The Australian Journal of Agricultural and Resource Economics, 48:3, pp. 419–443

What's it worth? An examination of historical trends and future directions in environmental valuation*

Wiktor L. Adamowicz†

The present paper reviews activity in environmental valuation by examining trends in publication rates over the past three decades. It also provides an overview of the demand for environmental valuation by academic markets and by policy markets. The results of this historical analysis suggest that there is not as much use of environmental valuation in policy analysis as could be expected given the academic efforts on this topic. The paper also provides an overview of the future directions that environmental valuation research is likely to take given current research efforts.

1. Introduction

Environmental valuation has been a part of the environmental economist's toolkit for over 50 years. Hotelling's 1949 discussion of the value of parks implied by travel costs signalled the start of the travel cost valuation era (Hotelling 1949). Similarly, suggestions by Ciriacy-Wantrup in the late 1940s led to the use of stated preference techniques in resource and environmental economics (Ciriacy-Wantrup 1947). Since then the published literature has advanced significantly. It has also merged with other literatures where the researchers were interested in elicitation of preferences for private goods or public goods. The published valuation literature has also swum upstream, influencing the economics profession as a whole, particularly with respect to experimental and behavioural economics. In the present paper I will review some of the advances in environmental valuation and provide an opinion on

* I would like to thank Natalie Zimmer for research assistance and Peter Boxall and Sean Cash for their comments on the present paper. I also thank the participants at the Australian Agricultural and Resource Economics annual meeting in Melbourne, February 2004, where I was invited to present an earlier version of the present paper, for their comments and questions. Finally, I thank two anonymous reviewers for very helpful comments. Any errors are the responsibility of the author.

† Vic Adamowicz is Canada Research Chair and Professor in the Department of Rural Economy, University of Alberta, Edmonton, Alberta, Canada.

where the field will go in the next decade. Making such predictions is a dangerous exercise if one is penalised for inaccuracy, but I will proceed nonetheless, hoping that my predictions are accurate or the penalties are small.[1]

My approach to the history of advances in environmental valuation will not be a method by method literature review. Rather, I will try to outline the preferences for or implicit demands for valuation innovations. Demand for these tools can be thought of as demands for services or techniques. Innovations in design that capture the eye of academics or policy makers will tend to rise to the top. Therefore, one can consider two markets for advances in environmental valuation. The first is the academic market. The proportion of research effort spent on these tools is an indicator of the interest and returns to the academic community. A second market for valuation methods is in the policy/regulatory/application arena. To what extent are these techniques actually used to make real decisions? I examine each of these markets in turn. In the second half of the present paper I explore emerging issues in environmental valuation. I examine theoretical, empirical (econometric) and data issues associated with the challenge of assessing preferences for environmental goods and services.

2. Environmental valuation in the academic world

A measure of the academic demand for environmental valuation research is implicit in journal publication and citation. If a profession is interested in the development of a set of techniques this will be illustrated by the generation of publication and citation. Naturally, critiques of methods will also be evident in the published literature, but an evaluation of publications and citations over time should show trends of interest or decline in a particular method. Hopefully this level of activity will be related to the demand for services from public agencies, resource managers, consultants and other groups who apply these methods to actual management problems.

Figures 1–4 provide some insight into the activity in environmental valuation research over the past few decades. These figures were constructed by examining the ISI Web of Science, an index of scientific publications.[2] Searches

[1] Several reviews of the published environmental valuation literature have been developed elsewhere. These reviews, including Smith (2000), Freeman (2003), Carson (2000), chapters in Champ, Boyle and Brown (2003), Haab and McConnell (2002) and several chapters in Bateman and Willis (1999), provide much more detailed examination of environmental valuation methods. In this review I focus on the historical evidence on generation and use of environmental valuation tools and speculate on the future directions of the research area.

[2] *Web of Science*®: the multidisciplinary collection of bibliographic information from over 8600 evaluated scholarly journals. Source: http://www.isinet.com/aboutus/

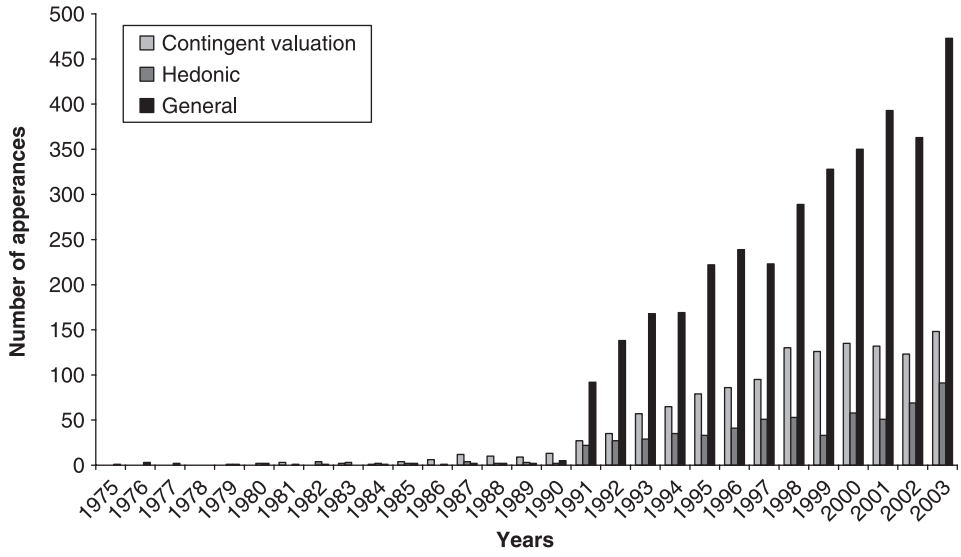

Figure 1 Publications in environmental valuation (general), contingent valuation and hedonic pricing.

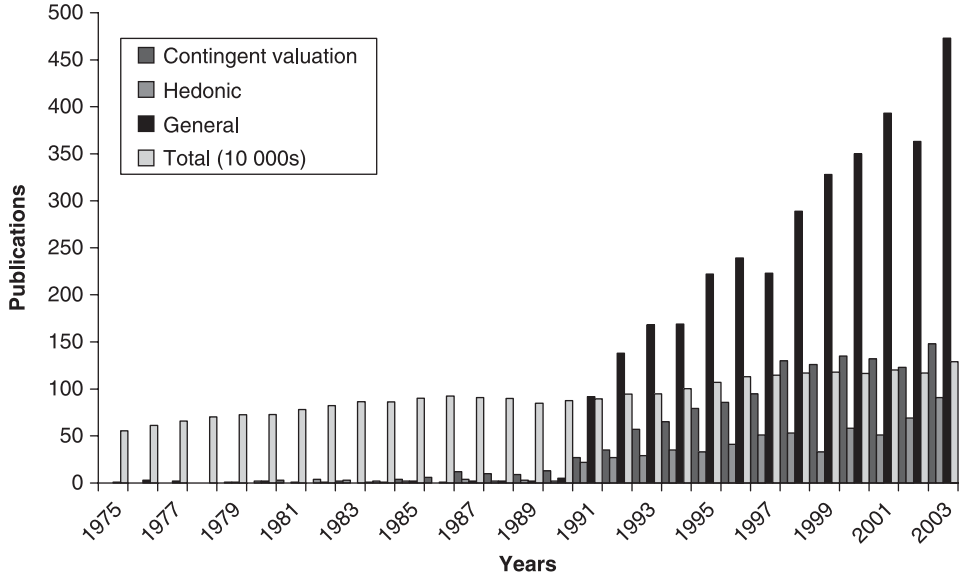

Figure 2 Valuation publications versus total publications.

