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# Valuing Unfamiliar and Complex Ecosystem Services

*The influence of survey mode, knowledge and dishonesty*

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*A dissertation for the degree of Philosophiae Doctor – May 2016*

**Contents**

## List of Tables

**List of Figures**

**Acknowledgement**

Four years ago when I was writing my master thesis, Eirik Romstad asked me during one of our many meetings if I had considered pursuing a Ph.D.. Honestly, I hadn't. He thought it would be a good fit and suggested that I consider it. I did, and guess what? You were right! Looking back at my time here in Tromsø, there are many who deserve a special mention, and without your support and encouragement this work would not have been possible, and certainly much less enjoyable.

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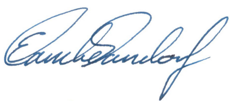


Erlend Dancke Sandorf

**Summary**

Increasing demand for valuation of ecosystem services has led stated preference methods to be applied to public goods that are increasingly complex and unfamiliar. