ISSN 1835-9728

Environmental Economics Research Hub

Research Reports

Choice Experiments: identifying preferences or production functions?

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Research Report No. 40

November 2009

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Environmental Economics Research Hub Research Reports are published by The Crawford School of Economics and Government, Australian National University, Canberra 0200 Australia.

These Reports present work in progress being undertaken by project teams within the Environmental Economics Research Hub (EERH). The EERH is funded by the Department of Environment and Water Heritage and the Arts under the Commonwealth Environment Research Facility.

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Abstract

This paper presents an alternative perspective on the process by which respondents consider options within choice experiments. Building on the "new" model of consumer demand by Stigler and Becker (1977), it suggests that the attributes within choice experiments are not valued directly, but are used to generate higher level "constructs" (i.e. improvement in the environment) which are then valued. The implication is that what are currently viewed as marginal utilities of attributes are in fact marginal utilities of an environmental outcome mixed with (subjective) marginal productivity of the attribute to achieving the environmental outcome. It is suggested the Hierarchical Information Integration methods may allow one to separately identify the utility and production functions, and identify individual heterogeneity therein.

1. Introduction and scope

In a democratic society where government expenditure is funded through public taxes, the public have considerable influence in directing spending of public funds. Through voting for particular candidates, and lobby groups, elected governments are given signals as to what the public desires their taxes to be spent on. Yet the result of an election can seldom be regarded as an unequivocal indication of public desires (Bowen, 1944). And it would be prohibitively expensive to use referenda to decide on all public expenditure decisions.

Many have enlisted samples of individuals, for purposes of polls, surveys, interviews etc. (Bowen, 1944). However these methods have been criticised for not capturing tradeoffs between public programs. Furthermore, the public is criticised as lacking complete, consistent, and unrealistic preferences on most public policy issues, wanting to spend more on everything without considering the tradeoffs required in implementing government budgets (Hansen, 1998). Although, this critique may be better directed at the survey instrument than the individuals.

Policy makers could refer to the market to provide information on how much people will pay for some public goods, such as health care, however a problem arises when the price system is not able to provide a complete measure of value for public goods (Hanemann, 1994). This is often the case for environmental goods, where related markets are missing.

Policy makers could also refer to experts for guidance on how funds should be spent. This has occurred with environmental policy where government relies on expert opinion to direct expenditure. One example is the development of NRM policy in Australia, which was dominated by expert based decisions in the early days, but is now more open to public opinion through regional governance structures and consultation (Cleland, 2008).

Hanemann (1994) questions whether expert judgement is an alternative to consulting the public. Whilst experts can determine the biophysical affects on the environment and assess the costs of alternative actions, he states that this is different to assessing what something is worth. If it were true - the experts cannot capture true value of a environmental good - then the policy maker may be unable to select an optimal choice of action.

Stated preference (SP) techniques are used to assign money values to outcomes of choices about policies, projects and programmes (Bateman *et al.,* 2002). The value of the good is assumed to be the respondent's willingness to pay for a hypothetical change in the provision of that good. However the willingness to pay values obtained from stated preference techniques have been criticised as inaccurate, unreliable and invalid. Several factors have been found to affect this inconsistency in preferences elicited, yet most relate to the respondents information set and cognitive ability to process the valuation task. If the public are indeed incapable of expressing coherent and reliable preferences (as opposed to holding them), a key question is whether their true preferences are really divergent to experts?

Literature comparing public and expert preferences for environmental goods is sparse (McCartney, 2009; Arãna *et al.*, 2006; Goodman *et al.*, 1998; Kenyon and Edwards-Jones, 1998; Groom *et al.*, 2007; Carlsson *et al.*, 2008; Colombo *et al.*, 2009). Given an experts prior knowledge of the good, experience in decision making and a likely higher cognitive ability to process information, it is thought that preferences would diverge between experts and the public. The public may also have

difficulty in understanding the process by which the good is "produced" (i.e. the specific technology or management option that leads to a particular outcome).

If the inherent difference between public and expert samples is the level of prior knowledge and ability to use new information, changing information levels could potentially affect the system at two levels: (1) to change preferences for the public good, or (2) to change ones understanding of the process by which the public good is 'produced', and hence the value of any particular intervention. This is analogous to the *new theory of consumer behaviour*, proposed by Michael and Becker (1973) and tested in Stigler and Becker (1977). The theory proposes a model which distinguishes between preferences for high level constructs, and derived demands for 'goods' that the household uses to produce these constructs. The marginal value or shadow prices for the goods may vary as information/ technology/social- and personal-capital varies, both across individuals and across time. In other words fixed, or stable, preferences for fundamental "commodities" are produced by "goods" of which consumption of these good varies with the respondents information and cognitive ability.

The aim of this study is to determine whether the conceptual model proposed by Michael and Becker (1973) is suitable for investigating the preference structure for environmental goods. Particularly, whether differences that previous studies have observed between groups or between information treatments are due to differences in fundamental preferences, or changes in an understanding of how management options will deliver outcomes. The value of the conceptual model in exploring differences in expert and public preferences will also be considered.

This discussion is divided into a number of sections. Section 2 outlines the theory behind preference elicitation for non-market goods, issues and criticisms of these techniques are discussed, and a review of the literature pertaining to the effect of information and prior knowledge on preferences for environmental goods given. Section 3 outlines how the *new theory of consumer choice* can be applied to unpack the decision process for valuing environmental goods, with particular reference to expert vs. public preferences. In section 4 we present two survey design options and guidance to estimation. Section 5 concludes by outlining further research requirements before implementation of the *new theory of consumer choice*.

2. Preferences for environmental goods

Before we proceed, we will provide a brief definition of what is meant by 'preferences'. For the purposes of this paper we work with a very tight, technical definition: preferences are represented by the arguments, parameters and functional form of the utility function of the individual. Stability of preferences therefore implies stability of these features. Anomalies such as "preference reversals" are interpreted as observed behaviour that is inconsistent with a well behaved, stable utility function. We maintain the separation between preferences as defined, and behaviour (revealed or stated) that is (hypothesised to be) conditioned by those preferences.[1]

Standard economic theory assumes a rational consumer with well defined preferences, that do not depend on the methods used to elicit the preference nor on the description of the options (Bettman *et al.* 2006). Economic preferences for goods and services are usually revealed through market choices. Consideration of non-marketed goods cannot rely on a market to assign values through prices (e.g. increased species biodiversity), or costs (e.g. increased air pollution).