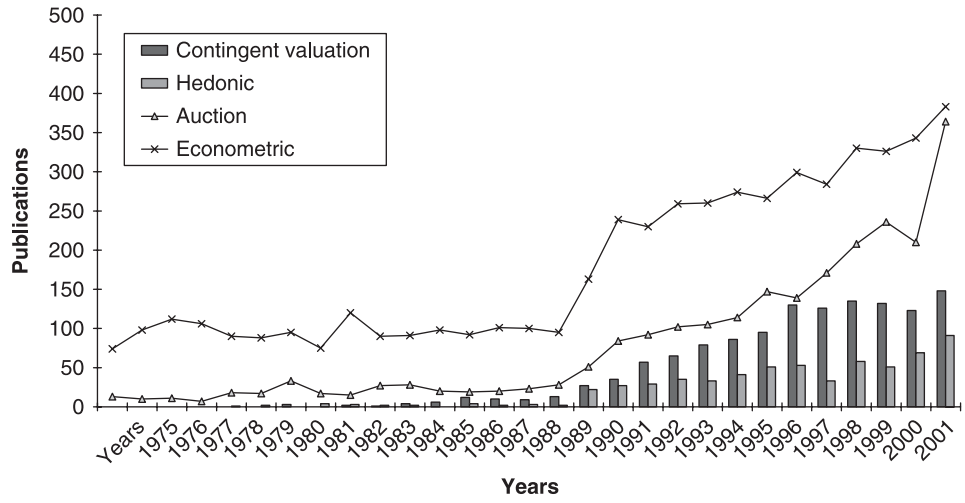

Figure 3 Valuation publications compared to general topics.

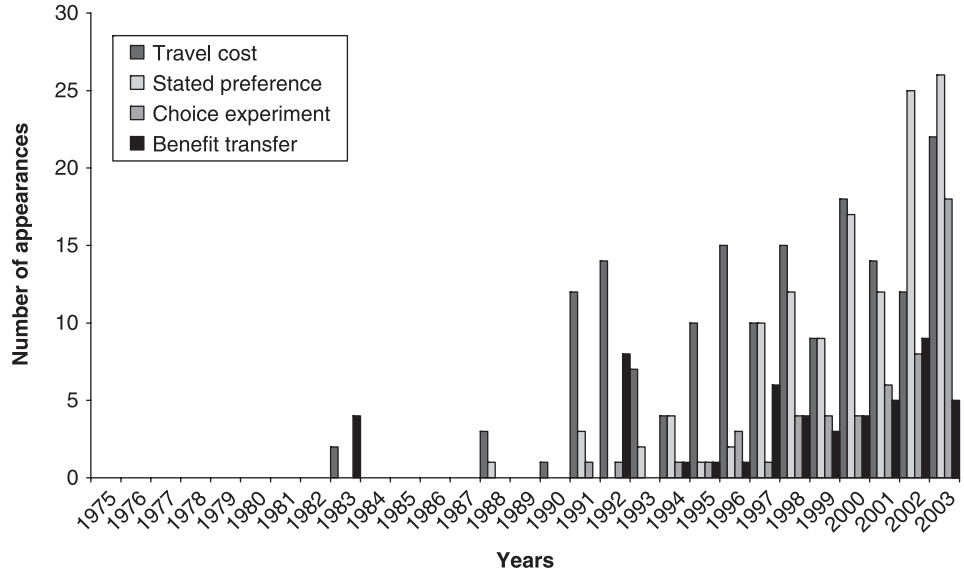

Figure 4 Comparison of environmental valuation publications.

were conducted for the major approaches to environmental valuation, modifying the search terms so that the publications were in fact economic analyses and related to valuation. The general categories examined included contingent valuation, travel cost, hedonic pricing, choice experiments, stated preference, benefit transfer,[3] and others.[4]

Figure 1 presents the publications over time for the general area of environmental valuation as well as the two top techniques found in terms of publications: contingent valuation and hedonic pricing. The rapidly increasing trend, particularly in contingent valuation, is noteworthy. It is also worth noting that the event that likely sparked the interest in contingent valuation as well as other valuation techniques, the Exxon Valdez oil spill, occurred in March 1989, just before the rapid increase in publication. This is also approximately the time that Mitchell and Carson's book, *Using Surveys to Value Public Goods*, appeared (1989). There has been considerable scepticism about contingent valuation and its merits, and some may assume that the number of publications is at least partially composed of papers criticising the technique. However, a scan of the most recent publications shows that the technique is alive and well, and is being applied to a variety of issues. It could also be the case that the more recent publications using contingent valuation are appearing in published literatures other than economics; however, an examination of these same keywords and modifiers in the narrower EconLit (the database of the American Economics Association) reveals similar values and trends.

Figure 2 presents the same graph but includes the total number of records (in tens of thousands) in the ISI database. This comparison is provided to determine if the growth in valuation publications is solely the result of a larger number of total publications, and not growth in the proportion of papers published. The graph shows that the total number of publications has grown from 1975 to 2003; however, this growth is nowhere

[3] Benefit transfer is not actually a valuation technique but involves the transfer of existing valuation results to other cases. It is included here to capture how important it is relative to actual valuation techniques. As indicated by an anonymous reviewer, benefit transfer is an aspect of the published valuation literature that has arisen specifically because of the interest in policy application of valuation methods. Therefore, research in benefits transfer is very relevant to policy applications of valuation research and perhaps less relevant to the academic market for valuation research. A recent review of benefit transfer issues and techniques can be found in Navrud (2004).

[4] Analyses of this type suffer from the fact that these specific terms are not always used by researchers, and the terms used to describe methods vary. Therefore, these data probably underestimate the actual publications in these areas. Other search terms were also examined (defensive expenditures, contingent ranking etc.) but these entries were also relatively small in magnitude and did not change the qualitative nature of the results.

near as large as the growth in the publication of these environmental valuation methods.

Figure 3 presents the information on valuation techniques but also includes the number of publications arising from the keywords 'auction' and 'econometric'. These keywords are chosen to represent two areas in economics where there has been considerable recent innovation. The intent is to examine the trend in valuation relative to other areas in economics. There were more publications in auctions and econometrics in the recent past; however, the difference is surprisingly small (at least in my opinion). The difference between contingent valuation and auctions is very small until the late 1990s. For most years after 1997 there were not quite twice as many publications on auctions as there were on contingent valuation. This illustrates the importance of contingent valuation in the academic market for ideas.

