: $r = \delta + \eta g$, where δ is the utility discount rate (pure rate of time preference), η is the elasticity of the marginal utility of consumption and g is the consumption growth rate.

Critics of the 'low' social discount rate used in Stern (2007), for example, have argued forcefully that this is inconsistent with societal preferences as revealed by real data. For example, Nordhaus (2007) notes that savings rates would, in this counterfactual world, be substantially (and arguably implausibly) higher than are typically observed. Responses to such criticism note that apparently higher discount rate revealed in actual decisions about consumption and saving are essentially short-term and individualistic and so perhaps questionable as an appropriate basis for social choices being made about the far-off future.

An important development is the solidifying of support in the academic literature for declining discount rates. Thus the interim conclusion of this work which was reviewed in Pearce et al. (2006) appears to have held steady. This can be seen clearly in Arrow et al. (2012) which summarised the views of a number of key experts in this research field. Interestingly, the justification for this declining discount rate draws on a variety of insights (Hepburn and Gosnell, 2014), notably uncertainty (or pessimism) about economic growth but also limited (asset) substitutability, intergenerational equity and (existing) evidence about the way in which current individuals actually discount the future.

More problematic, however, is empirically determining the schedule for these declining rates; i.e. the initial discount rate and the term structure of its decline. Arrow et al. (2012) review a number of studies. These include extensions of the Ramsay formula, reflecting uncertainty in the (consumption) growth rate and the impact of this on precautionary saving. Critical to the significance of this effect is the estimated variance of these growth rates as well as questions about whether past data about consumption trends (and shocks) in particular countries are relevant to possible future systemic risks to consumption (Pindyck and Wang, 2012).

Other methods have made use of expert opinion – and divergences in these views about future prospects – in generating a schedule for declining discount rates, although there has been some reflection about whether these opinions are positive forecasts or normative judgements and, even if the former, how these expert opinions should be combined (e.g. Freeman and Groom, 2014). A number of studies have also sought to model determinants of past interest rates in a variety of ways. Groom et al. (2007), for example, apply five models (to data earlier used by Newell and Pizer, 2003). This results in divergent declining discount rate schedules and so clearly raises the question as to which should be selected particularly for practical discounting in official CBA and what are the critical criteria for making this choice (Arrow et al., 2012).

An important element of the discounting debate has been arguments about the value of parameters of say the Ramsay equation; in particular, the elasticity of the marginal utility of consumption, or η. Groom and Maddison (2013) review the evidence on the value of η for the UK. Interestingly, this evidence is drawn from a variety of methods. This includes established methods, such as looking at the parameter value implicit in the UK income tax schedule (e.g. according to some equal-sacrifice hypothesis about the utility of taxpayers) as well as more novel approaches based on the findings of the literature on subjective wellbeing. Pooling these findings – that this elasticity is in the region of 1.5 as a 'best-guess' – results in a not insignificant practical implication for UK discounting of long-term projects. This is that the short-term discount rate should be higher: i.e. 4.5% as opposed to 3.5% currently. Additionally, the discount rate declines along a less accelerated path than in current UK discounting practice.

Atkinson et al. (2009) discuss the conceptual interpretations of η. In the 'workhorse' model of welfare economics as applied to climate change, η simultaneously represents preferences over three significant dimensions of the policy issue, namely: (a) *risk* (how risky bundles of consumption are for the same given individual); (b) *space* (consumption inequality across different people in the 'here and now'); and, (c) *time* (across people at different points in time). This standard model assumes that all these contexts are viewed the same. That is, any value of η calculated in any of these contexts can be used to parameterise the social discount rate. However, there is no reason to think about all of these estimates will be equal. One reason for this is that these estimates are drawn from very different contexts (and preferences may differ accordingly, in principle at least).

Whether this is the case or not is investigated in Atkinson et al. (2009) – using a stated preference survey – to examine whether public attitudes to climate change support a model in which inequality preferences over risk, space and time are identical, or whether they in fact support a model in which these preferences are distinct. The survey posed direct questions about hypothetical consumption choices under each of the three defining characteristics framed in terms of distributional aspects of the climate change problem. Aversion to temporal inequality was the greater value followed by consumption risk and then spatial inequality. Moreover, these differences were statistically significant and, moreover, there was low correlation between the measures. On the face of it, this provides a rationale for disentangling the three concepts when discussing empirical estimates of η.

Nevertheless, there is a legitimate question to ask about the role of stated preferences in framing this debate. Arrow et al. (2012), for example, speculate as to whether such preferences are sufficiently well

formed. Presumably such concerns also carry over to using revealed preference data (given this is also based on "uninformed" preferences albeit revealed in actual decisions). Nor do any of these data resolve ethical debates about what the discount rate should be. However, building up an empirical record on these critical magnitudes, using a variety of approaches, could usefully contribute to and complement on-going discussion. For example, the findings in Groom and Maddison (2013) paper are that the estimated elasticity is similar statistically across the different approaches to estimation they use. This is a striking result given these approaches are very different apart from being based on revealed data[12] and contrasts with the findings in the study by Atkinson et al.

Uncertainty about future growth rates of consumption has focused on probabilistic risks and e.g. the implications for declining discount rate schedules. Recent research on uncertainty has also focused on *ambiguity*. This concept brings the notion of genuine – or Knightian – uncertainty within the ambit of social CBA. Specifically, the presence of ambiguity aversion means that people disprefer uncertainties which are partially or genuinely unknown (i.e. prospects which are unknowable, as distinct from possible outcomes which are uncertain but can be understood according to probability distribution) (Hepburn and Gosnell, 2014). One implication of all this is a further adjustment to the standard Ramsay rule, which is additional to the "prudence effect" identified more than a decade ago (e.g. for a review, see Gollier, 2012).[13]

Millner et al. (2013) look at one source of ambiguity relevant to climate – climate sensitivity (to changes in atmospheric carbon concentrations) – and identify the implications for the discount rate. This decreases the social discount rate for greater ambiguity (i.e. genuine uncertainty) and a longer time horizon when climate change damages could be far higher. It crucially also depends on the magnitude of the elasticity of the marginal utility of consumption (which again emphasises the importance of debates about what this parameter value should be). For example, for values of this elasticity greater than one, then this decrease is especially significant and large (relative to where there is no ambiguity).

One further implication of emerging evidence about climate change damage in the future is that the threats could be very large indeed. Yet an implicit assumption in applying the tools of social CBA is that these interventions are marginal and hence small enough such that analysts need not to be concerned about more indirect or economy-wide impacts. For proposals involving climate (and related) policy, there is growing questioning of whether this assumption is likely to be adequate. In some cases, this requires that the analyst looks at the ripple of effects through a number of sectors comprising an economy.[14] In other cases, the non-marginal effect could so large (potentially) that it shifts the growth rate of the economy.

12. Note that the SWB approach is based, of course, on estimating life satisfaction though a stated response.

13. This human motivation to be prudent (rather than risk-loving) combined with probabilistic uncertainty about future economic growth provides a rationale for precautionary saving. That is, greater investment than would be chosen if the future was certain. This has the effect of decreasing the discount rate (Gollier, 2012).

14. In some cases, this might require straightforwardly that models are used which capture these broader linkages; such as CGE models for example. In the literature on transport appraisal, there is on-going debate about valuing wider economic benefits of investing in transport infrastructure and, moreover, integrating those findings in cost-benefit studies. Some of this research has focused on market failures that this investment could ease. If, for example, there is large (involuntary) unemployment then the new transport infrastructure might improve matters by linking labour markets and decreasing job search costs (see, Department of Transport, 2012a, 2012b). Other mechanisms are possible too (de Rus, 2010). This includes: (a) giving firms easier/ quicker access to specialised input markets; (b) economies of agglomeration; (c) mitigating (some of) the adverse effects on output of imperfect competition (by expanding output); and, (d) encouraging greater competition by reducing entry costs for new firms into markets.

For example, Dietz and Stern (2015) in an extension using the DICE model look at the implications for consumption growth when climate change has adverse effects on (produced) capital accumulation and the rate of technical change (which is embodied in new assets). This has implications not only for climate change damage estimates but for the social discount rate with which these damages are discounted. Put another way, the discount rate becomes endogenous to the decisions about climate policy and an investigation of general equilibrium effects is needed when this is the case (Hepburn and Gosnell, 2014; Dietz and Hepburn, 2013).

As important as all these conceptual and empirical developments are, clearly the end game is how these insights are translated into official CBA guidelines and practices. In this respect, it is important to have an (updated) baseline of CBA practice within and across countries (how and why this differs as well as an interpretation of whether this is justified and its implications). Hepburn and Gosnell (2014) and Spackman (2015) review existing use and, in doing so, are confronted with an extraordinary range of practices. Notably, very few countries – currently France and UK – utilise a declining rate, although Arrow et al. (2012) note that in the US while a constant rate is used this may be lower for projects with long-term impacts. Similarly, Zhuang et al. (2007) notes that China has discount rates which distinguish between whether a project is 'short-/ medium-term' or 'long-term'. That review also notes differences in practice within countries such as in Spain where a different discount rate is used depending on whether public spending on investments in transport or water.

Spackman (2015) takes an historical perspective on developments in official use of the discount rate in social CBA used by governments. For example, he argues that the social opportunity cost rate (SOCR) can be viewed as appropriate where the key criterion for judging decisions about public investment was the return these outlays should generate. Contemporary issues about how to deal with the long-term have provided clear challenges to the usefulness of this approach. As a result, some countries have switched emphasis for estimating the social discount rate based on the social time preference rate. This includes those countries using the Ramsey equation (e.g. the UK) or risk-free market rates (e.g. Norway). However, not all have followed this trend with a number of countries sticking to the SOCR, with a tendency then to use higher social discount rates. Many developing countries are in this camp (such as India, Pakistan and the Philippines) as well as developed countries such as Australia and Canada. However, practical generalisations are not without limitation. Canada, for example, uses a social discount rate of 3% for assessing environmental regulations (but with sensitivity analysis conducted at the higher rate of 7%).

4. Distribution, equity and CBA

In recommending proposals that confer the largest net benefits, CBA appears to neglect questions of distribution and, moreover, views the worth of a proposal in terms of the outcomes that it generates rather than, say, other dimensions such as justice. Given that equity concerns often dominate discourse about social decisions, this singular focus on efficiency strikes many as odd. Of course, procedures to address equity concerns in economic appraisal – particularly those that involve how project outcomes are distributed – are long standing. So too are the reasons why conventional CBA has tended to downgrade the status of these procedures (although this is subject to shifting favour over time and across policy context).

Arguably, little has changed over the years. There is concern about the affordability of policies evident, for example, in practical examples of CBA in the implementation of environmental Directives amongst relatively new (and lower-income) entrants to the European Union (e.g. European Commission, 2008). There is more recent concern about environmental justice (EJ) problems (e.g. Walker, 2012). This does have relevance for economic appraisal, based as it is on rationing economic resources to those projects and policies where willingness to pay is highest, whereas the contribution of EJ has been to

emphasise how benefits and burdens are distributed amongst different socioeconomic or ethnic groups and whether the processes that have led to this distribution can be judged to be fair.[15]

Day and Maddison (2015) suggest that cost-benefit practitioners could usefully respond to these environmental justice concerns. For example, they note the potential for using evidence about the way in which (air) pollution burdens are distributed by (household) income. These could be summarised in a Gini-coefficient, perhaps calculated for a policy proposal (and compared to the status quo). Examples of this work can be found in the water resource literature (via the so-called 'Water Gini'; see, for example, Wang et al., 2012; Seekel et al., 2011). Clearly, however, there are multiple dimensions to inequality and, to be meaningful, such summaries of distribution also need to explicitly account for this (e.g. by age, vulnerability, and so on).

While it is harder now to find examples which argue that CBA has no responsibility to comment on the distributional impacts of proposals being appraised, exactly how this remit is fulfilled is still open to debate. The proposal by Day and Maddison (2015) stops short of adjusting the cost-benefit decision rule and, in doing so, reflects a judgement that practical obstacles to calculating distributional weights are unlikely to be overcome and that simpler approaches are more realistic (and do offer insights). This view can be found in earlier contributions, such as Pearce et al. (2006).

Nevertheless, there is a need to keep a watching brief on proposals for distributional weights. Arguably (explicit) weighting is used in environmental CBA but it is used inconsistently, or at least the reasons for this uneven use are not explained. For example, such use can be found in the literature on climate change damages (e.g. Anthoff et al., 2009; Anthoff and Tol, 2010). In addition, the value of a key parameter in the social discount rate – the (elasticity of the) marginal utility of consumption – has been informed by distributional debates (although this has not been without controversy).

Adler (2013) and Fleurbaey et al. (2013) are recent examples of serious contributions that seek to put distributional weighting back into the heart of debates about how CBA is conducted more generally. Adler (2013), for example, argues that distributional weighting – based on explicit social welfare functions – is just a way for economists to organise discussion about how social (ethical) preferences should inform decisions. And while this formal approach may seem abstruse to those unfamiliar with the framework, there remains nagging doubts that the reasons usually cited for downgrading distributional CBA are satisfactory (notably about the justification for the separation of efficiency and distribution in the Kaldor-Hicks criterion).