[1] In this framework "attitudes" are manifestations of unconstrained (or incompletely constrained) preferences.

SP techniques are an empirical approach to measuring economic concepts (Hanemann, 1999). Two such techniques, contingent valuation (CV) and choice experiments (CE) have been used extensively to value a variety of non-market goods which include environmental assets, public transport routes, health services and new consumer products.

SP techniques are used to obtain economic values for goods, by presenting the individual with a hypothetical market in which they are asked to express their willingness to pay (WTP) for a change in provision to the good. The CV technique offers the respondent a choice between maintaining the status quo of a good or paying for a change in provision of the good. In this paper we focus our discussion on CE's, although some examples given are from CV studies.

A CE is currently the most popular SP tool due to the respondent evaluating several policy options within the one survey framework. Lancasters' (1966) theory of the characteristics of value provides the economic theory on which choice experiments (CE) were formed. Lancaster forwarded the previous consumer theory by saying that goods are not just goods; rather there are intrinsic properties of a good which determine utility. The properties or attributes of each good are assumed to collectively equal the value of the whole good.

A choice set consists of alternative options, each of which consist of several attributes chosen by the researcher. The respondent chooses their preferred option based on the collective utility they derive from the attributes within the options, including their cost. In terms of environmental public goods, each option can be considered as an alternative policy. The respondent then chooses there preferred policy option. The attributes of particular value to the respondent and the total economic value of the good can be determined (Bateman *et al*, 2002).

2.1 Are preferences stable?

Many have argued that economic choice theory is an inadequate approach to understanding consumer decision making (e.g. Bettman, 1979; Spash, 2002; Fujii and Garling, 2003; Azjen, 2004). Gary Becker, a staunch advocate of rational choice theory, argues not that all behaviours conform to the notion of stable preferences rather that the economists approach to explain behaviour provides the most generality and power than any other approach (Stigler and Becker, 1977)

Others point to the variety of problem-solving modes, rules and heuristics individuals adopt when choosing between options (McFadden, 1999). Tversky and Kahneman (1981) conclude that the susceptibility of preferences to variations of framing raises doubt over the feasibility and adequacy of coherent preferences as the sole criterion of rational choice. Slovic (1995) points to the evidence on preference reversals (e.g. Tversky and Thaler, 1990), as contradictory to individuals maximising their utility.

Economic theory does not deny preferences are a construct (Hanemann, 1994): individuals are not born with a pre determined preference map. The survey design and context may exert an influence on preference expression, either through a process of preference construction through the survey (Lichtenstein and Slovic, 2006) or through demand characteristics of the survey, which are defined as "the totality of cues which convey an experimental hypothesis to the subject" (Orne, 1962). McFadden (1999) cautions that valuation exercises for non-market goods may not invoke a utility

maximising response, due to valuation questions being posed in ways that make them vulnerable to rule-driven responses. However Hanemann (1994) concludes,

"One cannot avoid the fact that surveys, like all communication, are sensitive to nuance and context and are bound by the constraints of human cognition." (Hanemann, 1994. p 27)

There has been ongoing research into maximising the validity of responses from stated preference methods, by refining the survey instrument. Yet McFadden questions whether they can be eliminated entirely.

2.2 Information effects

SP techniques essentially demonstrate a transfer of information. A researcher, through the survey method, conveys information about the good being valued and respondents, in turn, provide information on their value of the good (Boyle, 1989).

The issue with valuing public goods is that they are often unfamiliar to the respondent in a market setting. With marketed goods the price conveys information about the good and may, in certain circumstances, equalize information sets across all individuals (Grossman and Stiglitz, 1981). For instance if one stock-market trader learns something significant about a traded company, this information may be transmitted to others on the market when the trader buys stock. Information could also be filtered through the media. However even with traded goods such an outcome may be rare (Munro and Hanley, 1999), and with non-market goods near impossible.

In light of this issue, information disclosure in contingent markets is to a large extent the responsibility of the researcher. Yet there has been much debate in the literature over the quantity and framing of information provided. Randall *et al.* (1974) argued the need for adequate information to make the hypothetical market plausible. The NOAA panel recommended

''Adequate information must be provided to respondents about the environmental program that is offered. It must be defined in a way that is relevant to damage assessment'' (Arrow *et al.*, 1993).

Table 1. Summary of results on the sensitivity of WTP to information provision.

Study	Good	Information levels	Result
Bergstrom, Stoll and Randall (1990)	Louisiana wetlands (USA)	2 groups: (1) did not explicitly remind respondents of beneficial wetland services; (2) reminded respondents of beneficial wetland services. Negative consumption services of wetlands were not provided.	Wetland services information provided to group (2) induced a significantly higher WTP estimate.
Samples, Dixon and Gowen (1986a)	Humpback whale (USA)	2 groups: (1) shown film on humpbacks; (2) shown film on making a TV commercial.	No significant difference in WTP between groups before or after the films despite group (1) having significantly more whale sightings than group (2). Zero bids were excluded from the analysis, and hence increased WTP for both groups.

Study	Good	Information levels	Result
Samples, Dixon and Gowen (1986b)	Endangered species (rabbit, monkey and rat)(USA)	(1) no information; (2) information on physical appearance; (3) information on endangered species and status; (4) information on endangered species, status and physical appearance. Respondents were given a fixed amount of money to be distributed amongst the 3 species after each information set.	Given no information mean allocation was not significantly different across unknown species. Given detail on physical appearance and endangered species status, mean allocation differed significantly across species.
Pope and Jones (1988)	Utah areas for wilderness designation (USA)	2 groups: (1) no information; (2) information on wilderness designation in Utah.	Detailed information on wilderness designation did not significantly impact WTP.
Boyle (1989)	Wisconsin brown trout fishery (USA)	3 groups: (1) basic commodity description; (2) basic commodity description, brown trout stocking efforts and catch composition; (3) basic commodity description, brown trout stocking efforts, catch composition and program cost.	The commodity specific information provided to groups 2 and 3 did not significantly affect mean WTP. However the estimated variance of WTP values between groups was significantly changed.
Whitehead and Bloomquist (1991)	Kentucky wetlands (USA)	3 groups: (1) reclaimed grassland presented as a replacement for Clear Creek wetland, no information on related wetlands provided; (2) reclaimed wetland presented as a replacement for Clear creek wetland; (3) reclaimed grassland and nearby undisturbed environmental good presented as a replacement for Clear Creek wetland. Information on a reclaimed wetland is provided.	Information provided on substitute environmental goods decreased the WTP estimate.
Hanley and Munro (1992)	Dorset heathland (UK)	4 groups: (1) control; (2) site-specific; (3) endangered habitat; (4) all.	No impact on WTP with different information levels.
MacDonald and McKenny (1996)	Designated wilderness parks (Canada)	2 groups: (1) high information; (2) low information.	Low information group generated more zero values and a greater range in their WTP response. When outlier responses were removed, there was a significant difference in WTP between high and low information groups.
Tkac (1998)	Harlequin duck (USA)	2 groups: (1) economics students hence no background knowledge, WTP measured after low and high information; (2) wildlife students, hence background knowledge, WTP measured after low and high information.	WTP was significantly higher for the wildlife students. WTP for group (1) was significantly different when given higher information. WTP for group (2) was not significantly different when given high information.