Finally, figure 4 presents the results for various other valuation techniques including travel cost methods, benefit transfers etc. First, note that the scale is very different in figure 4. The number of publications reported with these key words is, at most, less than 30 per year. All of these techniques have had less success than contingent valuation and hedonic pricing (at least in terms of interest in the market of academic publications). Of note is the fact that benefit transfer methods appear relatively rarely as publications in the academic literature (although they are quite common in applied work). Stated preference/choice experiment methods appear to be on the rise, and travel cost methods have been relatively steady over the past decade or so.

This examination of publishing activity across the range of environmental valuation approaches reveals a demand that is strong and growing among academics. It appears that stated preference methods are increasing in popularity in terms of academic publication. One can speculate on the reasons for the rise of contingent valuation, and more recently other stated preference methods, in the published academic literature. The following are my personal hypotheses on the issue. First, the potential payoff is relatively large. Because stated preference methods can provide measures of passive use value, and passive use value is the most uncertain form of value, innovation in this area will be significant and will likely be highly rewarded. The academic climate has been supportive of such work as has the policy environment (in some countries at least). Researchers in the area are engaged in a difficult but potentially high payoff area (or may be searching for the Holy Grail?) in trying to measure passive use values and reap the benefits from innovation in this area.

Second, stated preference methods offer researchers more control over the experimental design than revealed preference methods. There has, in

general, been movement towards methods with control in economics, as indicated by the rise of experimental economics (Shogren 2003).

Third, the collection of data and the costs associated with data manipulation can be smaller in stated preference research than in revealed preference research. This last statement is an overgeneralisation, since some stated preference data collection exercises are very expensive. However, it also possible to generate data sets from classrooms of students or small, easily collected surveys. Collection of data for use values like recreation visits or hedonic price analyses most often involves significant effort in the collection of primary data and in the manipulation of these data (e.g., measuring travel costs) and the collection of supplementary data (e.g., collection of attribute data). Therefore, the (potentially lower) cost of production for publications using stated preference methods may be contributing to the differences in the number of publications arising over these categories.[5] Finally, given the Exxon case, there has been significant activity in the published literature on the merits and drawbacks of stated preference techniques.

It is clear that the academic market in environmental valuation research is alive and well. This market appears to be leaning towards the use of stated preference methods, although revealed preference research methods are not declining. The next section raises the question of whether these techniques are used in policy and resource management.

3. Environmental valuation in the real world

In the environmental valuation area most of the final demand comes from policy makers and public agencies (reviews of the use of valuation research in policy include Navrud and Pruckner (1997), Silva and Pagiola (2003), Government of South Australia (1999) and Smith (2000)). There may be some private market demand for these services if the techniques apply to market processes or opportunities, but in the present paper I will focus on the demand by public agencies. Of course, as in any system of exchange what we actually observe is a temporary equilibrium outcome between demanders (public agencies) and suppliers (researchers, consultants). The public agencies are influenced by the legal setting, the information base and other contextual factors. These agencies cannot demand services that do not exist, yet their preferences will influence development of new techniques and services. Information, technology and preference change, generating a new equilibrium.

[5] This is not to say that the cost of stated preference research should be, or always is, lower than revealed preference research. That depends on the research question at hand.

One can think of this examination as a type of random utility model. Consider the policy maker/analyst who is operating in a benefit-cost framework.[6] The issues being considered may be the determination of the level of particulate matter allowed in pollution regulation or the general approach to biodiversity conservation in forests. There may also be more focused issues such as the choice of approaches for determining compensation payments for environmental damages. The analyst has a choice of approaches that can be used to assess alternatives. The analyst (or group of analysts representing the public agency) chooses an approach from the many that exist. The choice is made based on some form of preference function that may include the match with the policy problem, confidence in the technique (perhaps based on published literature and contacts with professionals), cost of implementation, history of application, and other aspects including consistency with the priors and philosophy of the agency.[7] Naturally there are budget constraints and a limited set of alternatives. The analyst's choice may be between competing valuation approaches and/or between valuation approaches and other approaches to addressing the problem.

How have environmental valuation techniques performed in this arena? There are a few areas in which valuation approaches are well established. These areas include damage assessment cases in the USA (particularly use value damage assessment and resource compensation), and more recently evaluations of human health benefits arising from environmental quality changes (USA, Canada, Europe etc.). There is also some use of valuation results in benefit cost analysis of water resource planning (in-stream flow needs), planning for forest resource use (US Forest Service) and tax increment financing initiatives (initiatives that invest in environmental improvements with the hope that these will increase property values and provide offsetting tax revenues (see Ihlanfeldt and Taylor 2004). In other areas, however, there have not been as many applications as one would hope for.

[6] Some jurisdictions require that regulations be subject to benefit-cost analysis. In many other cases it is not unusual for policy makers to operate in an informal benefit-cost fashion. However, the use of formal benefit-cost approaches in policy analysis in health and environmental areas is still quite controversial (see Arrow *et al.* 1996) and even prohibited in some contexts. The use of valuation methods is largely predicated on some form of benefit-cost framework. This topic will be examined in more detail later in present the paper.

[7] In various published literatures in economics there is discussion of the notion that public agency demand for economic tools/approaches is significantly affected by the philosophy and objectives of the agency. An example is supply side revolution in USA macroeconomics, in which agency objectives and the theory were well aligned.

3.1 Use of environmental valuation in natural resource management

In my opinion, in the natural resource planning area (land use, policy making) there have been relatively few applications of environmental valuation, especially when the cases deal with passive use values. This may be in part as a result of the lack of understanding about, or confidence in, benefit cost analysis in such situations. Regardless of the fact that many jurisdictions require benefit cost analysis of regulatory change, these analyses are often more qualitative than quantitative. In the natural resource management area there is hesitation on the part of public agencies to consider, or quantify, outputs from management of natural systems such as forests and wetlands. There also appears to be a drive, particularly in North America, for some form of nature emulation that is almost directly at odds with a benefit cost framework. It is these areas of ecosystem service valuation and passive use values where the policy problems are wicked and the valuation methods are probably weakest. To a certain extent the use of economic analysis methods may also have been limited because these agencies were largely staffed by individuals with biology or forestry backgrounds and, therefore, maintained a different culture of policy analysis.

The discussion above highlights the linkage between institutions, particularly property institutions, and the valuation frameworks. Valuation of recreation benefits becomes a service desired by private agencies when recreation is privatised. In Canada public land institutions preclude such an approach. The public agency continues to be responsible for recreation resource allocation yet often chooses approaches for such allocation that are at best informally based on benefit cost or economic principles.[8] This is in spite of the fact that the link between actual behaviour and expenditures often provides some information to analysts about preferences for such services.

In the case of resource allocation, where passive use values are important, decisions are typically not made in an explicit benefit cost framework. Protected area decisions, for example, are still largely based on biological information. There is some use of economic information in endangered species recovery plans, but this tends to be information on impact assessment and not on the value associated with the levels of protection/recovery. Given the potential for irreversibilities and our limited understanding of values and preferences in the context of irreversibility and dynamics, this may be quite appropriate. However, if ignoring passive use values results in placing zero values on such services, then this is likely not a desirable practice.

[8] An exception may be the US Forest Service with its long history of including recreation values in forest planning approaches on public lands.