Where distributional weights are applied in CBA, these tend to be defined only in terms of people's income. That is, the weight that a given unit of WTP receives for any given individual depends on where that person is in the income distribution relative to everyone else. So while it is recognised that people differ in non-income attributes (e.g. HM Treasury, 2003), typically this will not be reckoned in distributional CBA. One interesting proposal to incorporate these non-income equity concerns is to calculate weights using the concept of *equivalent income* (e.g. Adler, 2011; Fleurbaey and Blanchett, 2013). Fleurbaey et al. (2013) provide an application of this approach to health appraisal. Intuitively, a

15. The lessons also work in the other direction. Proposed solutions to environmental (in) justices are sometimes naïve from an economics perspective. For example, in the case of locally unwanted land uses (or LULUs), such as waste disposal facilities, simply locating these more equally may trigger behavioural responses – via the housing market – which quickly unravel the solution. This is what is meant by the "move to nuisance" phenomenon. A new LULU might lower local residential property prices (and rents) and may lead, for example, to a relocation of people with lower incomes who move to take advantage of these lower housing costs. This does not mean that environmental injustices do not matter (even if, on the face of it, people have chosen to locate in the vicinity of the LULU). However, it does mean that policy responses need to consider behavioural responses.

person's distributional weight in a CBA is greater if that individual has a lower (current) health status than others and the further away it is from some idealised reference point of "perfect health". The exact computation of this weight is somewhat more complicated and relies on eliciting information from people – in stated preference surveys – of the *money value* they place on moving from their current health status to the reference point.

Whether this approach can be routinely applied remains to be seen. For one thing, determining reference points for non-income dimensions of wellbeing (such as those for the environment) is a challenge.[16] However, one aspect of this work has a more immediate practical implication. This involves using stated preference studies, and environmental valuation methods, more generally to throw light on the way in which policy benefits are distributed across people (e.g. respondents who differ in terms of socioeconomic characteristics). This potential has been scarcely realised in this otherwise growing literature, a point made forcefully by Loomis (2011) with reference to two empirical studies of non-market values from the United States.

One of these examples is a hedonic price study in an area of Los Angeles. Specifically, the policy benefits are the effects on property values of public actions that would decrease the risks of forest fires. The benefits, it appears, are skewed towards particular groups. Specifically, those benefitting are those with higher income, as well as people from particular ethnic groups (i.e. predominately White and Hispanic neighbourhoods). These households would enjoy, post policy, increased asset values of their homes as a result of the lower forest fire risks. The extent to which this distributional outcome matters is debatable. The proposal passes a cost-benefit test and conclusions about whether this runs counter to equity concerns partly depends on how the costs of the policy are to be financed. Put another way, if policy costs can be targeted (in some way) on those groups who predominately benefit, then at least some of this distributional concern is mitigated. The more important take-home message from both of these examples is that distributional insights could be garnered from the growing empirical record about environmental valuation. That this potential remains unrealised is a missed opportunity.

5. Risk and uncertainty

While costs and benefits are rarely known with certainty, the "flipside" of this – namely, uncertainty – whether about a physical impact or its value is a question of extent as well as its nature. In some cases, a risk probability distribution might be known although such distributions differ according to their degree of sophistication. In other cases, those of genuine uncertainty, there is no known probability distribution. The ways in which risk and uncertainty has been integrated into CBA has not changed much over the years. In practice, this has meant use of sensitivity analysis or the calculation of expected values (where the decision-maker is assumed to be risk-neutral) and expected utilities (where decision-makers are assumed to be risk-averse).

This does not mean that novel insights have been wholly lacking. Progress in climate economics, for example, has highlighted key points (understood in other sub-fields of economics) about the way in which project risks may or not be correlated to broader economic prospects. For example, Quinet et al. (2013) discuss CBA practice in the context of systemic risks to the economy. This, they argue, suggests a premium to projects that are uncorrelated with the growth rate of the economy. Put another way, a 'distinct' (or identifiable) category of project benefit is whether or not it magnifies these broader fluctuations.

16. Nor does the approach overcome debates about other key parameters determining distributional weights; notably the elasticity of the marginal utility of consumption.

One major challenge is translating some of these more sophisticated conceptual approaches to considering risk such that these can be routinely usable in official CBA (Day and Maddison, 2015). Quinet et al. (2013) propose for example possible magnitudes for risk premia. Another example could include the use (and interpretation) of option prices: i.e. how much (risk averse) individuals are willing to pay for removal of the causes of undesirable wellbeing prospects. A further challenge in terms of lessons for official CBA is to consider more comprehensively and formally the possible value of postponing decisions; specifically those which otherwise would result in irreversible damaging consequences for the environment. Postponement here has a value where there is potential for learning. In environmental economics, this is mostly known as quasi-option value, although elsewhere, in financial economics, it has been called 'option value' or 'real options'.

Traeger (2014) provides a recent elaboration on both these emerging traditions and their respective implications for the cost-benefit rule. For example, in the case of quasi-option value, the relevant comparison is with the net present value of a development project if undertaken 'now' and the value of learning if the project is postponed in addition to any future (net) benefits which be realised if the option to develop is taken up in a future period. For Day and Maddison (2015), a promising way of integrating this framework in official appraisal is by promoting the greater use of probabilistic decision trees (which illustrate various combinations of benefits in different states of the world). Of course, while encouraging greater scope for consider benefits from postponing development decisions in this way might be a better use of recent economic insights, political deliberations may downgrade approaches which appear to give a premium to inactivity.

6. Sustainability and natural capital

Arguably unresolved is the bridging of the gap between CBA and the strategic objective of sustainable development. How large this gap is depends on how sustainable development is defined. If it is defined broadly (i.e. covering development processes and multidimensional outcomes) – as in existing national sustainable development strategies and, as seems highly likely, in the United Nations' Sustainable Development Goals – then CBA is not enough because it cannot possibly cover the breadth implied by these high-level frameworks. If instead sustainable development is conceptualised less broadly – in terms of the economic definition of non-declining (per capita) wellbeing over time and to manage wealth or assets in order to achieve that end – then the gap narrows (and for some is eliminated), or at least differences in approach can be understood more clearly.

All this suggests a number of (possibly) complementary paths. One is that given that concern about sustainable development is based explicitly on judgements about distributional outcomes, this also reinforces the need for official guidance to be followed in practice on minimum requirements for reporting how costs and benefits are distributed over time. This call is not new (e.g. IPCC, 1996) but has been recently reiterated in Day and Maddison (2015). Additionally, in terms of decision rules based on CBA, what is currently within the 'art of the possible' – in terms of reconciling CBA with sustainability concerns – this forces explicit thinking about how much of nature should be put beyond *straightforward* cost-benefit thinking.[17] Finally, it is important to continue improving the reach and accuracy of valuation methods across a greater range of natural assets. In this way, the practice of CBA will be improved in order to better reflect, for example, the losses that are endured as natural assets become increasingly scarce.

17. There is a parallel here to the sustainable development debate about concepts of "weak" and "strong" sustainability. In the latter, special status is accorded to natural capital protection. And while it may be possible to reflect this by valuing these assets to reflect this importance – and so incorporate in a standard CBA test – this is argued by proponents to be currently 'difficult' or 'problematic' and more straightforwardly dealt with as a constraint on what policies and projects are permitted to do.

6.1 CBA and sustainability

CBA gives information about the (social) worth of individual projects and policies. Some of these interventions may be large but typically they are discrete and marginal changes (or at least are assumed to be for analytical purposes). There remains then a residual concern that this incrementalist approach to policy decisions does not consider the sustainability of the system; notably the sustainability of an economy's development path (or perhaps the cumulative impact of proposals on particular assets such as natural capital).

Quite how to deal with this concern is another matter. One approach is to say there is little wrong with the way with which CBA is conducted (although there are caveats to this view which its proponents readily recognise and that are being discussed later). For example, Day and Maddison (2015) suggest an interpretation of choosing proposals with positive net benefits *potentially* consistent with the sustainability of development. What they argue is that the measured benefits of such proposals can be viewed as investable economic resources. If a proposal also results in costs which amount to losses in asset values (perhaps because natural capital is depleted or degraded) then the corresponding gains can be used to invest to offset this and, as such, keep capital constant.

Whether this investment is actually made is a further judgement for decision-makers to come to. Hence, the contribution of positive net benefits to sustainability is potential. But if decision-makers who believe in using CBA to make policy choices also are committed to broader sustainable development then the resources to realise this latter obligation, in the light of policy choices, are available. For practical purposes, this suggests two bits of policy-relevant information should be co-joined. The first is the standard one: choose projects which maximise net benefits. The second is whether total assets in the economy are at least constant. This latter could be assessed by looking at whether adjusted net – or genuine – saving is positive or otherwise (given that this indicates how net assets are being accumulated in the economy).

This makes an important assumption that practitioners are able to comprehensively (and correctly) asses changes in natural capital – both from the perspective of conducting CBA and measuring genuine saving. Progress on environmental valuation – and particularly in the realm of ecosystem (service) valuation – offers some encouragement here. But important debates remain about this progress. And regardless of whether one views the glass as half-full or half-empty in interpreting those debates, addressing this valuation challenge remains work-in-progress. For example, it is clear that a great many development projects have an impact on biodiversity; i.e. by changing land-use and ecosystem habitats. However, it is far from clear that even state-of-the-art appraisal can provide an adequate assessment of the value of this loss.

One idea, dating back at least to the early 1990, is that limits to valuation mean that certain components of natural capital (notably "biodiversity", but not limited to this) need to incorporated within CBA as (sustainability) constraints (see, for example, Quinet et al., 2013) for a discussion of practical issues in valuing biodiversity in official CBA in France). More recent attention has focused on the form these constraints should take with, for example, an emphasis on thresholds and (safe) limits. This, in turn, necessitates reflection on how is known, as a practical matter, about such thresholds across different natural assets. A global example here is climate change. Economic thinking (and CBA as part of that) has been used to help the frame discussion about what should be the appropriate level of ambition in global climate policy (see, for example, Stern, 2007; Weitzman, 2007). However, these political debates about global climate targets arguably have been based to a far greater extent on judgements about what degree of

warming can be 'tolerated' without physical thresholds being breached (e.g. Rockström et al., 2009; Steffen et al. 2015).[18]

Incorporating information about scientific thresholds is then one way in these sustainability constraints can be envisaged. Another way is that constraints might reflect instead different "belief systems" thought to be focal to a policy problem. Put this way, CBA represents one belief system; based on an assumption of the importance of being explicit about the implications of policy choices for the way in which economic resources are used and, in particular, the trade-offs that this involves. Alternate belief systems might reject these trade-offs perhaps by prioritising protecting nature arrived at through particular ethical perspectives. Rather than rejecting CBA altogether, the 'sustainability constraint' approach becomes a useful way of viewing the implications of these different beliefs. Not least it facilitates some explicit understanding of the costs of observing constraints (as well as the benefits).

A recent development is the practical implementation of this idea in real-life settings under the guise of biodiversity offsetting. Common to this earlier literature, which viewed the principle of sustainability as applying to the portfolio of projects, under offsetting proposals, biodiversity – in the round – must be maintained (or enhanced) by requiring that to the extent that any one project degrades or destroys an ecosystem or damages biodiversity, this must be "covered off" by improvements or additions to ecosystems or biodiversity elsewhere: i.e. so-called shadow or compensating projects (e.g. NCC, 2015, Mace et al., 2015).

While resource compensation preserves some trade-offs between costs and benefits it plainly circumscribes cost-benefit thinking in a substantial way. Roach and Wade (2006) provide an empirical investigation of this resource compensation or 'equivalency' in the context of habitats. And as mentioned the practical counterpart are policy instruments which variously go by the names of "mitigation banking, 'habitat banking', resource equivalency (REMEDE, 2008) or 'biodiversity offsets'. A commitment to scaling up these schemes can be found variously in the Aichi targets,[19] EU Biodiversity Strategy to 2020[20] and the UK Natural Environment White Paper (Defra, 2011). BBOP (2012) defines the latter as: "… measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken." (p. 12).

Moreover, it asserts the goal of these interventions is: "… to achieve no net loss and preferably a net gain … with respect to species composition, habitat structure, ecosystem function and people's use and cultural value associated biodiversity" (BBOP, 2012, p. 13). This is a challenging array of attributes to offset. Not surprisingly, practical examples of biodiversity offset schemes have fallen short of this ambition, relying instead on relatively simple metrics on habitat extent and quality. This has led to debates about whether compensation is genuinely 'like-for-like' (and how this might be better guaranteed) as well as other issues such as governance and additionality / leakage (see, for example, Bull et al., 2013; Gardner et al., 2013; POST, 2011).

18. That is, there is little sense now (for a variety of reasons) in which global CBA is being suggested as a means to optimise the global response according to some assessment of the NPVs of different scenarios. CBA presumably will still have a role to play to help to guide policy actions, however, in individual countries (or groups of countries). That is, in choosing those mitigation options which are most effective in contributing to global targets or which adaptation projects should be implemented to cope with climate change to which the world is (likely to be) committed already.