Study	Good	Information levels	Result
Hoehn and Randall (2000)	Coeur d'Alene River basin (USA)	1 group: 8 pieces of information are given on resource injury and the perceived resource injury is assessed after each piece of information. WTP is elicited at the end of the information provision.	WTP varies with perceived injury. The affect of new information is different given respondents prior knowledge.
MacMillan, Hanley and Lienhoop (2006a)	Red kite reintroduction (UK)	3 groups: (1) low information provided; (2) low and advanced information provided; (3) low and advanced information given before group discussion. WTP was elicited after each information set was provided.	Final mean WTP is significantly different from initial mean WTP, suggesting that time to think and additional information were influential. However there is no significant different in WTP with low and advanced levels of information provided.
MacMillan, Hanley and Lienhoop (2006b)	Wind power (UK)	3 groups: (1) low information provided; (2) low, advanced and negative information provided; (3) low, advanced and negative information provided, group discussion. WTP was elicited after each information set was provided.	Level of information provided and group discussion did not significantly influence mean WTP. However mean WTP for participants in the low information group (1) significantly decreased after being provided with the negative information on wind power.
Groom, Kontoleon and Swanson (2007)	Remote mountain lakes	3 groups: (1) basic factual information; (2) basic scientific information; (3) subjective information on importance of the lakes for research. The information levels were constructed using survey results from an expert sample.	WTP increased with more complex information, although not in a uniform manner.
Shapansky, Adamowicz and Boxall (2008)	Forest management (Canada)	3 groups: (1) well informed through workshops, interaction with researchers and assistance with the CM survey; (2) medium informed through a workshop an assistance with the CM survey; (3) no prior information or involvement.	No difference in WTP between group 1 and group 3.
Hanley et al (2009a)	The Lake District woodland cover (UK)	Information provided is two travellers' historical view of the landscape. 4 groups: (1) no historical view; (2) negative historical view; (3) positive historical view; (4) both historical views.	Historical view did not significantly affect respondent's choice of land use.
Hanley et al (2009b)	The Trossachs woodland cover (UK)	Provision of historical land use. 4 groups: (1) no historical land use map; (2) historical map from 1750s; (3) historical map from 1890; (4) both maps.	Respondents who were shown a map of historical woodland cover were more likely to support a change in woodland cover. When the 1750s map was shown alone and with the 1890 map the probability of choosing a decline in woodland cover decreased.

The majority of studies summarised in Table 1 test the validity of WTP estimates given quantity and specificity of information provided to respondents through the survey. It has been established by Samples *et al.* (1986b) and Boyle (1989) that commodity specific information does influence WTP.

For example Samples *et al.* (1986) found when the species physical appearance was identified, respondents allocated a greater amount of money to the monkey and when the endangered species status was identified (not endangered, endangered with no salvation and endangered with salvation), respondents allocated a significantly greater amount of money to the rat, which was identified as endangered but salvageable ($21.60 opposed to $3.37 and $4.86 for the rabbit and monkey respectively). The authors conclude it is clear that information disclosure can influence an individuals budget allocation strategy.

Yet one would argue that the information provided by Samples *et al.* (1986b) was necessary for the respondent to make an informed allocation decision, as the initial allocation of funds was for unknown species. MacMillan *et al.* (2006a) found that WTP for an unfamiliar good, the reintroduction of the red kite, increased with addition information. When valuing a familiar good, wind generated power, MacMillan *et al.* (2006b) found that a higher level of information did not change WTP. It could be that information has a nonlinear effect on preferences, in that more and more information does not make for clear, well defined preferences (Bergstrom *et al.*, 1990). We will discuss this further in the next section.

It may be difficult to provide an information set with clearly defined benefits and costs of the good. The information provided by Samples *et al.* (1986b) could be construed as specific, yet balanced. On the other hand, Bergstrom *et al.* (1990) conceded that additional information provided to respondents in their second surveyed sample only describes beneficial attribute consumption. Negative attribute consumption was not given to respondents.

Hanley *et al.* (2009a) attempt to test respondent's resilience to the framing of information provided by giving respondents positive and negative literary views of the Lakes District. Their results were inconclusive in that no significant difference in choice probabilities was found given the different literary views. However when respondents learnt that a landscape had changed over time, they were less likely to desire it to remain fixed or unchanged.

MacMillan *et al.* (2006b) looked at the impact of providing negative consumption values on WTP for energy generated from wind power. With low information, respondents WTP decreased after a negative report on wind power. However with high information, WTP remained stable yet the number of unsure respondents increased. The authors conclude that respondents provided with a high level of information within the survey were more resilient to negative information.

There is inconclusive evidence on the impact of differing levels of information on WTP estimates. The effect of information seems also to be dependent on its specificity and framing. Samples *et al.* (1986a), Hanley and Munro (1992), Pope and Jones (1988), Boyle (1989), MacMillan *et al.* (2006) and Shapansky *et al.* (2008) all found no impact on WTP when additional information was provided to respondents.

2.3 Effects of prior knowledge

It is possible that the respondent is well informed on the good (termed prior knowledge throughout the rest of the paper). Evidence in the literature suggests that the effect of new information provided within the survey depends on how much it differs to the respondents prior knowledge (Hoehn and Randall, 2000).

Pope and Jones (1988) found no difference between WTP when specific information on wilderness designation was provided to respondents, and concluded that this was due to higher prior knowledge of respondents as the issue of wilderness designation was being actively debated in the community at the time of the survey[2]. The respondent's level of prior knowledge of wilderness designation was not formally measured within the survey, and hence not tested within the model.

Tkac (1998) used university students studying two different disciplines to value the Harlequin duck. Students studying wildlife were assumed to have background knowledge, while students studying economics were assumed not to have background knowledge. The WTP estimate for the wildlife students did not change (significantly) after additional information on the Harlequin duck was provided. After additional information, WTP estimates did change significantly for the economics students.