An interesting institutional change that is occurring in forestry is the development of certification (eco-labelling) standards. In some ways these are supplanting public policy as the mechanism that guides resource development. These certification schemes have desirable properties in that they are tied to markets and act as signals for products with environmentally sensitive processes (as well as processes that are cognisant of labour and Aboriginal Peoples' issues). However, certification processes essentially embed the valuation exercise in the standard setting process. The process generally provides a threshold or guideline, which must be met by the agency in order to be certified. These guidelines are based on negotiation by relevant parties, rather than on some form of social benefit cost analysis. One could characterise many applications of ecosystem management in the same way; stakeholder groups providing value based input on largely ecological information scenarios.

The use of environmental valuation in decision-making and policy analysis has been the focus of a number of studies. A study of the use of environmental valuation in Australia states:

> Although there have been many CVM and other environmental valuation studies undertaken, the number which have significantly influenced decisions has been small. The majority of studies has been of an academic nature and has not been intended to influence decisions. There appears to be a considerable level of skepticism among decision-makers and the community at large about the validity of 'putting a price on the environment' and the results of such studies are treated accordingly. (Government of South Australia 1999, p. 6)

A recent report from the World Bank provides a somewhat more positive view of the use of environmental valuation tools in World Bank projects:

> The results show that the use of environmental valuation has increased substantially in the last decade. Ten years ago, one project in 162 used environmental valuation. In recent years, as many as one third of the projects in the environmental portfolio did so. While this represents a substantial improvement, there remains considerable scope for growth. (Silva and Pagiola 2003, p. 1)

An examination of the types of valuation methods used in these World Bank studies shows that avoided costs and changes in productivity (market based methods) are far more common than are contingent valuation, hedonic price, or other actual environmental valuation techniques.

These are only two studies and, therefore, it is difficult to make bold conclusions; however, it appears that there is a schism between the academic work on valuation and the application/policy world, particularly in the area of natural resource decision making (forestry, wildlife etc.). While academics continue to investigate passive use values associated with biodiversity, land use decisions and endangered species, policy application of these studies seems to be rare.

3.2 Use of environmental valuation in environmental management

The use of environmental valuation, particularly passive use values, in resource management, appears quite limited. However, in the case of environmental policy making, specifically pollution control standard setting, the situation appears quite different. Some of the most important policy applications of environmental values have been those that are linking environmental quality to human health. The retrospective and prospective analysis of the USA Clean Air Act Amendments (CAAA) (so called 8/12 study) was designed to assess the benefits and costs of the CAAA, specifically those associated with particulate matter and ozone (US EPA 1999). In this process the values of reduced mortality risk, morbidity and ecosystem effects were considered. Without a doubt the most influential values are those associated with mortality risk. The linkage between pollution, human health and valuation of mortality risks (the damage function approach) accounted for approximately 90 per cent of the value of the program. A similar examination in Canada also produced values of this magnitude (Royal Society of Canada 2001). The values arising from ecosystem services (changes in recreational fishing, forest harvests, agriculture etc.) were relatively small. The values of ecosystem services, however, are also the most uncertain. There were no estimates of passive use values associated with ecosystem effects of pollution, in part because these estimates are difficult to construct and also because there may have been double counting with the other categories of effects.

One of the issues arising from the assessments of the CAAA is the increased use of benefits transfer for relatively generic values. Values of statistical life (VSL, or values of reduced mortality risk) are pooled from various studies and contexts to generate a distribution of values. Current research is examining how these values change with age, health status and other factors. There is considerable debate about the use of measures that directly address quality of life (QALY, or quality adjusted life years; see Hammitt 2002) and research that is ongoing that attempts to link QALY and VSL measures. Nevertheless, there is a surprising degree of agreement

and consistency regarding these values and their use in policy analysis. Furthermore, in the analysis of the CAAA the stated preference and revealed preference measures for mortality risk were blended, with recognition of the limitations associated with either approach.

3.3 Why the difference?

The interest in valuation in health: environmental policy appears to be strong, yet its application in resource policy and resource management appears to be limited. Why is this the case? The difficulty with more traditional values used in resource management (use values and particularly passive use values) is that both the context and the individual preferences are highly variable. Environmental conditions vary from region to region and there has been relatively little work to try to standardise values. It is possible to generate distributions of estimates for use values (fishing days, hunting days, hiking days) but even these are dependent on the person (income, preferences etc.) as well as the context (Grand Canyon, Great Barrier Reef, my backyard). Furthermore, these use values continue to be relatively small in the cases like the CAAA; therefore, little effort is put into further evaluation.

Passive use values present additional difficulties. They are even more dependent on context, as often their value arises from their uniqueness. There are few triangulation mechanisms (stated preference techniques are the only option) and there is a great deal of uncertainty regarding incentive compatibility, information presentation, salience, warm glow effects and other elements of survey design in elicitation of these values (Carson; Groves and Machina 2000). In the case of values of mortality risk reduction, however, the 'good' can be reasonably well defined. Of course the definition still depends on quality of life differences, perceptions, risk processing and other factors, although significant strides have been made in the communication of such issues. Furthermore, the same value can be examined with various approaches (wage differentials, stated preference methods etc.).

Values of mortality risk reduction, or longevity, are also being incorporated into other aspects of economic assessment. Nordhaus (2002) uses the value of mortality risk reduction to provide measures of economic well-being that include welfare arising from increased life expectancies. He shows that a significant proportion of welfare gain over time has arisen from the improvement in life expectancy and shows how such measures can be used to argue for health-care expenditures as investments, rather than costs. This links the value of health to economic accounting and the measurement of well-being in a rigorous economic framework. This is a health economics version of natural resource/green accounting. It is likely that many such exercises will be developed in the future as economic values are increasingly applied in health research.

One could argue that because of the direct linkage between health and human welfare, assessing estimates of value in the health–environmental area should be easier to develop and more clearly linked to policy application. In part this depends again on the underlying institutional framework. The CAAA studies, and similar work in many other countries, are based on strong benefit cost principles. There is still considerable debate about the use of benefit cost analysis in the area of health–environmental policy; nevertheless benefit cost analysis seems to have established a very strong foothold.

Will we see similar frameworks develop for the examination of endangered species policy or biodiversity conservation? Probably not in the near future. It is interesting to question, however, whether the move towards the use of benefit cost analysis in the health–environment area arose because of the confidence in monetary estimates, or whether advances in valuation arose because of the framework that made these values relevant to policy analysis.[9] The former is consistent with the notion of the analyst choosing among various approaches or techniques. The latter illustrates the endogeneity between valuation and policy institutions and feedback effects between the actors in the market for environmental valuation. Economic approaches to policy making, in large part benefit cost approaches, require by their nature individual preference information to assess trade-offs. As we shall see in the next section on advances in valuation methods, these issues of economic policy formation and elicitation of preference information will continue to play a role in the evolution of valuation methods.

4. Advances in environmental valuation: theory and methods

In this section I turn to some of the important developments in valuation methods, and some of the possible frontiers. The policy environment and the development of institutions surrounding economic evaluation of resource and environmental policy options will undoubtedly influence these developments. However, there also appears to be a cross-disciplinary synergy arising among those researchers who are interested in human choice behaviour. It is from these synergies that the most interesting innovations will likely arise.