19. See *www.cbd.int/sp/targets* (accessed April 2015).

20. See *http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm* (accessed April 2015).

6.2 Accounting for sustainability

The most prominent use of environmental valuation has had CBA applications in mind. Some agenda-setting contributions have sought to provide relatively aggregated assessments using valuation procedures. Costanza *et al*. (2014) update an earlier prominent study (Costanza et al., 1997) and so has sought to estimate the global value of ecosystem services. Essentially, this is an estimate of the global value of ecosystem services – i.e. the return – from the entire stock of all ecosystem assets. This revisits previous debates about the meaning of such values; that is, is the interpretation that this is the loss that would occur if there were no ecosystem assets at all? However, this more recent study estimates a measure of value of the *change* in ecosystems (which apparently lies in the range of USD 4.3 to USD 20.2 trillion per year). It therefore shifts debate to valuation based on accounting for policy-relevant changes. Criticisms remain, however, notably about whether or not it is possible to make such global assessments; that is, for example, does it stretch the existing empirical record to breaking point?

Nevertheless, there is a role for relatively highly aggregated assessment that use insights and approaches based on valuation techniques more commonly used in CBA, whether these are based on national accounting principles for looking at actual changes or economic analysis of clearly defined policy scenarios. Two recent studies, for example, have sought to calculate losses in natural assets likely to occur according to possible policy scenarios (and hence in principle ask a more defensible question than that about the totality of the current service flow). Hussain et al. (2012) estimates the losses arising from recent past and projected future loss of the world's aquatic ecosystems (specifically wetlands, mangrove and coral reefs). The present value of this loss over the period 2000 to 2050 (using a discount rate of 4%) is reckoned in excess of USD_{2007} 2 trillion (with two-thirds of this accounted for by wetlands). The annualised value of this total change is just under USD 100 billion (that is, the value of the loss of these ecosystem assets each year is estimated to be of this magnitude) which, e.g. in 2007, was just 0.2% of global gross income. Chiabai et al. (2011) conclude not entirely dissimilarly for the case of the loss of global forests over the same time period.

Such broad estimates of ecosystem loss still require some heroic assumptions and generalisations (with the same being true of efforts elsewhere to value the global impacts of climate change). Indeed, for some critics, a search for a global value is a flawed project because of this.

Taken at face value it appears that knowing the global magnitude of ecosystem losses might not add significantly to empirical discussion. So while it is entirely possible that these analyses are missing something possibly both large and critically important, a tentative conclusion is that the pragmatic demand for more highly aggregated indicators of trends and concerns about validity both point away from an emphasis on global trends. Greater practical significance, however, is to be found at the regional or country level. In the case of forests, for Brazil, estimated losses in natural wealth are found by Chiabai et al. (2011) to be substantial (as a percentage of the country's gross national income or GNI). Hussain et al. (2012) find that for aquatic ecosystems, for the South Asia region and for Indonesia, however, these annual losses in natural wealth were respectively 1.7% and 4.0% of GNI (in 2007).

These are magnitudes worth knowing more about. This would necessitate still closer scrutiny about the robustness of such estimates. The basic problem of accounting for the value of ecosystems can be put simply. The issue of spatial variability here is central. Some of this can be captured in aggregated analysis. For example, Gundimeda and Atkinson (2014) provide a broad assessment of the asset value of forests across a number of countries with valuation built from a meta-assessment of available studies and country characteristics. Dealing with these issues properly, however, is a challenge (Barbier, 2014). This includes properly accounting for variation in the supply characteristics – the type and extent of functions – of ecosystems as well as demand characteristics – of the human population that consumes services that these

functions give rise to. All this requires relatively sophisticated mapping and is demanding in information terms.

While it might be that at the national level (or sub-national levels) these issues become a little more tractable (see, for example, Kaveira et al., 2011), studies are likely to be imperfect. Examples do exist, however, of assessment built on spatially rich data about ecosystems. Barbier (2013), for example, illustrates one such study for mangroves in Thailand within an accounting framework and shows the implications for accounting aggregates such as net product and genuine saving.

One further interesting feature of this work is that accounting for deforestation (such as loss of mangroves but also more generally) builds solidly on CBA principles. The basic unit here – following Hamilton and Atkinson (2006) and Barbier (2009) and earlier contributions, particularly Hartwick (1992) – is land. That is, land under a particular use has a distinct asset value. When land-use is changed – as happens when forestland is cleared – this can be viewed from the perspective of CBA; that is, is the change net beneficial? Additionally, there is a corresponding implication for how wealth is changing in the economy that must be accounted for.

In the case of deforestation, decrease in the value of forestland leads also an increase in the value of in agricultural land assets. Put another way, what has happened here is a change in composition of the broader portfolio of land assets. For example, if one ecosystem service provided by woodland is climate regulation (via carbon sequestration and storage services), increasing the amount of woodland will increase the provision of these services. But there is likely also to be some loss in the climate regulation services provided by agricultural land and, ideally, these services that are lost also need to be recorded somewhere. Forestland is also an asset providing multiple benefits and it is important that as many of these are accounted for as possible.

In addition, there are further measurement issues. Clearly, other services that change as a result of the land-use switch need to be accounted for. The broader balance sheet, for example, will reflect the loss in agricultural output and so on. There are also presumably conversion costs associated with changing land use and those investment costs should also be accounted for.

6.3 Valuing natural capital

Clearly, there are practical questions about whether official CBA consistently conforms to best practice about say environmental valuation as laid down in guidelines. And, more ambitiously, do the guidelines reflect the knowledge frontier given that this is a rapidly developing field. In one respect a case can be made as to a positive answer to this. Recommendations about time-varying social discount rates allow much greater prominence (relative to previous practice) to be given in appraisal to impacts of policies and projects that arise in the distant future. This will help ensure – contingent on the term structure of the resulting discount factors – that concerns about the future consequences of current actions are not simply assumed away by the 'tyranny of discounting'.

There could be systemic problems such as evaluating future prospects using 'sustainability prices' – that is, prices which are consistent with realising a sustainable path (which is a different point to the matter of correcting prices for current market, and other, failures). The point here is that there might be some sustainability problem that appraisal at the project level or aggregate level, for that matter, will not pick up. Part of this agenda requires improving how environmental valuation takes future values in account generally and how increasingly scarce resources whose services cannot easily be replaced are valued more specifically. Clearly, one cannot possibly know exactly what future preferences will be – that is, what future people will value – beyond those things one can feel confident will continue to be required for survival or basic functioning. The usual practical response to this uncertainty is to assume that future

people have the same preferences as those living in the present but to uplift these values to take into account the likely effects of changing (i.e. growing) per capita income. Less common is taking account of the likely path of natural assets. That is, if it is thought that environmental amenities will become more scarce in the future then it is plausible that the (marginal) value that will be placed on future losses of this amenity will be higher (than now).

Contributions by Hoel and Sterner (2007) and Sterner and Persson (2008) take this somewhat further by asking whether estimated values adequately reflect substitution possibilities between nature and other (non-natural) assets. Both of these papers show how the value (or shadow price) of a scarce environmental amenity might increase over time. To calculate this, a number of assumptions must be made. Most notably, a judgement needs to be made about the ease (or difficulty) with which particular natural assets can be replaced; i.e. the 'elasticity of substitution'. The higher the value of this elasticity (reflecting the greater difficulties of replacing a natural asset with another type of wealth), the faster is the increase of the price of an environmental amenity as the natural asset (giving rise to that amenity) becomes more and more scarce.

Although the exact details are a little involved, the proposal is that a lack of substitution possibilities for a scarce resource provides a further reason to boost estimates of future willingness to pay to be used in a CBA that seeks to value what is lost when this resource is destroyed or degraded. Put another way, there is reason to assert that, if natural assets become scarcer, future changes in the amenities provided by those assets will be valued more highly (at the margin). This tendency will be reinforced where the asset in question is characterised by poor substitutability (such that the amenities that it provides cannot easily be compensated for by increases in other goods and services that future people might value).[21] There are important links to the discount rate debate in this work. Traeger (2011) shows limited substitutability affects the magnitude and term structure of the social discount rate.

7. Cost-benefit analysis in the real world

There is an important counterpart to taking stock of recent developments in CBA. This is assessing how these developments, and CBA more generally, actually are used in 'real world' economic appraisal. Commonly this is interpreted as the extent to which developments are translated into official guidelines which set out the procedures for undertaking CBA within a jurisdiction or organisation. Recent contributions such as Day and Maddison (2015) (for the UK) and Quinet et al. (2013) (for France) have sought to make recommendations about these guidelines and, in doing so, address new challenges. Given these guidelines are focal publications – in some sense, these are a bridge between the CBA textbook and policy applications – shaping these documents is important. However, the existence of guidelines – however good and reflective of the state-of-the-art – cannot be viewed as sufficient an indicator that CBA is actually used or that it is influential.

To make such claims, further evidence about actual practice must be sought and this itself is an important area of research that deserves more attention (Hahn and Dudley, 2007; Hahn and Tetlock, 2008). 'Use', for example, might be equated to actual uptake – i.e. its presence in an impact assessment – although this should also involve asking questions about how comprehensive these uses were as well as their quality. Assessing 'influence' is arguably more difficult still, requiring further quantitative and qualitative investigation. In what follows, some of the available evidence on these issues is considered.

21. The complications do not stop here. Nor do these additional considerations all work in the same direction of saying that WTP in the future is higher than now. For example, Horowitz (2002) reviews a number of compelling psychological factors that plausibly could come into play when thinking about how future people might value, in particular, environmental losses. Among these is the notion of reference dependence. This refers to the observation that people have an inclination towards valuing changes relative to some reference point: typically, the current situation that they face. Of course, if environmental quality is itself changing over time then so is the reference point against which change is evaluated.

7.1 The use and quality of CBA

One reflection on the use of CBA in the World Bank was revealed in a recent assessment by the Independent Evaluation Group (IEG) (2011). The proportion of World Bank projects using CBA dropped significantly from 1970 to 2000. According to IEG (2011), one (proximate) explanation for this trend was a shift in investment portfolio from policy sectors with a tradition of using CBA (e.g. energy, transport and urban development) and those which do not (e.g. education, environment and health). Nonetheless, the IEG report still found a significant reduction in the use of CBA in traditional sectors which the World Bank remains heavily committed towards investing in (e.g. physical infrastructure). Moreover, given the strides made in extending CBA thinking and practice to novel project venues, a question inevitably arises as to why this progress has not been translated into actual appraisal in these new sectors.

How general are such findings? In the US, a review of 74 impact assessments issued by the US EPA from 1982 to 1999 found that while all of these regulations monetised at least some costs, only about half monetised some benefits (Hahn and Dudley, 2007). Fewer still (about a quarter on average), provided a full monetised range of estimates of benefits although the number doing increased notably over the sample period. This raises important points. Clearly, there is more to do to increase the use of CBA, not least to bring actual practice in line with official guidelines. However, nor is it the case that use of economic appraisal is entirely lacking; it is usually present but often partial.

A logical further question is whether, when applied, CBA applications were any good. Some of the indicators assembled by Hahn and Dudley (2007), for the US, identify a number of relevant issues. For example, even for those (US EPA) applications which estimated costs and / or benefits, it was relatively uncommon for these estimates to be complete (rather than monetising a small sub-set of impacts) and for point estimates to be accompanied by a range (that is, low and high estimates of the value of a given impact). Moreover, the consideration of different options or alternatives, in cost-benefit terms, was also infrequent. More commonly, practice involved simply comparing some (presumably) favoured single option for a policy change with the status quo. A similar finding emerged from another recent study of EU studies of environmental projects for which financing was requested under regional assistance schemes (COWI, 2011).

Another way in which quality might be assessed is by asking: how accurate is CBA? Testing this might involve a mechanical exercise to compare the results of ex ante and ex post CBA studies of the same intervention. An ex ante CBA is essentially a forecast of the future: estimating likely net benefits in order to inform a decision to be made. Ex post CBA – i.e. conducting further analysis of costs and benefits of a project at a later stage – can be viewed therefore as a "test" of that forecast. That is, what can we learn – e.g. for future, similar applications or the accuracy with which CBA is undertaken generally – with the benefit of this hindsight? Actual use of ex post CBA is less common than use of economic appraisal ex ante. But there are some important exceptions.[22] For example, Meunier (2010) documents extensive official use of ex post CBA for transport infrastructure investments in France going back a number of years.

Such assessments can provide useful and additional insights which could improve the way the ex ante CBA is done (and its findings interpreted) (Meunier, 2010; Quinet et al., 2013). Flyvbjerg *et al*. (2003) provide a meta-study of the ex ante and ex post costs of transport infrastructure investment in Europe, USA

22. Whether ex post studies can be routinely undertaken is an open question. There may be little appetite amongst politicians for adding costly ex post studies to look at decisions which are literally history and a potential source of political embarrassment (Hahn and Tetlock, 2008). However, the fact that some countries (e.g. France) and institutions (e.g. the European Commission) appear keener to use the CBA in this way suggests that this is a matter of degree.

and other countries (from 1920s to 1990s). The results are revealing: ex post cost escalation affected 90% of the projects that they examined. Nor are cost escalations a thing of the past according to these data. HM Treasury (2003) for example provides guidance for incorporating such findings into actual appraisal through official premia on investment costs (and timetables to completions) in the case of physical infrastructure projects. However, the direction of bias is not uniform across policy contexts. The opposite can be found in the case of environmental policy regulations. For example, MacLeod et al. (2009) find evidence across the EU for lower regulatory costs ex post (than predicted ex ante), a finding they attribute to firms affected by these burdens finding more cost-effective ways of complying with policy. For the United States, however, Hahn and Tetlock (2008) find no systematic evidence of such bias for environmental regulations.

7.2 The influence of CBA

That the quality of many CBA applications could fall short, and possibly far short, of good practice or what is in official guidelines might lead to scepticism about whether there is a serious commitment to using economic appraisal to guide policy formulation. It may even be the case that CBA is seen simply as a box to tick, perhaps because it is an obligation (COWI, 2011). While it would be a mistake to claim that CBA has almost no influence at all, it would be equally erroneous to claim it is nearly always influential.

Yet, determining the extent of influence is far from straightforward. For example, IEG (2011) find *relatively* higher returns for World Bank projects for which ex ante CBA had been undertaken. Yet, disentangling the influence of appraisal from other confounding factors is a challenge. Hahn and Tetlock (2008) review evidence of influence of economic appraisal on a number of health and safety regulations in the United States. This appears to indicate little effect in weeding out regulations which protect life and limb at inexplicably high cost. Moreover, where influence can be identified, CBA has tended to be used to formulate the specific details of an already chosen option. That is, it is more difficult to find examples where CBA has been used to help guide thinking about appropriate policy responses from the outset of the decision process.

The fact that decisions are often inconsistent with, or downplay, CBA can be squared with the reality that, in practice, CBA is only one input to the decision and, in some circumstances, other considerations trump economic thinking. The experience of the London Congestion Charge (LCC) illustrates how economic considerations are balanced in this way. The LCC requires that those motorists entering the congestion charge zone around central London during designated hours must pay a charge. The cost-benefit case for a charge in London was arguably long-standing (Newbery, 2006). However, the (initial and uniform) GBP 5 daily charge appears to have been largely politically determined. So, while the actual scheme had a positive net benefit, it did not provide Londoners with the maximum net benefits. Santos and Fraser (2006) show how this would have required very different externality charges for different motorists (and substantially higher for some groups); something that may have been politically difficult given distributional and related concerns.

The evaluation of London's "Supersewer" perhaps provides an example of this. This project is a major physical investment in London's sewage system proposed by Thames Water plc and which in turn would be financed by higher water charges for its customers (e.g. see, for a discussion, Mourato et al., 2005). The benefits are largely intangible stemming from a substantial decrease in the wastewater discharges into the River Thames that occur currently. While an initial study of the costs and benefits to households in the Thames Water (TW) region concluded that the project yielded net benefits, the project was rejected by the water sector regulator (OfWat).

A second CBA study (of the same project) undertaken a few years later re-valued the intangible benefits on the basis of new ecological data as well as looked at benefits to people beyond the TW region

(given the cultural significance of the River Thames). While this second study found the cost-benefit lacking if only TW customers were considered; if benefits to people living beyond that area were considered, the project was justified on cost-benefit grounds. This time around the project gained the necessary political support and was approved. What circumstances changed between these two studies is a matter of speculation, although it is unlikely to be driven by the cost-benefit studies alone.

As Hahn and Tetlock (2008) note, policy decisions are by their nature political. It is probably also the case that this is more overt in some policy venues than others. Discussions about influence clearly need to consider the 'political economy of CBA' and behavioural incentives that policy actors face. For example, Florio and Santori (2010) look at the issue of appraisal optimism in the context of the EU appraisal of the Cohesion and Structural Funds disbursed as part of its regional policy.[23] An issue arises here because in making its decision to approve financing for projects, the EU is reliant on the information (about costs and benefits) that it receives from those in eligible regions proposing investments (such as in transport or environmental infrastructure). This might be a regional or national authority which in turn could be using information provided by private agents (e.g. a contractor of some description).

COWI (2011) illustrates the incentive problem starkly here in the following quotation from a Member State representation that appraisal is: "… a matter of making the financial analysis look as bad as possible in order to increase the funding need, and to make the economic analysis to look as positive as possible in order to justify the public funding" (p.x). There is an increasing suspicion that such incentives could explain a lot of what was previously thought to be simply analytical shortcomings. De Rus (2011) is particularly concerned about rail projects: demand forecasts always seem too high and cost forecasts always seem to be too low, all viewed from an ex post perspective. Forecasting is undoubtedly challenging and so may result in technical errors being made. However, strategy possibly plays its part as well.

There is a risk of concluding too gloomily about the use and influence of CBA on actual decisions (although that might be an interim conclusion based on the evidence available so far). More comprehensive evidence is needed both in respect of the use of CBA for discrete proposals and its agenda-setting role too. In the United Kingdom, the Stern Review on the Economics of Climate Change (Stern, 2007) and the UK National Ecosystems Assessment (NEA, 2011) are examples of this. Other large-scale ecosystem assessments – such as the TEEB Review (TEEB, 2010) – use benefit assessment to provide clues about what has been lost when ecosystems are depleted and degraded. While not a substitute for policy (which will then require evaluation), this sort of knowledge is important for framing policy thinking.

Such an assessment requires taking further stock of an array of experience across a variety of institutions and policy venues. Companies in the water industry in England and Wales, for example, make use of social CBA as one element of the investment case that they put forward to OfWAT under the periodic pricing reviews that this sector is subject to. This has resulted in a huge grey literature on the practical implementation of stated preference methods – notably approaches based on choice modelling – within the water sector. It is clear that the mass of experience from academic and technical expertise has had a big influence on this process. Lessons undoubtedly can found too in these studies; however, as these data are both proprietary and unpublished (in large part), the extent to which these lessons can be realised is more questionable.

CBA was extensively used in 2014 in a Canadian assessment of its air quality management options (Canadian Department of the Environment / Department of Health, 2014).[24] The values estimated included

23. The EU Structural & Cohesion Funds (SCF) disbursed more than EUR 300 billion over the period 2007-13. How parties applying to the SCF should carry out CBA is illustrated in a guidance document (European Commission, 2008).

24. See *www.gazette.gc.ca/rp-pr/p1/2014/2014-06-07/html/reg2-eng.html* (accessed July 2015).

those associated with health improvements as well as a range of environmental values, such as impacts on agricultural productivity (through reductions in ground-level ozone exposure), reduced soiling of residential and commercial buildings (through reductions in particulates) and improved visibility. This appears to give very high benefit-cost ratios – in the range of 15 to more than 30 – for regulations which increase the environmental standards that (non-transportation) engines, boilers and heaters as well cement production meet. Assuming these values are roughly accurate, this indicates some clear economic merits to tightening these standards. An interesting feature of this analysis is that it is the culmination of a collaborative institutional process involving, amongst others, federal, provincial and territorial governments across Canada.[25]

An important development is the growth of institutional infrastructure needed not only to set the rules for practical CBA applications (e.g. guidelines and manuals) but also to facilitate the processes as to how CBA is done – e.g. by building often substantial capacity – and to scrutinise (and rate) the quality of appraisals. Impact assessment in the EU is one prominent example of this and itself reflects an ongoing process with the most recent guidelines strengthening the potential role for CBA (European Commission, 2009a, b). This now requires that the executive summaries of Impact Assessment (IA) reports "… provide a clear presentation of the benefits and costs (including appropriate quantification) of the various options …" (p. 1). Presumably this makes this information more focal and thus more likely to be engaged with seriously throughout the appraisal process itself. In addition, this requirement for more prominent CBA in EU IA is supplemented by increased guidance on assessing and valuing non-market impacts. But a crucial element of these recent developments is the addition of independent scrutiny of IA conclusions and appraisal via an Impact Assessment Board (IAB). Banable (2013) summarises some of the key issues which have emerged from the scrutiny work that this body undertook in the period 2009 to 2012. Amongst the most prominent and frequent conclusions on the quality of IAs generally have been issues identified with the analysis of impacts, definitions of project objectives, baselines and options as well as the assessment of economic impacts.

A recent example of an IA subject to this scrutiny is European Commission (2013a) which sets out options for institutional rules to develop unconventional energy resources (e.g. shale gas) in Member States (including a potential new Directive if current legislation, particularly on environmental protection, is deemed insufficient). Important aspects of this appraisal that the IAB opinion document (European Commission, 2013b) focuses on includes asking for clearer identification of economic benefits (both in terms of assessing impacts on economic activity and fiscal revenues) and a greater consideration of costs and benefits of options more generally (as well as specific queries about how compliance cost estimates were calculated for those data which were presented in the original IA).

Evidence of scrutiny in the EU can also be seen in the institutions of the Chemicals Directive (i.e. REACH, see for example, European Commission, 2007). Under this regime, the use of (new and existing) chemicals by industry is licenced with these permissions only approved if an applicant can show that the net social benefits are positive. The recent establishment of the Regulatory Policy Committee in the United Kingdom replicates this sort of scrutiny process for domestic policy proposals within that country. This also provides a systematic (and publicly available) database of regulatory appraisals by HM Government as well as a summary record of the quality ratings of these appraisals. The UK case is not unique; other examples exist for other countries too, such as France (see, for example, Quinet et al. 2013). All of these measures could have an important influence on the quality of CBA from the outset (e.g. if poor quality or inadequately detailed appraisals become more likely to rejected). As such, these developments make an important contribution to more general discussions about institutional arrangements for conducting CBA (e.g. IEG, 2010).

25. See *www.ccme.ca/en/resources/air/aqms.html* (accessed July 2015).

Greater uptake of CBA, of course, depends in no small way on how practical and accessible the tool is to routine use. Renda et al. (2013) provide an assessment of the role and use of IA methods amongst other EU Member States and beyond and discuss critically how different approaches might be routinely used. That judgement is based on a range of criteria, including burdens imposed by data requirements and whether applications can be done by generalists or only those with access to specialist skills (of using economic models and so on). To some extent, this is a moving target. Stated preference methods are according to Renda et al. "… costly and time-consuming …" (p.122) although some developments such as on-line surveying should go some way to lowering these costs. Nevertheless, these authors are right not to underestimate the immensity of the data challenge more generally.

Responding to policy needs in a timely way is an important attribute for appraisal processes to be judged against. In this respect, the growing breadth and depth of environmental valuation databases is a notable development. This includes the pioneering EVRI database (Environmental Valuation Reference Inventory) maintained by authorities in Canada (*www.evri.ca/Global/Splash.aspx*). Pearce et al. (2006) noted that EVRI had 1 600 studies catalogued. This number has since grown to over 4 000 summaries of environmental and health valuation studies. Assuming ease of access to this empirical record, it potentially facilitates a better responsiveness mode for valuation practitioners both in terms of time and cost. Yet it also involves its own challenges as identified in Pearce et al. (2006), notably in terms of judging which values are suitable to use in a given appraisal (and how these values might be adjusted). It is also important to judge when 'look-up' values are no substitute for original valuation studies. Notwithstanding these concerns, the existence and continuing growth of these databases is surely a welcome development.

The data challenge is not just on the valuation side. Carsten et al. (2013) provide an example of this for establishing whether complying with the Water Framework Directive (WFD) in Denmark may lead to disproportionate costs. This evaluation provided by the authors first has to map and assess river basin characteristics (in terms of mapping water bodies, assessing ecological status and so on) before moving on to consider how to establish valuation data. Nevertheless, these challenges can be overcome as Carsten et al. show in identifying a potential three to five river basins in Denmark (out of a total of 21) where costs of WFD compliance appear to be disproportionately higher than benefits.

In the United Kingdom, the Environment Agency is using CBA to consider options for WFD compliance. An interesting feature of these appraisals is that much of the detailed appraisal work is undertaken by dozens of environment officers working in relatively local river management catchments. In this case, local knowledge of ecological conditions is combined with valuation data which has been collated more centrally. What this means is that if the data provision challenge can be surmounted, transforming this into meaningful appraisal need not be the preserve of the economic specialist. Developing the institutional infrastructure to facilitate such application more routinely across policy contexts deserves further consideration. Within the EU, Renda et al. (2013) suggest one option might be to establish an institution (perhaps within an existing organisation, such as EUROSTAT) that would coordinate these efforts to facilitate some of the data collection and provision.

8. Conclusions

Cost-benefit analysis or CBA has been developed over a long period of time and most of its advocates would argue that, even if policies are not solely formulated on the basis of CBA, decisions at least should be informed by this tool. Thus, CBA is a normative policy formulation tool for making recommendations to policy makers about what they should do. This paper has reviewed a number of developments over the past decade or so (and largely since the completion of Pearce et al. 2006). All these developments have sought to improve this normative role for CBA through evolved procedures for evaluating costs and benefits.

This has included progress in the field of environmental valuation. While it is arguable that the most exciting breakthroughs occurred pre-2006, a number of recent developments have been worth noting. One of these is the extension of valuation into different and new policy domains and the more routine application of these methods in environmental policy. In this respect, environmental valuation now shows signs of being a mature and established sub-field of enquiry in environmental economics (and is gaining broader acceptance elsewhere too). Another development is the emergence of valuation based on subjective wellbeing approaches. This is important as it possibly opens up a new frontier within this field.

Serious deliberations have also surrounded recent discussion of discounting in projects and policies with long-term impacts. Some of this progress can be seen well before 2006 but progress in understanding the issues has continued apace since. Indeed, this has hardened the consensus behind core propositions, notably declining discount rates. Important conceptual developments as well as empirical work have been a feature of this recent discussion. The implications for CBA of concerns about the sustainability of development paths and in particular what is happening to natural capital (and how project proposals affect this) have also been notable. Challenges still persist in that domain, notably in the questions it raises about when it is appropriate to use CBA or whether 'non-economic' decision rules should dominate or circumscribe economic appraisals (e.g. via sustainability constraints). However, if CBA is to be relevant to the new natural capital agenda, it must respond to these challenges and evolve appropriately.