In comparing public and expert preferences, where prior knowledge is thought to by influential, Goodman *et al.* (1998) found that both groups were consistent in their identification of the conservation quality of coastal sites, however differed on management strategies. Kenyon and Edwards-Jones (1998) found that by including ecological data the public group valued the sites similarly to the expert group. However there are significant issues with their comparison of the estimates: the public and experts were valuing different aspects of the good in question (Kenyon and Edwards-Jones, 1998) and both studies use different elicitation methods for the public and expert samples (McCartney, 2009).

Direct comparison between public and expert preferences for an innovative cancer screening program is investigated by Arãna *et al.* (2006). Social science students, assumed unfamiliar with health issues, were surveyed along with academics and professionals who have oncology knowledge and experience in the medical field experienced in oncology. Prior knowledge did not alter the attribute parameters and WTP estimates.

2.4 Information processing

In half of the studies reviewed in section 2.3, the information provided to respondents was identified as a possible cause of discrepancies in preferences from stated preference surveys. In particular, there is support for variability in preferences, given additional information, when the public good is unfamiliar to the respondent (McMillan *et al.*, 2006; Samples *et al.*, 1986; Groom *et al.*, 2007). Slovic *et al.* (1982) argue that there is need to provide extra information to offset the systematic biases that

[2] The detailed information supplied to respondents in the survey was not given in the paper and hence its content is not known. However it was noted that at the time of the survey there was significant debate in the community about competing uses of reserved parks, and how these weren't compatible with a designation "wilderness area".

would otherwise be present. This view is also supported by Bergstrom *et al.* (1990) who state that the effect of information on WTP is not an undesirable bias, rather information increases the completeness and accuracy of the preferences elicited.

However to what extent do differences in the cognitive ability of respondents to process information and too much information hinder the respondents decision process? Bergstrom *et al.* (1990) note that the information provided to respondents is likely to have a nonlinear relationship with the preference given. Grether and Wilde (1983) investigate "information overload", yet found the subjects in their experiments were not affected and appeared able to ignore unnecessary or unwanted information.

Respondent's cognitive processes are complex and the complexity of choice experiments has posed issues in terms of the cognitive burden imposed on respondents. Survey length and the number and type of attributes included are pointed to by choice experiment practitioners as the usual culprits, and accounted for accordingly.

Yet the issue is potentially far more complex. The affect of heuristics and decision rules on choice has been recognised by economists and psychologists for some time (Simon 1955; Slovic and Lichtenstein 1968). In particular Simon (1955) points to the transaction cost of information processing, suggesting individuals satisfy their wants to avoid the full cognitive cost of complexity contained within the choice task. Grether and Wilde (1983) find that untrained people do use simplifying strategies in quite complicated decision problems. Additionally a large body of work from psychology centres on preference inconsistency due largely to the complexity of choice tasks and variation in human cognition (Tversky and Kahneman 1974; Tversky and Kahneman 1981).

Attribute selection was highlighted by Nobel Laureat Daniel McFadden in his address.

"The potentially important role of perceptions, ranging from classical psychophysical perception of attributes, through psychological shaping of perceptions to reduce dissonance, to mental accounting for times and costs, remains largely unexplored in empirical research on economic choice." (McFadden, 2001, p 373)

This issue of recognising and accounting for the transaction costs involved with attribute selection has been receiving increasing attention in the environmental valuation literature (Cameron and DeShazo 2008).

DeShazo and Fermo (2002) empirically tested preferences from CE's and found that the complexity of the choice set (i.e. number of alternatives and attributes) affected the consistency of respondents choices. To deal with the cognitive issues involved with choice tasks, whilst upholding a rational choice model, DeShazo and Fermo (2002) find the effects can be mitigated by choosing the optimal number of alternatives and correlation structure of attributes, and can be identified and controlled for in the analysis by using heteroscedastcity models.

The causal relationship, or correlation, between attributes and the effect on choice was explicitly investigated by Blamey *et al.* (2002). If some attributes are causally related (i.e. that the level of one attribute is viewed as being a precursor, at an ecological level, for another), some respondents may pay more attention to their relationship when comparing alternative options. This could lead to assigning greater meanings to options with casually related attributes, and potentially causing respondents to simplify the decision making process (Blamey *et al.*, 2002). An example is given in Text Box 1.

Blamey *et al.* (2002) propose reducing the extent to which respondents have issues with causally related attributes in choice tasks by (1) excluding the causal attribute (2) explaining to respondents

that the attributes are uncorrelated (3) including correlations through the use of composite attributes and (4) removing nonsensical attribute combinations from the choices model. However, all four of these strategies may conflict with the desired design properties of the experiment.

Gregory *et al.* (1993) propose redefining the stated preference techniques to accommodate their known cognitive issues. Preference construction is encouraged through time to think, more information and possibly group discussion. MacMillan *et al.* (2006) used the approach to value an unfamiliar good, the red kite, using the three rounds of value estimates. They gave participants additional information and the opportunity for group discussion, and then up to 2 weeks before eliciting their WTP through a CV survey. The authors conclude that the approach may be a more appropriate methodology for valuing unfamiliar goods.

Using choice modelling, Shapansky *et al.* (2008) investigated the effect of information and respondents prior knowledge, accumulated over workshops and feedback from experts, on stated preferences for passive use values of forests in Saskatchewan, Canada. Preferences were elicited for forest management options, given attributes of moose and caribou population size, forest age, recreation restrictions and forest access, amount of protected areas, forestry employment and change to household income tax. The highly informed and involved group did not display significantly different preferences nor was the variance in preferences significantly different from those who were not informed or involved.

Bateman *et al.* (2009) explore the issue of evaluability of conventional numerical modes of information provision within the choice set. They do this by comparing current practice with a virtual reality exercise to convey policy options to respondents. Attributes in the standard approach allowed for both loses and gains. A strong loss aversion heuristic was influential in the decision making. In comparison, the virtual reality exercise, which presented respondents with visual representation of the same attributes (and their levels), resulted in marked lower loss aversion effect. Additional there was a decrease in the error variance in the visual reality exercise, suggesting more certainty in preferences/ less influence of other heuristics (Bateman *et al.*, 2009).