4.1 Theory

Some analysts of human choice behaviour suggest that ‘everything is context’ and that there is no systematic choice model representing human decisions.

[9] It may also be the case that the levels of expertise and familiarity with economic techniques differ across jurisdictions.

Preference elicitation, the foundation of environmental valuation, would be without basis. This would also make present policy making and economic analysis irrelevant. On the contrary, what we should strive for is a more structured representation of choice behaviour in which systematic relationships between contexts, incentives, constraints and the decision structure are developed. Recent research that has uncovered preference anomalies, for example, can be thought of as a deadly blow to the economists' model of preferences and choice, or can be considered a challenge for economists to focus more on the reasons for such outcomes and to develop models of behaviour that incorporate such outcomes into systematic representations of behaviour.

In many ways the issue of whether individuals have preferences is the fundamental challenge for valuation research, and for much of economic policy. McFadden, in his Nobel lecture (2000), sets out the issue clearly. He writes:

> The existence of underlying preferences is a vital scientific question for economists. If the answer is affirmative, then the evidence from cognitive psychology implies only that economists must look through the smoke screen of rules to discern deeper preferences that are needed to value economic policies. This is a difficult task but not an impossible one. If the answer is negative, then economists need to seek a foundation for policy analysis that does not require that the concept of 'the greatest good for the greatest number' be meaningful. I am guardedly optimistic that the question has an affirmative answer. (McFadden 2000, pp. 345–346)

A slightly different position has been expressed by Sunstein:

> In this essay I offer support for cost-benefit analysis, not from the standpoint of conventional economics, but on grounds associated with cognitive psychology and behavioural economics. My basic suggestion is that cost-benefit analysis is best defended as a means of overcoming predictable problems in individual and social cognition. Most of these problems might be collected under the general heading of *selective attention*. Cost-benefit analysis should be understood as a method for putting 'on screen' important social facts that might otherwise escape private and public attention.' (Sunstein 2001, p. 1)

The search for the deep preferences that McFadden (2000) describes, and the identification of systematic relationships between choices and contexts, will help establish the use of preferences as the basis for economic policy

and the basis for understanding environmental preferences. This search, however, will require continued evolution of theory as well as innovative use of data and methods.

The most significant advance in the area of preference elicitation has been the movement towards the analysis of individual level data using random utility models and their related methods. Paralleling this set of advances has been the interest in behavioural economics and understanding individual choice behaviour (e.g., List 2002). Even hedonic price analysis is being reconsidered in light of theoretical and empirical advances in random utility frameworks. In part this has meant a movement away from examination of aggregate demands and a focus on individual utility maximisation and preference elicitation. Of course this movement occurred not only in environmental valuation but also in demand analysis in general (McFadden 2000), as well as in transportation economics, marketing, health economics and other areas where information on individual preference is critical in analysis. The development of random utility theory may have arisen to a degree because of the availability of individual level survey data, something that has been available in environmental economics for some time. It has also spurred efforts in data collection at the individual level, including detailed collections of data on historical behaviour and demographics. Differences between individuals are no longer assumed away or masked by aggregate analysis, rather these difference are embraced as an integral element of the analysis of choice behaviour.

The movement towards modelling individual behaviour in order to assess trade-offs has been accompanied by sophistication in econometric analysis of individual level choice data. Indeed, one of the most fundamental differences in the use of random utility theory is that the econometric analysis is not separable from the economic theory/behavioural analysis. The specification of the random component is a fundamental component of the analysis. Therefore, advances in econometrics associated with modelling large numbers of alternatives or options, incorporating unobserved heterogeneity (Train 2003), including panel data effects in repeated choices (Train 2003), and a large number of other innovations have progressed rapidly.

The use of random utility models has been paralleled by increased individual level data (scanner panel data, intense surveys including internet or WebTV surveys etc.) and by significant advances in econometrics. The focus on individuals has also brought valuation and choice research closer to research in psychology, decision sciences and other social sciences that focus on human choice behaviour. In particular, behavioural economics and experimental economics developments have intertwined with valuation/choice research. A new breed of economist is being developed. This new breed seldom works with supply and demand graphs and is much more comfortable with

literature from psychology, survey research, experimental design and other disciplines.

While the random utility revolution has generated significant improvements in understanding human choice behaviour, many questions remain. McFadden (2000) states that what economists typically examine as choice is only one part of a process that includes perceptions, memory and motivation. He also shows that various data sources can be applied to the examination of the various components of choice and recognises the need for pluralistic approaches in examination of preferences.

Another useful model to consider is the framework presented by Swait *et al*. (2002) in which choice behaviour is modelled in general terms as follows. Let D be the decision strategy for individual n and C the individual's choice set. Subscript j indexes alternatives and t is time. The strength of preference is captured in V and ε is an error process arising from elements unobserved by the researcher. The stylised decision model is the process of choosing alternative i_{nt}^* in the form:

$$i_{nt}^* \leftarrow \underset{j \in C_{nt}}{D_n} \{V_{jnt}, \varepsilon_{jnt}\}. \tag{1}$$

Within such a structure the following issues arise. Decision strategies, typically assumed to be compensatory, become a variable within the system. Noncompensatory decision strategies (strategies that do not involve tradeoffs among the attributes of alternatives) may arise because of cost, time or complexity constraints within the system. The choice set is also individual specific and in this case varies by time and context.

Choice set formation continues to be a vexing issue in such models and behavioural models of choice set formation are still relatively rare. Preferences are captured in V, but changes in context (different choice environments, social interdependence etc.) may affect these evaluation weights. The error component will also be affected by context changes with increased variability over a sample or within an individual over time arising because of changes in complexity, situation etc. Therefore, a more general model of choice, influenced by contextual factors, may be written as:

$$i_{nt}^* \leftarrow \underset{j \in C(\Omega)_{nt}}{D(\Omega)_n} \{V(\Omega)_{jnt}, \varepsilon(\Omega)_{jnt}\}. \tag{2}$$

where Ω represents context factors (Swait *et al*. 2002).

There are several key areas of context that are on the research horizon.[10] The analysis of complexity (Swait and Adamowicz 2001a,b) and attention

[10] An example of a 'context' issue directly relevant to environmental valuation is the recent work by Alevy *et al.* (2003) on the 'more is less' phenomenon.

(Gabaix *et al.* 2003) is emerging with interesting results that explain variability in choice behaviour. Improved understanding of the way that humans process information and allocate mental effort resources should help us understand choices in various contexts. Surprisingly little has been done in economic analysis of this area, even though the problem of mental effort allocation can be considered a fundamental type of economic problem.

Examining social contexts is also an emerging area of research. Decisions are seldom made in isolation. Understanding of household choices and intrahousehold decisions has increased over the past two decades (e.g., Browning and Chiappori 1998). However, most of the analyses of these intrahousehold processes have used aggregate data. Examining these processes using individual level data and aggregating up to the household or group should provide additional insight into the theory and empirical applications. It will also provide information on household value and intrahousehold distribution of values arising from policy options. More generally, analysis of social interdependence and its effect on preferences and trade-offs, is a challenging and largely unexplored area of research (Manski 2000).