This paper has also identified the important role that a growing number of studies have played in providing a positive analysis of when and why CBA is relied upon to formulate actual policy decisions (and when it is not). This literature has sought also to understand at what stage in the policy process this assessment actually takes place (e.g. is it at the beginning when establishing potential policy options or is it well after the political decision to do something has been made?). Reading the evidence to date provides a sobering moment of reflection for those who believe that CBA is always used, is always done well and is always influential in policy formulation. This suggests the importance of ultimately placing developments in policy appraisal, including CBA, within a realistic understanding of how the policy formulation process actually works.

A conclusion that "real world" decisions downplay CBA needs to be interpreted with care. However, the policy literature contains some useful insights for doing better. Some of this emphasises the importance of understanding behavioural incentives and perceptions on reliability of those who undertake and use CBA for policy. This does not negate the merits of continued efforts to improve and advance the methods used by cost-benefit practitioners. Indeed, the two concerns are likely connected. To the extent that practical CBA is perceived as lacking a robust basis it is presumably less likely to be used. Importantly, there are increasing signs in real policy processes that the institutional infrastructure needed for greater use and influence of CBA in policy is evolving rapidly and in a way that will reinforce and strengthen uptake and use of (environmental) CBA in the future.

Nevertheless, there is a possible irony at work here. A number of recent developments, while diverse, reflect relatively technical and, increasingly, specialised debates. Continuing discussion about discount rates is one prominent example of this. This specialisation has clearly been crucial to proper and sustained progress on unavoidably complex issues. But it arguably risks less chance of actual uptake unless, for example, these lessons can be easily translated in practical terms (and moreover economic capacity-building is present in decision-making venues). Moreover, this may also distract from other (no less important) practical concerns about the information and capacity needed for more routine use of CBA (which, in turn, often emanate from developments in the past). This suggests the virtue of not only updating the CBA policy community on recent advances in environmental CBA (perhaps in a fuller revised volume of Pearce et al., 2006), but also evaluating fully how these advances might be implemented and the extent to which practical needs are being met.

REFERENCES

Aabø, S. (2005), "Are public libraries worth their price? A contingent valuation study of Norwegian public libraries", *New Library World*, Vol. 106, pp.487-495, http://dx.doi.org/10.1108/03074800510634973.

Adler, M. (2013), Cost-Benefit Analysis and Distributional Weights: An Overview, Working Paper EE 13-04, Duke University, Durham. http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=5813&context=faculty_scholarship.

Adler, M. (2012), *Well-Being and Fair Distribution: Beyond Cost-Benefit Analysis*, Oxford University Press, Oxford.

Akter, S., J. Bennett and S. Akhter (2008), "Preference uncertainty in contingent valuation", *Ecological Economics*, Vol. 67, pp. 345-351.

Alberini, A. and A. Longo (2009), "Valuing cultural monuments of Armenia: Bayesian updating of prior beliefs in contingent valuation", *Environment and Planning A*, Vol. 41, pp. 441-460.

Alberini, A. et al. (2004), *Information and willingness to pay in a contingent valuation study: the Value of the S. Erasmo in the Lagoon of Venice*, FEEM Working Paper Series, Fondazione Eni Enrico Mattei, Milan. *www.feem.it/userfiles/attach/publication/ndl2004/ndl2004-019.pdf*.

Alemu, M. H. et al. (2013), "Attending to the reasons for attribute non-attendance in choice experiments", *Environmental and Resource Economics*, Vol. 54, pp. 333-359.

Alpizar, F., F. Carlsson and O. Johansson-Stenman (2008b), "Does context matter more for hypothetical than for actual contributions. Evidence from a natural field experiment", *Experimental Economics*, Vol. 11, pp. 299-314.

Anthoff, D. and R. Tol (2010), "On international equity weights and national decision making on climate change", *Journal of Environmental Economics and Management*, Vol. 60, pp. 14-20.

Anthoff, D., C. Hepburn and R. Tol (2009), "Equity weighting and the marginal damage costs of climate change", *Ecological Economics*, Vol. 68, pp. 836-849.

Apostolakis, A. and J. Shabbar (2005), "Stated preferences for two Cretan heritage attractions", *Annals of Tourism Research*, Vol. 32, Issue 4, pp. 985-1005.

Araña, J. E., C. J. Leon and M. W. Hanemann (2008), "Emotions and decision rules in discrete choice experiments for valuing health care programmes for the elderly", *Journal of Health Economics*, Vol. 27, pp. 753-769.

Arentze, T. et al. (2003), "Transport stated choice responses: effects of task complexity, presentation format and literacy", *Transportation Research Part E*., Vol. 39, pp. 229-244.

Ariely, D., G. Loewenstein and D. Prelec (2003), "'Coherent arbitrariness': stable demand curves without stable preferences", *Quarterly Journal of Economics*, Vol. 118, Issue 1, pp. 73-105.

Arrow, K. et al. (2012), "How should benefits and costs be discounted in an intergenerational context? The views of an Expert Panel", RFF Discussion Paper 12-53, Resources for the Future, Washington DC.

Arrow, K. et al. (1993), "Report of the NOAA panel on contingent valuation", *Federal Register*, 58: 4601-4614.

Atkinson, G. et al. (2009), "Siblings, not triplets: social preferences for risk, inequality, and time in discounting climate change", *Economics – The Open-Access, Open-Assessment E-Journal*, No. 2009-26, 1-28.

Baez, A. and L. Herrero (2012), "Using contingent valuation and cost-benefit analysis to design a policy for restoring cultural heritage", *Journal of Cultural Heritage*, Vol. 13, Issue 3, pp. 235-245.

Balcombe, K. et al. (2014), "Using attribute rankings within discrete choice experiments: An application to valuing bread attributes", *Journal of Agricultural Economics*, Vol. 65, pp. 446-462.

Balcombe, K. G., M. Burton and D. Rigby (2011), "Skew and attribute non-attendance within Bayesian mixed logit model", *Journal of Environmental Economics and Management, Vol.* 62, pp. 446-461.

Banable, S. (2013), "*The European Commission Impact Assessment System*", paper presented to the Conference on Theory and Practice of Regulatory Impact Assessments in Europe", Paris, June 2013.

Barbier, E. B. (2014), "Challenges to ecosystem service valuation for wealth accounting", in UNEP/ UNU-IHDP (eds.), *Inclusive Wealth Report 2014: Human Capital*, Cambridge University Press, Cambridge.

Barbier, E. B. (2012), "Ecosystem services and wealth accounting", in UNU-IHDP and UENEP (eds.), *Inclusive Wealth Report*, Cambridge University Press, Cambridge.

Barbier, E. B. (2009), "Ecosystems as natural assets", *Foundations and Trends in Microeconomics*, Vol. 4, pp. 611-681.

Bateman, I. J. et al. (2011a), "Economic analysis for ecosystem service assessments", *Environmental and Resource Economics*, Vol. 48, pp. 177-218.

Bateman, I. J. et al. (2011b), Chapter 22: *Economic Values From Ecosystems, National Ecosystem Assessment*, Final report to United Nations Environment Programme (UNEP), / World Conservation Monitoring Centre (WCMC).

Bateman, I. J. et al. (2009), "Reducing gain-loss asymmetry: a virtual reality choice experiment valuing land use change", *Journal of Environmental Economics and Management*, Vol. 58, pp.106-118.

Bateman, I. J. et al. (2008), "Learning design contingent valuation (LDCV): NOAA guidelines, preference learning and coherent arbitrariness", *Journal of Environmental Economics and Management*, Vol. 55, pp. 127-141.

Bateman, I. J. et al. (2002), *Economic Valuation with Stated Preference Techniques: A Manual*, Edward Elgar, Cheltenham.

BBOP (Business and Biodiversity Offsets Programme), (2012), *Standard on Biodiversity Offsets*, BBOP, Washington DC.

Bech, M., T. Kjaer and J. Lauridsen (2011), "Does the number of choice sets matter? Results from a web survey applying a discrete choice experiment", *Health Economics*, Vol. 20, pp. 273-286.

Bedate, A., L. Herrero and J. Sanz (2004). "Economic valuation of the cultural heritage: application to four case studies in Spain", *Journal of Cultural Heritage*, Vol. 5, pp. 101-111.

Bell, J., J. Huber and W. Kip Viscusi (2011), "Survey mode effects on valuation of environmental goods", *International Journal of Environmental Research on Public Health,* Vol. 8, pp.1222-1243.

Bille, T. (2002), "A contingent valuation study of the Royal Theatre in Copenhagen", in Navrud, S. and R. Ready, (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

Blanchflower, D. G. and A. J. Oswald (2004), "Well-being over time in Britain and the USA", *Journal Public Economics*, Vol. 88, pp.1359-1386.

Boeri, M. et al. (2012), "Site choices in recreational demand: a matter of utility maximization or regret minimization?", *Journal of Environmental Economics and Policy*, Vol. 1, pp. 32-47.

Bosworth, R. and L. O. Taylor (2012), "Hypothetical bias in choice experiments: is cheap talk effective at eliminating bias on the intensive and extensive margins of choice?" *B.E. Journal of Economic Analysis and Policy*, Vol. 12, http://dx.doi.org/10.1515/1935-1682.3278.

Brander, L. M. and M. J. Koetse (2011), "The value of urban open space: meta-analyses of contingent valuation and hedonic pricing results", *Journal of Environmental Management*, Vol. 92, Issue 10, pp. 2763-2773.

Bravi, M., R. Scarpa and G. Sirchia (2002), "Valuing cultural services in Italian museums: a contingent valuation study", in Navrud, S. and R. Ready (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

Brown, J. (2004), *Economic values and cultural heritage conservation: assessing the use of stated preference techniques for measuring changes in visitor welfare*, Doctoral thesis, Imperial College London.

Brown, G. and D. A. Hagen (2010), "Behavioral economics and the environment", *Environmental and Resource Economics,* Vol. 46, pp. 139-146.

Bull, J. W. et al. (2013), "Biodiversity offsets in theory and in practice", *Oryx*, Vol. 47, pp 369-380, *http://dx.doi.org/10.1017/S003060531200172X*.

Cai, B., T. A. Cameron and G. R. Gerdes (2008), "Distributional preferences and the incidence of costs and benefits in climate change policy", *Environmental and Resource Economics*, Vol. 46, pp. 429-458.

Camerer, C. F., G. Loewenstein and M. Rabin (2011), *Advances in Behavioral Economics*, Princeton University Press, USA.

Camerer, C. F., and G. Loewenstein (2004), "Behavioral economics: past, present, future", in Camerer, C.F., G. Loewenstein and M. Rabin (eds.), *Advances in Behavioral Economics*, Princeton University Press, Princeton, USA.

Cameron, T. A. and J. R. de DeShazo (2010), "Differential attention to attributes in utility-theoretic choice models", *Journal of Choice Modelling*, Vol. 3(3), pp. 73-115.

Campbell, D., W. G. Hutchinson and R. Scarpa (2006), "Lexicographic preferences in discrete choice experiments: consequences on individual-specific willingness to pay estimates", Nota di lavoro 128.2006, Fondazione Eni Enrico Mattei, Milano. *www.feem.it/getpage.aspx?id=1626&sez=Publications&padre=73*.

Campbell, D. and V. S. Lorimer (2009), *Accommodating attribute processing strategies in stated choice analysis: do respondents do what they say they do?*, 17th Annual Conference of the European Association of Environmental and Resource Economics, Amsterdam.

Cantillo, V. and J. de D. Ortuzar (2005), "Implication of thresholds in discrete choice modelling", *Transport Reviews*, Vol. 26, pp. 667-691.

Carlsson, F. (2010), "Design of stated preference surveys: is there more to learn from behavioral economics?", *Environmental and Resource Economics*, Vol. 46, pp. 167-177.

Carlsson, F., M. R. Mørbak and S. B. Olsen (2012), "The first time is the hardest: A test of ordering effects in choice experiments", *Journal of Choice Modelling*, Vol. 5(2), pp 19-37.

Carroll, N., P. Frijters and M. Shields (2009), "Quantifying the costs of drought: new evidence from life satisfaction data", *Journal of Population Economics*, Vol. 22, pp. 445-461.

Carson, R. and T. Groves (2007), "Incentive and informational properties of preference questions", *Environmental and Resource Economics*, Vol. 37, pp. 181-210.

Carson, R., R. Mitchell and M. Conaway (2002), "Economic benefits to foreigners visiting Morocco from the rehabilitation of the Fes Medina", in Navrud, S. and R. Ready (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

Cassuade, S. et al. (2005), "Assessing the influence of design dimension on stated choice experiment estimates", *Transportation Research Part B*, Vol. 39, pp. 621-640.

Chiabai, A. et al. (2011), "Economic assessment of forest ecosystem services losses: costs of policy inaction", *Environmental and Resource Economics*, Vol. 50, pp. 405-445.

Chorus, C. G., T. A. Arentze and H. J. P. Timmermans (2008), "A random regret-minimization model of travel choice", *Transportation Research Part B Methodology*, Vol. 42, pp. 1-18.

Chorus, C. G., S. van Cranenburgh and T. Dekker (2014), "Random regret minimization for consumer choice modeling: assessment of empirical evidence", *Journal of Business Research*, Vol. 67, pp. 2428-2436.

Church, A. et al. (2011), *Chapter 16: Cultural Services*, *National Ecosystem Assessment*, Final Report to United Nations Environment Programme (UNEP), / World Conservation Monitoring Centre (WCMC).

Clark, A. E. and A. J. Oswald (2002), "A simple statistical method for measuring how life events affect happiness", *International Journal of Epidemiology,* Vol. 31, pp. 1139-1144.

Clark, A. E. and A. J. Oswald (1996), "Satisfaction and comparison income", *Journal of Public Economics,* Vol. 61, pp. 359-381.

Climate for Culture (2014), Project website: *www.climateforculture.eu/.*

Cohen, M. A. (2008), "The effect of crime on life satisfaction", *Journal of Legal Studies,* Vol. 37, pp. 325-353.

Colombo, S., M. Christie and N. Hanley (2013), "What are the consequences of ignoring attributes in choice experiments? Implications for ecosystem service valuation", *Ecological Economics,* Vol. 96, pp. 25-35.

Costanza, R. et al. (2014), "Changes in the global value of ecosystem services", *Global Environmental Change,* Vol. 26, pp. 152-158.

Costanza, R. et al. (1997), "The value of the world's ecosystem services and natural capital", *Nature,* Vol. 387, pp. 253-260.

COWI (2011), *Ex post evaluation of cohesion intervention 2000-2006 financed by the Cohesion Fund (including ISPA)* WP C – CBA of Environmental Projects, Directorate-General Regional Policy, European Commission, Brussels.
http://ec.europa.eu/regional_policy/sources/docgener/evaluation/expost2006/wpc_en.htm.

Cummins, R. A. (1996), "The domains of life satisfaction: An attempt to order chaos", *Social Indicators Research,* Vol. 38, pp. 303-328.

Czajkowski, M., M. Giergiczny and W. Greene (2014), "Learning and fatigue effects revisited. The impact of accounting for unobservable preference and scale heterogeneity", *Land Economics,* Vol. 90, pp. 324-351.

Danthurebandara, V. M., J. Yu and M. Vanderbroek (2011), "Effect of choice complexity on design efficiency in conjoint choice experiments", *Journal of Statistical Planning and Inference,* Vol. 141, pp. 2276-2286.

Day, B. and D. Maddison (2015), *Improving Cost-Benefit Analysis Guidance*, Report to the Natural Capital Committee (NCC), NCC, London.

Defra (UK Department of Environment, Food and Rural Affairs), (2011), The Natural Choice: Securing the Value of Nature (Natural Environment White Paper), Defra, London.
www.gov.uk/government/uploads/system/uploads/attachment_data/file/228842/8082.pdf.

Dellaert, B. G. C., J. D. Brazell and J. Louviere (1999), "The effect of attribute variation on consumer choice consistency", *Marketing Letters,* Vol. 10(2), pp. 139-147.

DellaVigna, S. (2009), "Psychology and economics: evidence from the field", *Journal of Economic Literature,* Vol. 47, pp. 315-372.

Del Saz Salazar, S. and J. Montagud Marques (2005), "Valuing cultural heritage: the social benefits of restoring an old Arab tower", *Journal of Cultural Heritage,* Vol. 6, pp. 69-77.

De Palma A., G. Myers and Y. Papeorgiou (1994), "Rational choice under imperfect ability to choose", *American Economic Review*, Vol. 84, pp. 419-440.

DeShazo, J. R. and G. Fermo (2002), "Designing choice sets for stated preference methods: The effects of complexity on choice consistency", *Journal of Environmental Economics and Management*, Vol. 44, pp. 123-143.

Dickie, M., S. Gerking and W. L. Goffe (2007), "Valuation of non-market goods using computer-assisted surveys: a comparison of data quality from internet and Rdd samples", presented at European Association of Environmental and Resource Economists, Thessaloniki, Greece.

Dietz, S. and C. Hepburn (2013), "Benefit-cost analysis of non-marginal climate and energy projects", *Energy Economics*, Vol. 40, pp. 61-71.

Dietz, S. and N. Stern (2015), "Endogenous growth, convexity of damages and climate risk: how Nordhaus' framework supports deep cuts in carbon emissions", *Economic Journal*, Vol. 125, pp. 574-602.

Dolan, P., R. Layard, R. and R. Metcalfe (2011), "Measuring subjective wellbeing for public policy: recommendations on measures", Centre for Economic Performance, London School of Economics and Political Science, Special Paper No. 23, *http://cep.lse.ac.uk/pubs/download/special/cepsp23.pdf*.

Dolan, P., T. Peasgood and M. White (2008), "Do we really know what makes us happy? A review of the economic literature on the factors associated with subjective well-being", *Journal of Economic Psychology*, Vol. 29, pp. 94-122.

Dutta, M., S. Banerjee and Z. Husain (2007), "Untapped demand for heritage: a contingent valuation study of Prinsep Ghat, Calcutta", *Tourism Management*, Vol. 28, pp. 83-95.

European Commission / DG ENV (2013a), *An Initiative on an Environment, Climate and Energy Assessment Framework to Enable Safe and Secure Unconventional Hydrocarbon Extraction*, European Commission, Brussels.

European Commission / Impact Assessment Board (2013b), *Opinion on 'DG ENV - An Initiative on an Environment, Climate and Energy Assessment Framework to Enable Safe and Secure Unconventional Hydrocarbon Extraction,* European Commission, Brussels.

European Commission (2009a), *Impact Assessment Guidelines, SEC(2009)92*, European Commission, Brussels.

European Commission (2009b), *Memo: Main Changes in the 2009 Impact Assessment Guidelines Compared to 2005 Guidelines*, European Commission, Brussels.

European Commission (2008), *Guide to Cost-benefit Analysis of Investment Projects*, Brussels: Directorate General Regional Policy.

European Commission (2007), *Reach In Brief*, European Commission, Brussels.

Fehr, E. and S. Gächter (2000), "Fairness and retaliation: the economics of reciprocity", *Journal of Economic Perspectives*, Vol. 14(3), pp. 159-181.

Ferreira, S. and M. Moro (2010), "On the use of subjective well-being data for environmental valuation", *Environmental and Resource Economics*, Vol. 46(3), pp. 249-273.

Ferrer-i-Carbonell, A. and B. van Praag (2002), "The subjective costs of health losses due to chronic diseases. An alternative model for monetary appraisal", *Health Economics*, Vol. 11, pp. 709-722.

Finn, A., S. McFadyen and C. Hoskins, (2003), "Valuing the Canadian Broadcasting Corporation", *Journal of Cultural Economics*, Vol. 27, pp. 177-193.

Fishbein, M. and I. Ajzen (1975), *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, Addison-Wesley, Reading, MA.

Fleurbaey, M. and D. Blanchet (2013), *Beyond GDP: Measuring Welfare and Assessing Sustainability*, Oxford University Press, Oxford.

Fleurbaey, M. et al. (2013), "Equivalent income and fair evaluation of health care", *Health Economics*, Vol. 22, pp. 711-729.

Florio, M. and D. Sartori (2010), "Getting incentives right, do we need ex post CBA?", Working Paper No. 01/2010, Centre for Industrial Studies, Milan, *www.csilmilano.com/docs/WP2010_01.pdf.*

Flyvbjerg, B., M. K. Skamris Holm and S. L. Buhl, (2003), "How common and how large are cost overruns in transport infrastructure projects?", *Transport Reviews*, Vol. 23(1), pp. 71-88.

Forrest, D., K. Grime and R. Woods, (2000). "Is it worth subsidizing regional repertory theatre?", *Oxford Economic Papers*, Vol. 52, pp. 381-397.

Freeman III, A. M., J. Herriges, and C. Kling (2014), *The Measurement of Environmental and Resource Values: Theory and Methods*, 3rd Edition, Resources for the Future, Washington, DC.

Freeman, M. and B. Groom (2014), "Positively gamma discounting: combining the opinions of experts on the social discount rate", *Economic Journal*.

Frey, B.S., S. Luechinger and A. Stutzar, (2009), "The life satisfaction approach to environmental valuation", Discussion Paper No. 4478, Institute for the Study of Labor. *http://ftp.iza.org/dp4478.pdf.*

Frey, B.S., S. Luechinger, and A. Stutzer (2004a), "Valuing public goods: the life satisfaction approach", *Institute for Empirical Research in Economics University of Zurich Working Paper Series* 184. *www.iew.uzh.ch/wp/iewwp184.pdf*.

Frey, B.S., S. Luechinger and A. Stutzar, (2004b), "Calculating tragedy: assessing the costs of terrorism", *CESIFO Working Paper* 1341.

Fujiwara, D. (2014), "The social impact of housing providers", HACT, Legal & General, Plus Dane Group, London, UK.

Fujiwara, D. (2013a), "Museums and Happiness", *Happy Museum Research Paper*.

Fujiwara, D. (2013b), "A general method for valuing non-market goods using wellbeing data: three-stage wellbeing valuation", *CEP Discussion Paper* No 1233, *http://eprints.lse.ac.uk/51577/1/dp1233.pdf.*

Fujiwara, D. and D. Campbell (2011), *Valuation Techniques for Cost Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches*, HM Treasury, London. *www.gov.uk/government/uploads/system/uploads/attachment_data/file/209107/greenbook_valuationtechniques.pdf.*

Fujiwara, D., R. Lawton and S. Mourato (2015), *The health and wellbeing benefits of public libraries*. Report for the Arts Council England. *www.artscouncil.org.uk/media/uploads/Health_and_wellbeing_benefits_of_public_libraries_full_report.pdf.*

Gardner, J. and A. J. Oswald (2007), "Money and mental wellbeing: A longitudinal study of medium-sized lottery wins", *Journal of Health Economics*, Vol. 26, pp. 49-60.

Gardner, T.A. et al. (2013), "Biodiversity offsets and the challenge of achieving no net loss", *Conservation Biology*, Vol. 27, pp. 1254-1264.

Garrod, G. and K. Willis (2002), "Northumbria: castles, cathedrals and towns", In Navrud, S. and R. Ready (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

Garrod, G., K. Willis, H. Bjarnadottir and P. Cockbain (1996), "The non-priced benefits of renovating historic buildings", *Cities*, Vol. 13, pp. 423-430.

Gelso B R, J. M. Peterson (2005), "The influence of ethical attitudes on the demand for environmental recreation: incorporating lexicographic preferences", *Ecological Economics*, Vol. 53(1), pp. 35-45.

Glass, R. et al. (1999), *Economic scope, impact and marketing study of the Kansas Arts Commission*. Report No. 257, Institute for Public Policy and Business Research, University of Kansas. *www2.ku.edu/~ipsr/resrep/pdf/m257a.pdf*.

Gollier, C. (2012), *Pricing the Planet's Future: The Economics of Discounting in an Uncertain World*, Princeton University Press, Princeton, New Jersey.

Gough, I. and J. A. McGregor, (eds.) (2007), *Wellbeing in Developing Countries: From Theory to Research*, Cambridge University Press, Cambridge.

Groom, B. and D. Maddison (2013), "Non-identical quadruplets: four new estimates of the elasticity of marginal utility for the UK", GRI Working Paper No. 121, Grantham Research Institute on Climate Change and Environment, London School of Economics, London. *www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/WP121-Non-identical-quadruplets.pdf*.

Groot, W. and H. M. van den Brink (2006), "The compensating income variation of cardiovascular disease", *Health Economics Letters*, Vol. 15, pp. 1143-1148.

Grosclaude, P. and N. Soguel (1994), "Valuing damage to historic buildings using a contingent market: a case study of road traffic externalities", *Journal of Environmental Planning and Management*, Vol. 37(3), pp. 279-287.

Gsottbauer, E. and J. C. van den Bergh (2011), "Environmental policy theory given bounded rationality and other-regarding preferences", *Environmental and Resource Economics*, Vol. 49, pp. 263-304.

Gundimeda, H. and G. Atkinson (2014), "The forest wealth of nations", in UNEP/ UNU-IHDP (eds.), *Inclusive Wealth Report 2014: Human Capital*, Cambridge University Press, Cambridge. *http://mgiep.unesco.org/wp-content/uploads/2014/12/IWR2014.pdf.*

Hahn, R.W. and P. M. Dudley (2007), "How well does the U.S. Government do benefit-cost analysis?", *Review of Environmental Economics and Policy*, Vol. 1, pp. 192-211.

Hahn, R.W. and R.C. Tetlock (2008), "Has economic analysis improved regulatory decisions?", *Journal of Economic Perspectives*, Vol. 22, pp. 67-84.

Hájek, P. and J. Stejskal, (2014), "Modelling public library value using the contingent valuation method: The case of the Municipal Library of Prague", *Journal of Librarianship and Information Science*. *http://dx.doi.org/10.1177/0961000614525217.*

Hamilton, K. and G. Atkinson (2006), *Wealth, Welfare and Sustainability: Recent Advances in the Measurement of Sustainable Development*, Edward Elgar, Cheltenham.

Hartwick, J.M. (1992), "Deforestation and national accounting", *Environmental and Resource Economics*, Vol. 2, pp. 513-521.