Whilst these approaches may reduce the cognitive burden when choosing between options, the researcher is no closer to understanding whether the cognitive process, information provided and respondents prior knowledge changes fundamental preferences. It's possible that these factors change the respondents understanding of how those outcomes are produced. Our example given in Text Box 1 illustrates this point. Frank and Bella value the same outcome, yet their understanding of how the outcome is generated differs and hence their inferred preference structure for the policy as presented differs. In the next section we focus on developing an alternate model for testing preference stability, using CE's as the explicit example.

Text Box 1

An environmental policy aimed at conserving forest biodiversity targets outcomes of increased areas of native vegetation, a decrease the loss of threatened species and increase in the number of plant species.

Frank is an economics student who highly values conserving forest biodiversity yet he has no prior knowledge of forest ecosystems. Seeing all outcomes as credible options, Frank distributes his preferences evenly across all three.

Bella is an ecology student and also highly values conserving forest biodiversity. Through her studies she knows that by increasing the area of vegetation, the number of plant species will increase and there is a good chance the number of threatened species will decrease. Bella prefers the policy option which achieves outcomes of larger areas of vegetation, knowing it is inherently linked to increasing plant species and decreasing the number of threatened species.

Given their preferences for outcomes, Frank and Bella's utility functions will seem quite different: Frank's selected options reveal he is placing weights on large areas of vegetation, more plant species and a decrease in threatened species, while Bella's reveal that she is making choices based only on large areas of vegetation. The researcher may conclude that respondents with prior knowledge have different preferences to respondents with no prior knowledge. However both highly value biodiversity conservation, yet differ in the way they believe it will be achieved.

3. A new approach to investigating preference stability

Its currently not clear through the literature whether the information provided to respondents, the respondents prior knowledge and cognitive processes change preferences for environmental goods. An alternate explanation is that they change the respondents understanding of the process by which the good is "produced" (i.e. the specific technology or management option that leads to a particular outcome). In the following discussion we focus on preferences derived through choice experiments (CE).

The Lancaster (1966) theory of the characteristics of value provides the economic theory on which choice experiments (CE) were formed. Lancaster extended previous consumer theory by saying that goods are not just goods; rather there are intrinsic properties of a good which determine utility. The properties or attributes of each good are assumed to collectively equal the whole value of the good.

Michael and Becker (1973) modified the theory of consumer behaviour further to provide a theory which is capable of explaining a wider range of behaviours than the old consumer choice theory. The principal conceptual novelty lies in determining utility by a set of "z commodities", which are produced by the household from purchased goods and services.

Under the *new theory of consumer behaviour*, the household seeks to maximise

$$U=U(Z_1,..., Z_m) \quad (1)$$

with

$$Z_i=f_i(X_{1i},..., X_{ki}, t_{1i},..., t_{ji}, S_1,..., S_l, Y_i), \quad i=1...m \quad \text{subject to M} \quad (2)$$

Where Z_i are a set of produced commodities of choice entering the utility function. The Z commodities are produced by goods, the purchase of which are constrained by full income (including time endowments) M. Where f_i is the production function for the ith commodity, X_{ji} is the quantity of the jth market good (or service) used in the production of the ith commodity, t_{ji} is the jth person's own time input, S_j the jth persons human capital and Y_i represents all other inputs (Becker, 1996).

In Lancaster's model the good is "made-up" by a suit of characteristics. Whereas under the *new theory of consumer behaviour* the commodity is "produced" by goods via the production function (2).The production function is essentially a combination of inputs which produce an output (commodity).

The preference for Z commodities is hypothesised stable, as they are envisaged to be more fundamental human requirements, and changes are seen only in the level of the goods that produce the commodities. Both Michael and Becker (1973) or Stigler and Becker (1977) provide minimal guidance on what these Z commodity's are, simply stating they are objects of choice. However, the minimal requirement is that some arguments of the utility function be defined over outcomes that have to be 'constructed' from the purchased goods and/or services.

In some cases, Becker uses examples which are quite narrow (music appreciation, or nutrition), but in others the examples are quite broad i.e. "health, social standing and reputation, and pleasures of the senses" (Becker, 1996, p5). In the initial exposition, preferences for Z goods were suggested to be constant across time and individuals with all variation in observed behaviour due to heterogeneity in factors relating to the production function (2). However, this is not a requirement for the model to generate potentially novel insights.

Findings in the psychology literature lend support for this notion of high level utility determinants. The Schwartz Value Scale (Schwartz, 1992), presents a set of basic human values termed "universal values". Extensive research in over 200 samples in more then 60 countries supported the comprehensiveness of the major, motivationally distinctive 10 values defined (Schwartz and Boehnke, 2004). It is possible that actions will generate opposing changes in the values, so that decisions require some degree of tradeoffs across them. For example, benevolence values (enhancing the welfare of others) are likely to conflict with achievement values (seeking personal success for oneself) (Schwartz, 1992).

3.1. Application to environmental valuation

Essential, using the *conceptual model* to elicit fundamental preferences for environmental outcomes provides a way to account for heterogeneity in the understanding of how the outcomes are generated. Attributes used in the CE would then take on the form of "intermediate inputs", and the respondent provides preferences for final outcomes, which are dependent upon those "intermediate inputs". The influences of information provision, prior knowledge on the understanding of how the attributes generate the final outcomes, and divergence in individuals cognitive processes, can be accounted for.

Consider the following example. In response public pressure over the decline in the ecological quality of an iconic river system, a policy maker decides to run a choice experiment to provide guidance on expenditure of public funds to improve the quality of the river system. A set of management outcomes are chosen, in consultation with land managers and scientists, to target river quality. They are level of nitrogen pollution runoff into the river, preservation of riverside vegetation and reduction in the number of non-native fish species within the river. Respondents are asked to choose between options which offer different levels of these attributes given a certain cost to the tax payer (respondent). For simplicity we assume the river system has only non-use values to the individual. The traditional model has the household seeking to maximise utility defined as,

$$U=f(\text{Pollution, Veg, Fish, Tax}) \quad (3)$$

However, the new conceptual model suggests that the utility function should be expressed in terms of a constructed Z good, river quality.

$$U=f(Z_{env}, \text{Tax}) \quad (4)$$

The change in the level of river quality implied by the management outcomes is derived through a subjective production function:

$$Z_{env}=g(\text{Pollution, Veg, Fish}) \quad (5)$$

The expected value of river quality, $E(Z_{env})$, is a score of how well the respondent thinks each combination of the attributes "produce" the desired outcome. In the production function (5), it is important to note that respondents are not revealing preferences, but their understanding of how the actions they are being asked to fund will have an impact on the higher level construct they actually value. In this specification, a large part of the action is focused on what is happening with the production function, and not the utility function. For example, it would be more accurate to express the problem as one of expected utility:

$$U_i=f(E(Z_{env}), \text{Tax}) \quad (6)$$

$$E(Z_{env})=g(\text{Pollution, Veg, Fish}| I_i,K_i) \quad (7)$$

Variables *I*, information provided, and *K*, respondents prior knowledge, are now specific to individual i, and introduce heterogeneity in the expected production of the targeted outcome[3]. Thus, different personal capital stocks, either acquired prior to or during the experiment will introduce variations in the expected effectiveness of the outcomes. This is analogous to the role of personal capital with the conventional model, except here that capital is not influencing the individual's ability to personally generate the outcome, but their expectation of the outcome that will be generated by the government if it follows through its actions. Poor prior understanding (or information provided) on the role of non-native fish on reducing the quality of the eco-system may lead to a zero (expected) functional relationship between changing fish stocks and ecological quality for some people.