4.2 Data generating mechanisms

Researchers interested in valuation are interested in assessing trade-offs that people make. Theory tells us a great deal about factors that influence trade-offs (substitutes in space, time, income etc.). More recent theory is expanding the list of items that we expect will affect trade-offs (cognition, attention, ability, a host of context issues etc.). However, environmental valuation research is, by its nature, an empirical branch of economics. Some of the most significant advances in environmental valuation have arisen from the use of a variety of data generating mechanisms (DGM), as well as a recognition of the limitations of the DGM. McFadden (2000) describes the choice process or the mechanism that generates revealed preference data. In his framework a number of other data types can be elicited, including stated preferences, stated perceptions and attitudinal scales. All of these pieces of information have been shown to be useful in understanding choices and preferences. Furthermore, a controlled environment through laboratory (Harrison 2002) or field experiments (Harrison and List 2003) can provide information on another set of choices and preferences.

Recognition that revealed preference data alone are often not sufficient for understanding preferences and trade-offs is a major advance in the profession. However, we still have a long way to go to understand how to combine and calibrate DGM and how to best make use of the desirable properties of various DGM. Other social science disciplines routinely use some form of triangulation of data or information types. In economics the

rules of triangulation may be more rigorous as the DGM will have to pass strong theoretical requirements. However, the merit of knowing how to cleverly combine different sources of data is a key to unlocking information on preference. More rigorously controlled data sources may also be the key to understanding when deviations from our more traditional economics models are processing and information errors and not weaknesses in the standard model (McFadden 2000; List 2003).

Several strands of research are emerging on these fronts. The combination of stated and revealed preference data that entered the environmental valuation field with the work of Cameron (1992) and Adamowicz *et al*. (1994) has progressed to the assessment of multiple data sources and the inclusion of preference and variability factors (Cameron *et al.* 2002). Continuing work on this front will help identify the properties of different data forms and describe procedures for the combination of such data. An important recent strand of research in this area is preference calibration (Smith *et al*. 2002) in which benefit transfers are conducted with data sets or benefits estimates combined according to an underlying theoretical frame. This modular approach to understanding trade-offs shows that data and parameters from various data generating mechanisms can be combined to provide insights into specific situations.

Experimental economics is having an increasing impact on valuation research. Experiments have long been part of the published literature on environmental valuation but this has been bolstered by recent effects on eliciting homegrown values (or personal values) (Harrison 2002; Shogren 2003). The advantages of experiments are clear: researcher control over the setting and manipulation of the setting as well as clarity in instructions. Experiments are providing important information on hypothetical bias, calibration possibilities and question design. Experiments are particularly valuable in providing incentives for truthful responses. In doing so experiments will also help survey designers with question design. The use of such tricks as cheap talk scripts[11] (Cumming and Taylor 1999) and degree of certainty of response[12] (Harrison 2002) in contingent valuation has arisen largely because of the use of experiments to assess these methods. Using

[11] Cheap talk scripts are scripts in the survey that tell respondents that people often respond differently to hypothetical questions and their valuations are often lower when there are real consequences. These scripts in some cases outline the degree to which hypothetical and real valuations differ.

[12] After a valuation question researchers ask the respondent how certain they were about their choice. There is evidence that people who respond 'yes' to paying for a program but state that they are uncertain are better represented as 'no' respondents. When such a practice is used the results of the hypothetical choices better mirror results using real choices.

methods such as cheap talk scripts in hypothetical surveys can result in responses that are more like those that arise in experiments with incentive compatible formats.

However, the jury is still out on the degree to which experiments alone can provide estimates of environmental values that are suitable for public policy. First, the challenging cases are real public goods that are difficult for experiments to deal with. Second, the experimental context itself may be affecting the responses of individuals. While current approaches to experiments may have difficulty in revealing values of actual public goods, there are undoubtedly opportunities for calibration of experimental data with other data. This calibration could be based on methods like those used by Adamowicz *et al*. (1994) and Adamowicz *et al*. (1997) or on the framework provided in the preference calibration literature (Smith *et al*. 2002). Nevertheless, experiments are certainly one of the data generating mechanisms that economists must use and continue to refine and they will increase in importance for environmental economists.

Paralleling the advances in data collection on individual choice and behaviour are advances in data on attributes and environmental conditions. Geographic information systems technologies have provided spatially explicit information on neighbourhood characteristics, recreation attributes, ambient air quality, and other variables, which have never been collected with such richness. These data at times overwhelm the data on human behaviour, but it is a pleasure to have such data available.

4.3 Econometric methods

The advances in the econometric analysis of individual level data have been astonishing. The development of tools and easily accessible software for discrete choice methods, including analysis of heterogeneity (mixed logit models and latent class models), temporal linkages and dynamics, panel data, and a host of other issues has been remarkable. Similar advances have occurred in spatial econometrics and have led to improvements in hedonic price analysis. As mentioned above, in modern analysis of preferences using random utility theory and its variants, the theory is not separable from econometric methods. Therefore, advances in modelling behaviour will depend on advances on both fronts simultaneously. While some of these issues have been discussed above, a few more points are worth mentioning.

Mixed logit models and Hierarchical Bayesian econometric methods provide insights into individual behaviour and provide powerful tools for the analysis of complex theoretical models (Train 2003). However, these approaches have largely examined preferences, or the V component in equation (2). There have not been similar advances in assessing the other components

of this decision structure. Louviere and colleagues (e.g., Louviere 2003) have made a convincing case for the careful analysis of the error component or response variability (as opposed to heterogeneity). Similarly, there are efforts on choice set formation (van Haefen 2003) and decision strategy selection (Yang and Allenby 2000; Swait and Adamowicz 2001a). However, these published literatures are relatively small. One of the challenging issues is the fact that there is a significant identification problem in developing the most general model. Changes in context, for example, may affect error components and preferences. Untangling these effects will be a challenge for econometric models of individual level choice.

Almost all environmental valuation estimates are based on static models. There have been few examples of valuation based on dynamic or intertemporal analyses, where the concept of compensating variation is derived from an explicit dynamic utility model. It is also unclear how preference for environmental goods and services evolve. There is evidence that non-market values are increasing relative to market values (Costa and Kahn 2003); therefore, understanding these trends will be important for policy development. However, sound policy development in this area will require appropriate theory and empirical analysis. Economic theories of intertemporal choices are fairly well developed but individual level data on choices/behaviour over long time periods are rare. Furthermore, econometric methods are complicated by the problem of heterogeneity in initial conditions, or difficulty in observing initial conditions. Given the emphasis on sustainability in resource and environmental policy it seems that improved understanding of intertemporal welfare, learning and preference evolution is critical. Some strides are being made (e.g., Brock and Xepapadeas 2003; Swait *et al*. 2004; Zhao and Kling 2004) but this remains a challenging area of research.

5. Conclusions

Environmental valuation continues to be an active and challenging area of research within economics. The area has evolved with improvements in theory, methods and data and has had its own impact on the economics profession and on policy makers. While there continues to be significant interest in academic research on the topic, the policy implementation of this work is not as active as one would hope. In part this is because of the institutional setting that environmental and resource policies are made in. The issues that are being dealt with are complex and often highly politicised. In addition, the sensitive issue of individual preferences as the basis for policy in the environmental and health areas makes the use of benefit-cost approaches challenging. At root are the issues of whether individual

preferences should matter, and whether we can accurately capture these preferences to use them in rigorous benefit-cost analysis frameworks. Most people would agree with the former,[13] far fewer would agree with the latter.

As environmental economists we must also not lose sight of the prize of improved allocation of resources arising from environmental and resource policy. Valuation of public goods like biodiversity or protected areas will not solve the problem of missing incentives for conservation by economic agents. The two issues of assessing benefits and costs, and designing institutions to efficiently and equitably allocate resources must be jointly investigated to address such environmental concerns. We cannot lose sight of the fact that valuation is a tool that will help us with these tasks, but at times more effort will have to be put into the design of institutions rather than the measurement of costs and benefits.

The most significant advance in environmental valuation may be to move away from a focus on value and focus instead on choice behaviour and data that generate information on choices. Advances in resource allocation are most likely to arise from better understanding of preferences and choice, rather than the generation of more value estimates and catalogues of these measures.[14] The continued synthesis of research from marketing, psychology, decision sciences, transportation research, environmental economics and other fields of social science research will also improve our understanding of and ability to model choice behaviour.

The recent advances in understanding choice behaviour, in particular using random utility theory, show that theory and econometric analysis are largely inseparable. In addition, there is increasing realisation of the importance of understanding the properties of the data generating mechanisms. Revealed preference data, the many varieties of stated preference data and experimental data all provide different insights into choice behaviour and

[13] The notion that human preferences should matter is rejected in some circles of ecology and conservation biology. This also helps explain why economic methods have not established themselves in ecosystem management.

[14] Furthermore, in many instances the value is not required. In some policy contexts we are simply searching for remedies to offset damages and these remedies can be made in kind rather than in monetary terms. Two examples of such cases are: (i) the method of resource compensation that calculates in-kind remedies for environmental damage assessments, for example the Lavaca Bay Texas natural resource damage assessment (http://www.darcnw.noaa.gov/lavdarpr.pdf); and (ii) the approach to maintaining a legal commitment to Aboriginal People of non-declining well-being from forest resources outlined in Adamowicz *et al.* 2004). In addition, an often used approach in natural resource damage assessment is Habitat Equivalency Analysis (Penn and Tomasi 2002). This approach attempts to offset environmental service losses by finding equivalent environmental services to replace those damaged. Therefore, it also offers an in-kind compensation but determines this independent of human preferences.

preferences, and all have different underlying properties arising from differences in research control, salience and variability. Advances will arise from clever ways of finding complementarity over these data sources and from triangulation. Such calibration and combination may also provide insights into the identification problem that confounds effects of preferences, variability, decision strategy and choice set formation.

Environmental valuation does not appear to be used in policy analysis to the extent that it could or should be. This may be because of a continued concern about the methods, or it could be because the research results need to be better communicated and focused more on policy application. Increased recognition by the research community of the needs of policy makers can help in this regard. In addition, development of more transferable value measures and further development of benefit transfer techniques, especially preference calibration, is very important in this regard.[15] Such research will have to include assessments of the degree to which benefit estimates vary by demographic, cultural and other factors.

In practical terms environmental valuation research has made great strides in measuring use values, including values associated with health risk reductions (morbidity and mortality), recreation values, and property value changes. There has been less success in measuring passive use values and ecosystem service values. This area presents the most significant challenges for environmental economists. Such efforts will necessarily include consideration of sustainability and irreversibilities as well as the complexities of ecosystem–social system interactions (see Brock and Xepapadeas (2003) for an excellent example of such a system). Perhaps the next decade will generate successes from the interdisciplinary work between economists and ecologists just as the previous decade has generated innovations from collaborations between economists, psychologists and other social scientists.

References

Adamowicz, W.L., Swait, J., Boxall, P., Louviere, J. and Williams, M. 1997, 'Perceptions versus objective measures of environmental quality in combined revealed and stated preference models of environmental valuation', *Journal of Environmental Economics and Management*, vol. 32, pp. 65–84.

Adamowicz, W.L., Louviere, J. and Williams, M. 1994, 'Combining stated and revealed preference methods for valuing environmental amenities', *Journal of Environmental Economics and Management*, vol. 26, pp. 271–292.

[15] I thank an anonymous referee for pointing out this issue. In addition to continued effort in the academic market there is also a need to place effort in the policy market. For environmental valuation the latter may be more important than the former at this point in time.

Adamowicz, W.L., Boxall, P., Haener, M., Zhang, Y., Dosman, D. and Marois, J. 2004, 'An assessment of the impacts of forest management on Aboriginal hunters: evidence from stated and revealed preference data', *Forest Science*, vol. 50, pp. 139–152.

Alevy, J.E., List, J.A. and Adamowicz, W.L. 2003, 'More is less preference reversals and non-market valuation', Department of Agricultural and Resource Economics working paper, University of Maryland, College Park, Maryland.

Arrow, K., Cropper, M., Eads, G., Hahn, R., Lave, L., Noll, R., Portney, P., Russell, M., Schmalensee, R., Smith, K. and Stavins, R. 1996, 'Is there a role for benefit-cost analysis in environmental, health, and safety regulation?', *Science*, vol. 272, pp. 221–222.

Bateman, I.J. and Willis, K.G. (eds) 1999, 'Valuing environmental preferences', *Theory and Practice of the Contingent Valuation Method in the USA, EC, and Developing Countries*, Oxford University Press, New York.

Brock, W.A. and Xepapadeas, A. 2003, 'Valuing biodiversity from an economic perspective: a unified economic, ecological and genetic distance approach', *American Economic Review*, vol. 93, pp. 1597–1614.

Browning, M. and Chiappori, P.A. 1998, 'Efficient intra-household allocations: a general characterisation and empirical tests', *Econometrica*, vol. 66, pp. 1241–1278.

Cameron, T.A. 1992, 'Combining contingent valuation and travel cost data for the valuation of nonmarket goods', *Land Economics*, vol. 68, pp. 302–317.

Cameron, T.A., Poe, G.L., Ethier, R.G. and Schulze, W.D. 2002, 'Alternative non-market value-elicitation methods: are the underlying preferences the same?', *Journal of Environmental Economics and Management*, vol. 44, 391–425.

Carson, R.T. 2000 'Contingent valuation: a users guide', *Environmental Science and Technology*, vol. 34, pp. 1413–1418.

Carson, R.T., Groves, T. and Machina, M.J. 2000, *Incentive and Informational Properties of Preference Questions*, Department of Economics, University of California, San Diego.

Champ, P., Boyle, K. and Brown, T. (eds) 2003, *A Primer on Nonmarket Valuation*, Kluwer, Dordrecht.

Ciriacy-Wantrup, S. 1947, 'Capital returns from soil conservation practices, *Journal of Farm Economics*, vol. 29, pp. 1181–1196.

Costa, D.L. and Kahn, M.E. 2003, 'The rising price of nonmarket goods', *American Economic Review*, vol. 93, pp. 227–232.