Hasler, B., T. Lundhede, T. and Bille (2006), "Valuation of nature restoration and protection of archaeological artefacts in Great Aamose in Western Zealand, Denmark", *Paper presented at the ENVECON Conference*, 24 March, London UK.

Heiner, R. (1983), "The origin of predictive behaviour", *American Economic Review*, Vol. 73, pp. 560-595.

Hensher, D. A., J. Rose and W. H. Greene (2005), "The implication on willingness to pay of respondents ignoring specific attributes", *Transportation*, Vol. 32, pp. 203-222.

Hensher, D. A. (2006), "How do respondent process stated choice experiments? Attribute consideration under varying information load", *Journal of Applied Econometrics*, Vol. 21, pp. 861-878.

Hensher, D. A. and J. M. Rose (2009), "Simplifying choice through attribute preservation or non-attendance: Implication for willingness to pay", *Transportation Research E,* Vol. 45, pp. 583-590.

Hepburn, C. and G. Gosnell (2014), "Evaluating impacts in the distant future: cost-benefit analysis, discounting and its alternatives", in G. Atkinson, et al. (eds.), *Handbook of Sustainable Development*, 2nd Edition, Cheltenham, Edward Elgar.

Hess, S., D. Hensher and A. J. Daly (2012), "Not bored yet- revisiting fatigue in stated choice experiments", *Transportation Research Part A*, Vol. 46, pp. 626-644.

Hess, S., J. M. Rose and J. Polak (2010), "Non-trading, lexicographic and inconsistent behaviour in stated choice data", *Transportation Research Part D,* Vol. 15, pp. 405-417.

Hess, S., D. A. Hensher and A. Daly (2012), "Not bored yet-revisiting respondent fatigue in stated choice experiments", *Transportation Research Part A,* Vol. 46, pp. 626-644.

HM Treasury (2003), *The Green Book, Appraisal and Evaluation in Central Government*, London: HM Treasury.

Hoel, M. and T. Sterner (2007), "Discounting and relative prices", *Climatic Change*, Vol. 84, pp. 265-280.

Hole, A. R. (2011), "A discrete choice model with endogenous attribute attendance", *Economics Letters,* Vol. 110, pp. 203-205.

Hole, A. R., J. R. Kolstad and D. Gyrd-Hansen (2013), "Inferred vs. stated attribute non-attendance in choice experiments: A study of doctors' prescription behaviour", *Journal of Economic Behavior & Organization*, Vol. 96, pp. 21-31.

Horowitz, J. K. (2002). "Preferences in the future", *Environment and Resource Economics*, Vol. 21, pp. 241-259.

Horowitz J. and K. McConnell (2002), "A review of WTA/WTP studies", *Journal of Environmental Economics and Management*, Vol. 44, pp. 426-447.

Horowitz, J. K., K. E. McConnell and J. J. Murphy (2008), "Behavioral foundations of environmental economics and valuation", in List, J. and M. Price (eds), *Handbook on Experimental Economics and the Environment*, Edward Elgar, Northampton, MA.

Hussain, S. et al. (2012), *The Economics of Ecosystems and Biodiversity Quantitative Assessment: Final Report*, UNEP, Geneva.

Independent Evaluation Group (IEG), (2011), *Cost-Benefit Analysis in World Bank Projects*, World Bank, Washington DC. *http://ieg.worldbank.org/Data/reports/chapters/cba_full_report1.pdf*.

Islam, T., J. J. Louviere and P. F. Burke (2007), "Modelling the effects of including/excluding attributes in choice experiments on systematic and random components", *International Journal of Research in Marketing*, Vol. 24, pp. 289-300.

Jura Consultants. (2005). *Bolton's Museum, Library and Archive Services; An economic valuation* (p. 85). London, UK: Museums Libraries and Archives Council, *http://webarchive.nationalarchives.gov.uk/20120215211001/http://research.mla.gov.uk/evidence/documents/bolton_main.pdf*.

Kahneman, D. (1986), "Comments", in R. Cummings, D. Brookshire, and W. Schulze (eds.), *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method*, Rowman and Allenheld, Totowa, NJ.

Kahneman, D. and A. B. Krueger (2006), "Developments in the measurement of subjective well-being", *Journal of Economic Perspectives*, Vol. 20, pp. 3-24.

Kahneman, D., P. P. Wakker and R. Sarin (1997), "Back to Bentham? explorations of experienced utility", *Quarterly Journal of Economics*, Vol. 112, pp. 375-405.

Kahneman, D. and R. Sugden (2005), "Experienced utility as a standard of policy evaluation", *Environmental and Resource Economics*, Vol. 32, pp. 161-181.

Kahneman, D., E. Diener and N. Schwarz (1999), *Well-being: The foundation of hedonic psychology*, Russell Sage Foundation, New York.

Kapteyn, A. et al. (2011), *Anchoring vignettes and response consistency*, Rand Working Paper WR-840, *www.rand.org/content/dam/rand/pubs/working_papers/2011/RAND_WR840.pdf*.

Kaveira, P. et al. (eds.), (2011), *Natural Capital: Theory and Practice of Mapping Ecosystem Services*, Oxford University Press, Oxford.

Kaye-Blake, W. H., W. L. Abell and E. Zellman (2009), "Respondents' ignoring of attributes information in a choice modelling survey", *Australian Journal of Agricultural and Resource Economics*, Vol. 53, pp. 547-564.

Kehlbacher A, Balcombe K, Bennet R (2013), "Stated attribute non-attendance in successive choice experiments", *Journal of Agricultural Economics*, Vol. 64, pp. 693-706.

Kim, G. (2011). "A critical review of valuation studies to identify frameworks in library services", *Library & Information Science Research*, Vol. 33, pp. 112-119.

King, G., C. J. L. Murray, J. A Salomon and A. Tandon (2004), "Enhancing the validity and cross-cultural comparability of measurement in survey research", *American Political Science Review*, Vol. 127, pp. 421-433.

Knetsch, J. L. (2010), "Values of gains and losses: Reference states and choice of measure", *Environmental and Resource Economics*, Vol. 46, pp. 179-188.

Kragt, M. E. (2013), "Stated and inferred attribute non-attendance models: A comparison with environmental choice experiments", *Journal of Agricultural Economics*, Vol. 64, pp. 719-736.

Lagarde M. (2013), "Investigating attribute non-attendance and its consequences in choice experiments with latent class models", *Health Economics*, Vol. 22, pp. 554-567.

Lancsar E. and J. Louviere (2006), "Deleting 'irrational' responses from discrete choice experiments: a case of investigating or imposing preferences?", *Health Economics*, Vol. 15, pp. 797-811.

Leong W. and D. A. Hensher (2012), "Embedding heuristics into choice models: An exploratory analysis", *Journal of Choice Modelling*, Vol. 5, pp. 131-144.

Lindhjem, H. and S. Navrud (2010), "Can cheap panel-based internet surveys substitute costly in-person interviews in CV surveys?", Department of Economics and Resource Management, Norwegian University of Life Sciences.

Lockwood, M., P. Tracey and N. Klomp (1996), "Analysing conflict between cultural heritage and nature conservation in the Australian Alps: a CVM approach", *Journal of Environmental Planning and Management*, Vol. 39, pp. 357-370.

Loewenstein, G. and P. A. Ubel (2008), "Hedonic adaptation and the role of decision and experience utility in public policy", *Journal of Public Economics*, Special Issue: Happiness and Public Economics, Vol. 92, pp. 1795-1810.

Loewenstein, G. and J. S. Lerner (2003), "The role of affect in decision making", in R. J. Davidson, K. R. Scherer and H. H. Goldsmith (eds.) *Handbook of Affective Sciences*, Oxford University Press, Oxford.

Loomis, J. (2011), "Incorporating distributional issues into benefit-cost analysis: how, why and two empirical examples using non-market valuation", *Journal of Benefit-Cost Analysis*, Vol. 2(1), Article 5.

Louviere, J. J. et al. (2008), "Designing discrete choice experiments: Do optimal designs come at a price?", *Journal of Consumer Research*, Vol. 35, pp. 360-375.

Mace, G. et al. (2015), "Towards a risk register for natural capital", *Journal of Applied Ecology*, Vol. 52, pp. 641-653.

MacKerron, G. (2012), "Happiness economics from 35 000 feet", *Journal of Economic Surveys*, Vol. 26, pp. 705-735.

MacKerron, G. and S. Mourato. (2013), "Happiness is greater in natural environments", *Global Environmental Change*, Vol. 23, pp. 992-1000.

MacKerron, G. and S. Mourato (2009), "Life satisfaction and air quality in London", *Ecological Economics* Vol. 68, pp. 1441-1453.

Macleod, M. et al. (2009), *Understanding the Costs of Environmental Regulation in Europe*, Edward Elgar, Cheltenham.

Maddison, D. and T. Foster (2003), "Valuing congestion costs in the British Museum", *Oxford Economic Papers*, Vol. 55, pp. 173-190.

Marta-Pedroso, C., H. Freitas and T. Domingos (2007), "Testing for the survey mode effect on contingent valuation data quality: a case study of web based versus in-person interviews", *Ecological Economics*, Vol. 62, pp. 388-398.

Martin-Lopez, B. et al. (2009), "Effects of spatial and temporal scales on cultural services valuation", *Journal of Environmental Management*, Vol. 90, pp. 1050-1059.

Mazzanti, M. (2003), "Valuing cultural heritage in a multi-attribute framework microeconomic perspectives and policy implications", *Journal of Socio-Economics*, Vol. 32, pp. 549-569.

Mazzotta M. J. and J. J. Opaluch (1995), "Decision making when choices are complex: A test of Heiner's hypothesis", *Land Economics*, Vol. 71, pp. 500-515.

Meunier, D. (2010), "Ex post evaluation of transport infrastructure projects in France: Old and new concerns about assessment quality", Laboratoire Ville Mobilité Transports, Université Paris-Est.

Meyerhoff J., M. Oehlmann and P. Weller (2014), "The influence of design dimension on stated choice. An example from environmental valuation using a design of design approach", *Environmental and Resource Economics*, Vol. 61, pp. 385-407, *http://dx.doi.org/10.1007/s10640-014-9797-5*.

Miller G. A. (1955), "The magical number seven, plus or minus two. Some limits on our capacity of processing information", *Psychological Review*, Vol. 101, pp. 343-352.

Millner, A. S. Dietz and G. Heal (2013), "Scientific ambiguity and climate policy", *Environmental and Resource Economics*, Vol. 55, pp. 21-46.

Mitchell, R. C. and R. T. Carson (1989), *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Resources for the Future, Washington DC. *http://econweb.ucsd.edu/~rcarson/papers/UsingSurveysToValuePublicGoods.pdf.*

Morey, E. et al. (1997), *Valuing acid deposition injuries to cultural resources.* Report to the National Acid Precipitation Assessment Program (NAPAP), Washington D.C.

Morris, A., J. Sumsion and M. Hawkins (2002), "Economic value of public libraries in the UK", *Libri*, Vol. 52, pp. 78-87.

Morrison, M. and T. C. Brown, (2009), "Testing the effectiveness of certainty scales, cheap talk, and dissonance-minimization in reducing hypothetical bias in contingent valuation studies", *Environmental and Resource Economics*, Vol. 44, pp. 307-326.

Morrison, W. and E. West (1986), "Subsidies for the performing arts: evidence on voter preference", *Journal of Behavioral Economics*, Vol. 15, pp. 57-72.

Mourato, S. et al. (2014), *The Economic Benefits of Cultural Built Heritage Interiors Conservation from Climate Change Damages in Europe*. WP6 Final Report, Climate for Culture. Final Report to European Commission.

Mourato, S. et al. (2005), "Cost-benefit test or statutory duty? The case of options to clean-up the River Thames", *Water International*, Vol. 30, pp. 174-183.

Mourato, S., A. Kontoleon, and A. Danchev (2002), "Preserving cultural heritage in transition economies: a contingent valuation study of Bulgarian monasteries", in Navrud, S. and R. Ready (eds.), *Valuing Cultural Heritage: Applying Environmental Valuation Techniques to Historic Buildings, Monuments and Artefacts*, Edward Elgar, Cheltenham UK.

National Ecosystem Assessment (2015), *http://uknea.unep-wcmc.org/*.

Navrud, S. and J. Strand (2002), "Social costs and benefits of preserving and restoring the Nidaros Cathedral", in Navrud, S. and R. Ready (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

NCC (Natural Capital Committee) (2015), *State of Natural Capital*, NCC, London.

NEA (UK National Ecosystem Assessment), (2011), *National Ecosystem Assessment Technical Report*, UK National Ecosystem Assessment, UNEP-WCMC, Cambridge.

Newbery, D. (2006), "Discussion", *Economic Policy*, Vol. 21, pp. 305-307.

Newell, R. and W. Pizer (2003), "Discounting the distant future: how much do uncertain rates increase valuations", *Journal of Environmental Economics and Management*, Vol. 46, pp. 52-71.

Noonan, D. S. (2003), "Contingent valuation and cultural resources: a meta-analytic review of the literature", *Journal of Cultural Economics* Vol. 27, pp. 159-176.

Nordhaus, W. D. (2007), "A review of the Stern Review on the economics of climate change", *Journal of Economic Literature*, Vol. XLV, pp. 686-702.