One question that arises is whether this leads to a functional difference in the way that one interprets the outcomes from such a choice experiment. One response could be that, observationally, the outcomes are the same. Substituting (7) into (6) gives:

$$U_i=k(\text{Pollution, Veg, Fish, Tax}| I_i,K_i,) \quad (8)$$

[3] It is important to note that the role of information is strictly in the respondents understanding of the process which generates the outcome, as the respondents are not expected to actually implement the process itself.

This would lead to a conventional empirical model, with the inclusion of individual specific measures that moderate parameters. Without an extended experimental design (see below for some initial thoughts) estimation based on (8) is all that is possible, but note that what would be reported as marginal utilities from such a model are in fact composites of marginal utilities and production function parameters, and what are interpreted as differences in tastes will in fact be (in part) differences in expected efficacy of attributes on outcomes.

One can extend the simple representation above to include multiple Z goods, and joint inputs. Take a case study where the utility function is extended to include a use value associated with the river, such as fishing. Assume the respondent is well informed: understands the ecological system and holds positive values for both its integrity and recreational fishing.

$$U_i=f(E(Z_{env}), E(Z_{rec}), Tax) \quad (9)$$

$$E(Z_{env})=g(Pollution, Veg, Fish| I_i,K_i) \quad (10)$$

$$E(Z_{rec})=h(Fish| I_i,K_i) \quad (11)$$

Reducing the level of non-native fish now operates on expected utility in two conflicting ways: it improves expected ecological quality, which increases utility, but reduces expected fishing quality. This implies that estimation of a reduced form function such as (8) will give parameters on the fish attribute that is a conflation of both marginal utility terms in (9), and the expected marginal productivity from both (10) and (11).

Even without considering issues of implementation, looking at choice experiments in this framework starts to change the way that one conceptualises the cognitive process being followed by respondents.

There are some echoes of this approach in the literature. Bergstrom *et al.* (1990) recognise the approach within the context of revealed recreational trip data, yet seem not to follow through in terms of its implications:

> "Following household production theory, consumers combine environmental commodity characteristics with other non-rationed market commodities to "produce" consumption activities (e.g., recreational trips). Services or attributes associated with these activities generate utility (Becker, Stigler and Becker, Michael and Becker, Stoll)." p. 616, fn 1

Blamey *et al.* (2002) identify that the changes in the attribute levels presented in a choice experiment have to be interpreted within an ecological production relationship,

> "When causally-related attributes are included in choice sets, a question arises as to how the associated relations are to be modelled from a production perspective. Whilst complex non-separable production functions can be assumed when predicting the environmental impacts of a policy proposal, these outcomes still need to be mapped into the attribute and label space of the experiment, if welfare estimates are to be obtained." p. 184

Rolfe *et al.* (2008) report on the possibility of including a single aggregate measure of outcome in a study of the Great Barrier Reef:

> "Given the need to introduce other attributes into the survey design, another option could be to combine all GBR attributes together into a single 'Health of GBR' index. While this would may limit feedback on preferences, and restrict the information that can be associated with different management options, it would have some advantages…It was an option favoured by focus group participants in the previous survey." p. 9

This suggests that respondents were comfortable with a single "Z commodity" being used. In our framework we would suggest that this approach would in fact give good feedback on preferences, yet

it would be limited in that any information on respondents understanding of the relationship between management actions and the outcome they value (i.e. the subjective expected production function).

Gregory *et al.* (1993) explicitly recognise the possible inability, nay un-necessity, of respondents to understand ecological systems. They use the example of bird species preservation and question whether it is appropriate and pertinent to the research for the respondent to distinguish the effect that 100 or 1000 pairs of birds has on species preservation.

3.2. Insight to expert and public environmental preferences

A relatively unexplored paradigm is the influence of prior knowledge, information and cognitive ability when comparing experts and public preferences. Given their complex nature, conflicting information provided by the media and general uncertainty of system functionality on a global scale, the public's perceptions of how natural systems work are often oversimplified and incorrect (White, 2008).

An experts prior knowledge set has been learned over time, using a set of developed cognitive tools. They may also have experience in resource allocation, critical thinking and an understanding of complex environmental systems. The expert also has access to a wider range of information sources, and the cognitive ability to understand the information conveyed in these sources.

In an investigation of the public's beliefs of causal processes in complex natural systems, White (2008) found respondents were only able to think about one-way interactions. Green (2001) found that the majority of respondents had the capacity to think in terms of two-way interactions, but their capacity was overwhelmed by the complexity of the task.

It is generally assumed that experts preferences would diverge from the public's (Hanemann, 1994). However literature comparing public and expert preferences for environmental goods is sparse and predominantly limited to priming the respondent to "act" like an expert by providing them with "expert level" information (Kenyon and Edwards-Jones, 1998; Goodman *et al*. 1998; Groom *et al.*, 2007).

Colombo *et al*. (2009) asked government officers to make judgements, using an Analytic Hierarchy Process, on the need for public access ways on behalf of the public. They compared this with preferences of the public elicited through a CE. They found no significant difference in preferences between government officers and the public, although they did use different methods to elicit preferences.

Colombo *et al*. (2009) argue that if a CE was used to elicit expert preferences, a true comparison may not be possible: experts may not be seeking to maximise their own utility subject to income, as they could be representing their role as an agency officer. This assertion is dependent on how the valuation question is framed i.e. are the experts asked to respond on behalf of an institution, or themselves. However, if it is the former, it does raise issues relating to the payment vehicle, which is commonly designed as a personal payment to allow for monetary values to be assigned to attributes.