Cummings, R., and Taylor, L. 1999, 'unbiased value estimates for environmental goods: a cheap talk design for the contingent valuation method', *American Economic Review*, vol. 89, pp. 649–665.

Freeman, A.M. 2003, *The Measurement of Environmental and Resource Values*, Resources for the Future Press, Baltimore.

Gabaix, X., Laibson, D. and Moloche, G. 2003, 'The allocation of attention: theory and evidence', working paper, Harvard University, Cambridge. [Online]. Available: http://post.economics.harvard.edu/faculty/laibson/papers/braug302xwithauthorsnames.pdf

Government of South Australia 1999, *Application of Environmental Valuation in South Australia*, Department for Environment, Heritage and Aboriginal Affairs, Adelaide.

Haab, T.C. and McConnell, K.E. 2002, *Valuing Environmental and Natural Resources*, Edward Elgar, Northampton.

Hammitt, J. 2002 'QALYs versus WTP', *Risk Analysis*, vol. 22, pp. 985–1001.

Harrison, G. 2002, 'An Introduction to experimental economics prepared for the Nineteenth Biannual Workshop of the Economy and Environment Program for Southeast Asia (EEPSEA)', Manila, November, Department of Economics, University of South Carolina, Columbia. [Online]. Available: http://dmsweb.moore.sc.edu/glenn/Manila/presentations/Introduction %20to%20Experimental%20Economics.pdf

Harrison, G. and List, J. 2003, 'What constitutes a field experiment in economics?', working paper, Department of Economics, University of South Carolina, Columbia. [Online]. Available: http://dmsweb.moore.sc.edu/glenn/wp/What%20Constitutes%20a%20Field%20Experiment%20in%20Economics.pdf

Hotelling, H. 1949, 'Letter to the Director of the National Park Service', in R.A. Prewitt (ed.), *The Economics of Public Recreation. The Prewitt Report*, Department of the Interior, Washington, DC.

Ihlanfeldt, K.R. and Taylor, L.O. 2004, 'Externality effects of small-scale hazardous waste sites: evidence from urban commercial property markets', *Journal of Environmental Economics and Management*, vol. 47, pp. 117–139.

List, J.A. 2002, 'Scientific numerology, preference anomalies and environmental policy-making', paper presented at Iowa State University, draft, Department of Agricultural and Resource Economics, University of Maryland, College Park, Maryland.

List, J.A. 2003, 'Does market experience eliminate market anomalies?', *Quarterly Journal of Economics*, vol. 111, pp. 41–71.

Louviere, J.J. 2003, 'Complex statistical choice models: are the assumptions true? If not what are the consequences?', paper presented at Advancing the Methodology of Discrete Choice Experiments in Health Economics, Oxford University, September.

Manski, C. 2000, 'Economic analysis of social interactions', *Journal of Economic Perspectives*, vol. 14, pp. 115–136.

McFadden, D.L. 2000, 'Economic choices: Prize Lecture December 8 2000', *Economic Sciences*, pp. 330–365. [Online]. Available: http://www.nobel.se/economics/laureates/2000/mcfadden-lecture.pdf

Mitchell, R.C. and Carson, R.T. 1989, *Using Surveys to Value Public Goods. The Contingent Valuation Method*, John Hopkins University Press, Baltimore.

Navrud, S. 2004, 'Value transfer and environmental policy', in T. Tietenberg and H. Folmer (eds), *The International Yearbook of Environmental and Resource Economics 2004/2005. A Survey of Current Issues*, Edward Elgar Publishing, Cheltenham, UK and Northampton, MA, USA, pp. 189–217.

Navrud, S. and Pruckner, G.J. 1997, 'Environmental valuation – to use or not to use? a comparative study of the United States and Europe', *Environmental and Resource Economics*, vol. 10, pp. 1–26.

Nordhaus, W.D. 2002, 'The health of nations', working paper w8818, National Bureau of Economic Research, Cambridge, MA.

Penn, T. and Tomasi, T. 2002, 'Calculating resource restoration for an oil discharge in Lake Barre, Louisiana, USA', *Environmental Management*, vol. 29, pp. 691–702.

Royal Society of Canada 2001, 'Report of the Royal Society of Canada Expert Panel to review the socioeconomic models and related components supporting the development of Canada-wide standards for particulate matter and ozone, The Royal Society of Canada, Ottawa, Ontario, June. [Online]. Available: http://www.rsc.ca

Shogren, J. 2003, 'Experimental methods and valuation', in *Handbook of Environmental Economics*, J. Vincent, and K.-G. Maler (eds), North Holland, Amsterdam.

Silva, P. and Pagiola, S. 2003 'A review of the environmental costs and benefits in world bank projects', paper no. 94, *World Bank Environmental Economic Series*, World Bank, Washington, DC.

Smith, V.K. 2000, JEEM and Non-market Valuation: 1974–98, *Journal of Environmental Economics and Management*, vol. 39, pp. 351–374.

Smith, V.K., Van Houtven, G. and Pattanayak, S.K. 2002, 'Benefit transfer via preference calibration: "prudential" algebra for policy', *Land Economics*, vol. 78, pp. 132–152.

Sunstein, C. 2001, 'Cognition and cost-benefit analysis', John M. Olin Law and Economics working paper no. 85, The Law School. The University of Chicago, Chicago. [Online]. Available: http://www.law.uchicago.edu/Publications/Working/index.html

Swait, J. and Adamowicz, W. 2001a, 'The Influence of task complexity on consumer choice: a latent class model of decision strategy switching', *Journal of Consumer Research*, vol. 28, pp. 135–148.

Swait, J. and Adamowicz, W. 2001b, 'Choice environment, market complexity and consumer behavior: a theoretical and empirical approach for incorporating decision complexity in models of consumer choice', *Organisational Behavior and Human Decision Processes*, vol. 86, pp. 141–167.

Swait, J., Adamowicz, W., Hanemann, M., Diederich, A., Krosnick, J., Layton, D., Provencher, W., Schkade, D. and Tourangeau, R. 2002, 'Context dependence and aggregation in disaggregate choice analysis', *Marketing Letters*, vol. 13, pp. 193–203.

Swait, J., Adamowicz, W. and van Bueren, M. 2004, 'Choice and temporal welfare impacts: incorporating history and expectations into discrete choice models', *Journal of Environmental Economics and Management*, vol. 47, pp. 94–116.

Train, K. 2003, *Discrete Choice Methods with Simulation*, Cambridge University Press, Cambridge.

US Environmental Protection Agency 1999, 'The benefits and costs of the Clean Air Act 1990–2010', report to Congress, November.

Van Haefen, R.H. 2003, 'Latent consideration sets and continuous demand system models', working paper, University of Arizona, Arizona. [Online]. Available: http://cals.arizona.edu/~rogervh/consider073103.pdf

Yang, S. and Allenby, G.M. 2000, 'A model for observation structural and household heterogeneity in panel data', *Marketing Letters*, vol. 11, pp. 137–149.

Zhao, J. and Kling, C.L. 2004, 'Willingness-to-pay, compensating variation, and the cost of commitment', *Economic Inquiry*, vol. 42, pp. 503–517.