Nussbaum, M. (1992), "Human functioning and social justice: In defense of Aristotelian essentialism", *Political Theory*, Vol. 20, pp. 202-246.

OECD (2014), *The Cost of Air Pollution*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264210448-en.*

OECD (2012), *Mortality Risk Valuation in Environment, Health and Transport Policies*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264130807-en*.

Payne J. W., J. R. Bettman and E. L. Johnson (1993), *The Adaptive Decision Maker*, Cambridge University Press, Cambridge, England.

Pearce, D. W., G. Atkinson and S. Mourato (2006), *Cost-Benefit Analysis and the Environment, Recent Developments*, OECD, Paris.

Pearce, D. et al. (2002), "Review of existing studies, their policy use and future research needs", in Navrud, S. and R. Ready (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

Peasgood, T. (2008), *Measuring Well-Being for Public Policy*. PhD thesis, Imperial College London.

Pindyck, R. S. (2007), "Uncertainty in environmental economics", *Review of Environmental Economics and Policy*, Vol. 1, pp. 45-65.

Plott, C. R. and K. Zeiler (2005), "The willingness to pay-willingness to accept gap, the 'endowment effect', subject misconceptions, and experimental procedures for eliciting valuations", *American Economic Review*, Vol. 95, pp. 530-545.

Plott, C. R. (1996), "Rational individual behavior in markets and social choice processes: the discovered preference hypothesis", in K. Arrow et al. (eds.) *Rational Foundations of Economic Behavior*, Macmillan, London and St. Martin's, NY.

Pollicino, M. and D. Maddison (1999), *Valuing the impacts of air pollution on Lincoln Cathedral*, CSERGE Working Paper GEC 99-03, *http://cserge.ac.uk/sites/default/files/gec_1999_03.pdf*.

POST (HoP Parliamentary Office of Science and Technology), (2011), "Biodiversity offsetting", *POSTNOTE*, No. 369, January 2011, *www.parliament.uk/documents/post/postpn_369-biodiversity-offsetting.pdf*.

Powdthavee, N. (2008), "Putting a price tag on friends, relatives, and neighbours: Using surveys of life satisfaction to value social relationships", *Journal of Socio-Economics*, Vol. 37, pp. 1459-1480.

Pretty, J. et al. (2011), *Chapter 23: Health Values from Ecosystems, National Ecosystem Assessment*, Final Report to United Nations Environment Programme (UNEP) / World Conservation Monitoring Centre (WCMC).

Provins, A. et al. (2010), "Valuation of the historic environment: The scope for using economic valuation evidence in the appraisal of heritage-related projects", *Progress in Planning*, Vol. 69, pp. 131-17.

Puckett S. M. and D. A. Hensher (2009), "Revealing the extent of process heterogeneity in choice analysis. An empirical assessment", *Transportation Research Part A: Policy and Practice*, Vol. 43, pp. 131-145.

Puckett S. M. and D. A. Hensher (2008), "The role of attribute processing strategies in estimating the preferences of road freight stakeholders under variable road user charges", *Transportation Research E*, Vol. 44, pp. 379-395.

Pung, C., A. Clarke and L. Patten (2004), "Measuring the economic impact of the British Library", *New Review of Academic Librarianship*, Vol. 10, pp. 79-102.

Quinet, É. et al. (2013) *Cost-Benefit Analysis of Public Investments: Summary and Recommendations*, Report of the Mission Chaired by Émile Quinet, Commissariat Général à la Stratégie et à la Prospective.
http://blog.en.strategie.gouv.fr/wp-content/uploads/2014/04/CGSP-CALCUL_SOCIOECONOMIQUE_english.pdf.

Ready, R. and S. Navrud (2006), "International benefits transfer: Methods and validity tests", *Ecological Economics,* Vol. 60, pp. 429-434.

Rehdanz, K. and D. Maddison (2005), "Climate and happiness", *Ecological Economics,* Vol. 52, pp. 111-125.

REMEDE (2008), *Toolkit for Performing Resource Equivalency Analysis to Assess and Scale Environmental Damage in the European Union*, Brussels, European Commission.

Renda, A. et al. (2013), *Assessing the Costs and Benefits of Regulation*, European Commission, Brussels.

Rockström, J. et al. (2009) "A safe operating space for humanity", *Nature*, Vol. 461, pp. 472-475, *http://dx.doi.org/10.1038/461472a*.

Rosenberger R. S. et al. (2003), "Measuring dispositions for lexicographic preferences of environmental goods: integrating economics, psychology and ethics", *Ecological Economics,* Vol. 44, pp. 63-76.

de Rus, G. (2011), *Introduction to Cost-Benefit Analysis, Looking for Reasonable Shortcuts*, Cheltenham: Edward Elgar.

Ryan, R. M. and L. E. Deci (2001), "On happiness and human potentials: A review of research on hedonic and eudaimonic well-being", in Susan Fiske (eds), *Annual Review of Psychology*, 52. Palo Alto: Annual Reviews Inc: 141–166.

Sælensminde K. (2001), "Inconsistent choices in stated choice data: use of the logit scaling approach to handle resulting variance increases", *Transportation,* Vol. 28, pp. 269-296.

Salazar Borda, J. (2007), "Valuing congestion costs in small museums: the case of the Rubenshuis Museum in Antwerp", Master thesis, Erasmus University Rotterdam.

Sándor Z and H. Franses (2009), "Consumer price evaluations through choice experiments", *Journal of Applied Econometrics,* Vol. 24, pp. 517-535.

Santagata, W. and G. Signorello (2002), "Individual preferences and allocation mechanisms for a cultural public good: Napoli Musei Aperti", in Navrud, S. and R. Ready (eds.), *Valuing cultural heritage: applying environmental valuation techniques to historic buildings, monuments and artifacts*, Edward Elgar, Cheltenham UK.

Santos, G. and G. Fraser (2006), "Road pricing, lessons from London", *Economic Policy,* Vol. 21, pp. 263-310.

Sanz, J., L. Herrero and A. Bedate (2003), "Contingent valuation and semiparametric methods: a case study of the National Museum of Sculpture in Valladolid, Spain", *Journal of Cultural Economics*, Vol. 27, pp. 241-257.

Scarpa, R. et al. (2013), "Inferred and stated attribute attendance in food choice experiments", *American Journal of Agricultural Economics*, Vol. 95, pp. 165-180.

Schkade, D. A. and D. Kahneman (1998), "Does living in California make people happy? A focusing illusion in judgments of life satisfaction", *Psychological Science*, Vol. 9, pp. 340-346.

Scott, A. (2002), "Identifying and analysing dominant preferences in discrete choice experiments: An application in health care", *Journal of Economic Psychology*, Vol. 23, pp. 383-398.

Seekel, D. A. et al. (2011), "Virtual water transfers unlikely to redress inequality in global water use", *Environmental Research Letters*, Vol. 6(2), *http://dx.doi.org/10.1088/1748-9326/6/2/024017*.

Seenprachawong, U. (2005), *Economic valuation of cultural heritage: a case study of historic temples in Thailand*, Research report No. 2005-RR12, National Institute of Development Administration, Thailand, https://idl-bnc.idrc.ca/dspace/handle/10625/46100.

Seligman, M. (2011), *Flourish: A new understanding of happiness and wellbeing and how to achieve them*, Nicholas Brealey Publishing, London.

Severin, V. (2001), *Comparing Statistical and Respondent Efficiency in Choice Experiments*, Ph.D. Dissertation, Faculty of Economics and Business, The University of Sydney.

Shogren, J. and L. Taylor (2008), "On behavioral-environmental economics", *Review of Environmental Economics and Policy*, Vol. 2, pp. 26-44.

Simon H. A. (1955), "A behavioral model of rational choice", *Quarterly Journal of Economics*, Vol. 69, pp. 99-118.

Skianis, V. (2012), *The influence of nature on secondary school students' subjective well-being in England and Greece*, PhD Thesis, London School of Economics and Political Science.

Spackman, M. (2015), "Social time discounting: institutional and analytical perspectives", GRI Working Paper No. 192, Grantham Research Institute on Climate Change and Environment, London School of Economics, London, *www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/03/Working-Paper-182-Spackman.pdf*.

Steffen, W. et al. (2015) "Planetary boundaries: Guiding human development on a changing planet", *Science*, Vol. 347 (6223), *http://dx.doi.org/10.1126/science.1259855*.

Stern, N. (2007), *The Economics of Climate Change - The Stern Review*, Cambridge University Press, Cambridge.

Sterner, T. and U. M. Persson (2008), "An even Sterner review: introducing relative prices into the discounting debate", *Review of Environmental Economics and Policy*, Vol. 2, pp. 61-76.

Stiglitz, J. E., A. Sen and J. P. Fitoussi (2009), *Report by the Commission on the Measurement of Economic Performance and Social Progress*, OECD, Paris, *www.insee.fr/fr/publications-et-services/dossiers_web/stiglitz/doc-commission/RAPPORT_anglais.pdf*.

Sugden, R. (2005), "Anomalies and stated preference techniques: a framework for a discussion of coping strategies", *Environmental and Resource Economics*, Vol. 32, pp. 1-12.

Swait, J. and W. Adamowicz (2001), "Choice environment. Market complexity, and consumer behavior: a theoretical and empirical approach for incorporating decision complexity into models of consumer choice", *Organizational behavior and human decision processes*, Vol. 86, pp. 141-167.

Swait, J. (2001), "A non-compensatory choice model incorporating attribute cutoffs", *Transportation Research B*, Vol. 35, pp. 903-928.

TEEB (The Economics of Ecosystems and Biodiversity), (2010), *The TEEB Synthesis Report Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*, European Commission/ UNEP/ BMU-Germany, *www.teebweb.org/our-publications/teeb-study-reports/synthesis-report/*.

Thompson, B., D. Throsby and G. Withers (1983), "Measuring community benefits from the arts", Research Paper No. 261, School of Economic and Financial Studies, Macquarie University, Sydney.

Thompson, E. et al. (2002), *Valuing the arts: a contingent valuation approach*, Working paper, University of Kentucky, *http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1048&context=cbafacpub*.

Traeger, C. P. (2014), "On option values in environmental and resource economics", *Resource and Energy Economics*, Vol. 37, pp. 242-252.

Traeger, C. P. (2011), "Sustainability, limited substitutability and non-constant social discount rates", *Journal of Environmental Economics and Management*, Vol. 62, pp. 215-228.

Tuan, T. and S. Navrud (2008), "Capturing the benefits of preserving cultural heritage", *Journal of Cultural Heritage*, Vol. 9, pp. 326-337.

UNESCO (2014), *http://en.unesco.org/*.

UNESCO (2015), *World Heritage List, http://whc.unesco.org/en/list/*.

van Praag, B. M. S. and B. E. Baarsma, B.E. (2005), "Using happiness surveys to value intangibles: the case of airport noise", *Economic Journal*, Vol. 115, pp. 224-246.

von Stackelberg, K. and J. Hammitt (2009) "Use of contingent valuation to elicit willingness-to-pay for the benefits of development health risk reductions", *Environmental and Resource Economics*, Vol. 43, pp. 45-61.

Vrontisi, Z. et al. (2014), *Impact Assessment of European Clean Air policies in a CGE framework*, JRC Technical Reports, Joint Research Centre/ Institute for Prospective Technological Studies, European Commission, *https://ec.europa.eu/jrc/sites/default/files/JRC92553_Air_policy_CGE.pdf*.

Walker, G. (2012), *Environmental Justice: Concepts, Evidence and Policy*, Routledge, London.

Wang, X.J. et al. (2012), "Gini coefficient to assess equity in domestic water supply in the yellow river", *Mitigation and Adaptation Strategies for Global Change*, Vol. 17, pp. 65-75.

Waterman A. S. (1993), "Two conceptions of happiness: Contrasts of personal expressiveness (eudaimonia), and hedonic enjoyment", *Journal of Personality and Social Psychology*, Vol. 64, pp. 678-691.

Welsch, H. (2009), "Implications of happiness research for environmental economics", *Ecological Economics*, Vol. 68, pp. 801-813.

Welsch, H. (2008), "The welfare costs of corruption", *Applied Economics*, Vol. 40, pp. 1839-1849.

Welsch, H. (2007), "Environmental welfare analysis: a life satisfaction approach", *Ecological Economics*, Vol. 62, pp. 544-551.

Welsch, H. (2006), "Environment and happiness: valuation of air pollution using life satisfaction data", *Ecological Economics*, Vol. 58, pp. 801-813.

Welsch, H. (2002), "Preferences over prosperity and pollution: environmental valuation based on happiness surveys", *Kyklos*, Vol. 55, pp. 473-494.

Welsch, H. and J. Kuhling (2009), "Using happiness data for environmental valuation: issues and applications", *Journal of Economic Surveys*, Vol. 23, pp. 385-406.

WHO (World Health Organization) (2015) *Economic Cost of the Health Impact of Air Pollution in Europe: Clean Air, Health and Wealth*, World Health Organization, United Nations, Geneva.

Willis, K. (1994) "Paying for heritage: what price for Durham Cathedral?", *Journal of Environmental Planning and Management*, Vol. 37, pp. 267-278.

Yahaya, A. (2006) "The scope and definitions of heritage: from tangible to intangible", *International Journal of Heritage Studies*, Vol. 12, pp. 292-300.