Carlsson *et al.* (2008) do use CE's for both expert and public samples. The experts were asked to choose alternatives they would recommend as a policy, and the public were asked to act as private citizens. They find attribute rankings and WTP differed between the two groups.

To take a different approach to previous studies and investigate whether expert and public preferences diverge, we refer to the *conceptual model* outlined above. The role of technical understanding held by experts can be summarised as a particular stock of prior knowledge *K*. Using the proposed framework, one has an immediate basis on which to identify whether it is the preference structure or the understanding of the technical production function that differs between experts and public.

This raises the question of whether there are common traits amongst experts, regardless of field of study, which enable a unique decision process. Additionally, are experts preferences congruent in the way they evaluate the importance and role of attributes in achieving final outcomes (White, 2008; Morgan et al. 2001)? It is possible to use the *conceptual model* to answer these questions.

4. Implications for choice experiments

The challenge for the new approach is to find a mechanism that allows one to differentiate the production function from the utility function components of the valuation task. As noted above in equation (7), if one does not have a mechanism to do so, then one is left with an observational equivalence between the proposed model, and the standard utility model extended for individual heterogeneity in preferences. If one is to identify the two separate components, additional information needs to be generated that will allow identification of the expected production relationship. Furthermore, one needs to make some judgement as to what the dimensions of the (unobserved) z goods are.

4.1 Experimental design and data requirements

A potential way to proceed with the design and analysis of CM surveys is to employ Hierarchical Information Integration (HII), first proposed by Louviere (1984), and which has had a number of implementations (e.g. Oppewal et al, 1994, Van Helvoort-Postulart et al 2009, Timmermanns *et al* 2009, Molin, E.J. E. and Timmermans, H. J. P. 2009). In part, the motivation of HII is to allow for the consideration of decisions over goods that have a large number of attributes. It assumes that respondents can summarise responses across sub-sets of attributes, to form what are described as "Decision Constructs", and then choices are made with consideration to these constructs. The statistical design has to account for the fact that, over the sub-sets of attributes, it has to have properties that allow for the identification of the relationship between the attributes and their respective construct. Within the design presented to individuals they are required to both make choices, and to rate a sub-set of attributes that define a single construct (see Figure 1 below).

APPENDIX B

EXAMPLE OF A DISCRETE CHOICE TASK

	Circumstances A	Circumstances B
Organization		
1. Day surgery unit	Not available	Available
2. Breast care nursing staff	Less than one full time equivalent	One full time equivalent or more
3. Compensation	No negative financial consequences	Financial decline
4. Discharge criteria	Formulated	Not formulated
5. Collaboration agreements with home care organizations	No	Yes
Please give your opinion about *Organization*	++++ +++ ++ + 0 - - - - - - - - - -	++++ +++ ++ + 0 - - - - - - - - - -
Cooperation partners	- -	++
Patient-centeredness of care	- -	++
Status of the guideline	Published	Not published
Time investment	As much or less	More time-consuming
Which circumstances would you choose?	Circumstances A ☐	Circumstances B ☐

☐ Neither (no implementation of breast cancer surgery in day care)

Figure 1 Example of an HII choice task, taken from Van Helvoort-Postulart et al, (2009).

In this example, there are 3 constructs (equivalent to Z goods): Organisation, Cooperation partners and Patient-centeredness of care. In the task presented above, only Organisation is represented by its full set of attributes (1-5 as listed) and the remaining 2 are represented by rating scores (in this case – or ++ in both cases). As well as making a standard choice, respondents also have to rate the outcome delivered for Organisation. In other split samples, respondents would see (and rate) the attributes of the other two constructs. The rating process for the construct is equivalent to the expression of the expected production function within the conceptual model above. It is important that the rating scores used for the constructs within a choice task (i.e. Cooperation above) are based on the same scale as the rating used to evaluate that construct, to ensure compatibility. Not all attributes need to be linked to constructs: in this example status and time investment are treated as independent attributes.

Although motivated by a different perspective, the HII framework effectively describes the conceptual model above. However, because the requirement in the current application is to identify the production relationship rather than use HII to deal with excessively complex attribute levels, it is

likely that within each survey only one construct (ecological) will be employed. This means that ratings information will be collected only for the ecological outcome in each alternative. It is interesting to note that in their review, Molin & Timmermans (2009) suggest that a key issue in its application is to investigate "heterogeneity.. in terms of different respondents or segments using different subsets of attributes or perhaps different decision constructs." i.e., in our terms, whether different individuals use different production functions.

Essentially the survey would consist of two sections: determining the production process and preferences for the Z commodities. Firstly, respondents are asked to complete a set of technical evaluations of the construct or Z good. The instructions and question format could take the form given in Box 2:

Text Box 2. Example of the question format used to generate the production function

"Assuming the current status of your local marine ecosystem has a score of 50, please indicate the score that you think would be achieved given the stated changes, with a score between 0-100 where 0 is the worst possible and 100 the best"

Attribute 1	Attribute 2	Attribute 3	Attribute 4	Score
Current	Current	Current	Current	50
+20%	+30%	-10%	-10%	
-20%	+30%	+25%	+20%	
+10%	-30%	-10%	+30%	

There is no requirement for any cost consideration to be given: respondents are simply scoring outcomes based on how they understand the attribute levels to generate the outcome

We propose two experimental designs to generate preferences for the Z commodities. In experiment 1, a standard CE, defined over the 8 attributes used in determining the production function, is undertaken. By undertaking a standard CE, welfare estimates can still be obtained if the production function process doesn't deliver meaningful results. Cost is included as an attribute (Text Box 3).

Text Box 3. Example of a choice set in experiment 1, which would be used to determine preferences for Z commodities

Attributes	Status quo	Option 1	Option 2
Attribute 1	Current	+20%	-20%
Attribute 2	Current	+30%	+30%
Attribute 3	Current	-10%	+25%
Attribute 4	Current	-10%	+20%
Cost	$0	$50	$70
Choice			

Using information gained through the respondents understanding of the production process (Text Box 2) and Experiment 1 (Text Box 3), a number of options in terms of estimation are available:

1. use the attribute levels to explain choices in the standard manner (which appears to be the standard approach in HII, with ratings used for validity tests only)

2. if all of the options used to define the choice sets have been scored, then estimate the choice model using the scores rather than the attributes (i.e. the choice model would include 2 variables: a Z score and cost. The Z scores would be individual specific).

3. if all of the options have not been scored, estimate an individual specific production function that rationalises scores reported against attribute levels, and then predict individual specific scores for each element of the choice experiment.

At this stage it is not clear whether estimation option 3 is less burdensome in terms of information needs. The number of scores to be given in order to reliably predict the Z scores by individual is not known, and could be substantial. However, alternative structures, such as Best-Worst scoring techniques may be more effective (Marley & Louviere, 2005).

What one is anticipating is that a substantial degree of the individual heterogeneity will manifest itself within the scoring of alternate production functions, and hence one would expect to see significantly lower levels of heterogeneity in the parameters of the utility function estimated for 2 or 3 than in estimation option 1, where the parameters are conflating utility and process heterogeneity.

In Experiment 1 the intention is to generate *ex post* the constructed Z good for inclusion in the estimated choice model. An alternative, Experiment 2, is to directly include a measure of the Z good

in the choice experiment, which is illustrated in Figure 4. The choice experiment may be prefaced by a statement such as:

"In the following questions we will show you hypothetical changes in the status of your local marine ecosystem. The scores will range from a 50% reduction in quality to a 50% increase".

Text Box 4. Example of a choice set in experiment 2

	Status quo	Option 1	Option 2
Z commodity	50	70	90
Cost	$0	$50	$70
Choice			

The choice experiment contains only two attributes: a score for the Z commodity and a cost. Under normal circumstances this process would be deemed very poor practice: although precise numerical values are being given for outcomes, the outcome itself is totally ambiguous. There is no way to be sure that a change of e.g. +20% is being thought of in the same way be each person, in terms of changes in the environment What is more, it gives no guidance for policy, as one has no means of linking the change in the score to any management actions. Yet in the revised model, this is exactly what is required. Choices are made conditional upon changes in the constructed environmental Z commodity, which by definition is known to the respondent, but opaque to the researcher.

However, in order to make the link between choice experiment and management, one has to reveal that relationship for the individual, which again, one can do through a series of scoring questions that simply reveal how the Z commodity is constructed for that individual.

The difference between the two versions (Experiment 1 and Experiment 2) lies in what is presented to the individual: attributes which they then combine on the fly to generate the Z commodity, or some motivated measure of the Z commodity which has to be subsequently deconstructed by the researcher. Experiment 1 has certain attractions in that it allows one to compare the consequences of the alternative estimation strategies, whereas in experiment 2 one has no option but use the Z scores.

In terms of exploring the implications of this re-focusing, one can make two hypothesis: that within Experiment 1, would expect there to be less heterogeneity in taste parameters if one uses the estimated Z scores as attributes as compared to using the attributes directly (because the latter included heterogeneity in the production function) and that information effects, in particular differences between expert and public samples, will manifest themselves in the production function, and not in the utility function.

5. Conclusions

In this working paper we reviewed current literature pertaining to the stability of preferences for environmental goods, particularly the impact of information provision, prior knowledge of respondents and cognitive processes. Despite the assertion by critics the reviewed studies failed to provide conclusive evidence that preferences elicited through stated preference techniques are invalid.

The *new theory of consumer behaviour* (Michael and Becker, 1973; Stigler-Becker, 1977) provides a flexible conceptual model for investigating the central issue of this study: whether instability of preferences is due to changes in fundamental preferences, or changes in an understanding of how planned management change will deliver outcomes. The influence of information provision, prior knowledge and cognitive processes on the understanding of how final outcomes are generated can be accounted for within the *conceptual model*. We outline three possible uses for the *conceptual model*:

investigating the impact of information and prior knowledge on fundamental preferences;

reducing the cognitive burden inherent in choice tasks; and

comparing fundamental preferences between public and expert samples.

Although this approach to the valuation question was initially conceived as a way to think about the issue of information/knowledge differences between different groups, the approach has a potential to explore a number of issues within the valuation literature. For example, the issue of causally prior attributes arises when it is conceived that attributes are functionally linked (i.e. pollution levels and water quality) or that attributes are requisites for outcomes (Blamey *et al.*, 2002). Within the proposed set up, these issues are concentrated within the production function, not the utility function. In cases where there is no technical substitution between attributes in achieving the outcome (i.e. a Leontief production function), expected ecological outcomes will be determined by the binding minimum attribute.

Where attribute levels appear to be technically inconsistent with each other (i.e. high numbers of a species even though, simultaneously, ecological attributes that support that species are said to be low) the uncertainty will likely manifest itself in high levels of uncertainty about the measure of the Z commodity, rather than how that commodity is valued *per see*.

The apparent lack of sensitivity to scope in some valuation studies may reflect a particular ecological Z commodity and understanding, rather than a cognitive error or strong decreasing marginal utility. Thus, if the constructed Z commodity is the probability of persistence of a species, then increasing species numbers beyond a certain threshold may genuinely generate only marginal increases in that probability.

However a few issues must be resolved before the conceptual model could be implemented in the context of a choice experiment. For one, is possible that the amount of information required to accurately retrieve each individual's production function is significant and coupled with several choice sets could add to the cognitive burden already encountered, hence defeating one purpose of the new approach.

Its possible that this approach provides an interesting conceptual framework for thinking about the way that people respond to multi attribute choice experiments, but one which leads to observationally equivalent or operationally impractical field applications. Its analogue in HHI provides a framework for possible experiments in implementation. However, there are a number of possible issues that can

be foreseen. As stated, estimation options 2 and 3 require one to include estimates of the score in the choice sets. It would be reasonable to expect that these should be treated as measured with error. Measurement errors in non-linear models leads to issues of bias in parameter estimates that can be overcome, but only at considerable computational cost.

However, estimation option 1 (using the actual stated attributes) does not overcome the issue. If one assumes that individuals are constructing expected ecological outcomes based on the attributes, then the attributes themselves can only be considered as instruments for the actual constructed outcome used to make choices. Any individual heterogeneity (or divergence from linearity in the production function) will mean they are instruments measured with error, and hence lead to bias (Gibson and Burton, 2009).

More fundamentally, the issue arises post-estimation of how to deal, within a policy context, with heterogeneity in understanding i.e. in errors in the production function. Heterogeneity in the utility function, from whatever source, may be accepted on the basis of the view that:

> "The individual may order all social states by whatever standards he deems relevant" (Arrow, 1951).

But differences in the subjective production function means that some individuals are evaluating interventions on the basis of erroneous expectations. In fact, such individuals would be disappointed if the policy choices they selected were acted upon because the experienced utility ex-post would not be what they were anticipating. In this case, whose production function should be used? One would anticipate that it should be the experts, which opens a further area of research: providing a consistent mapping and communication of outcomes between experts and public.

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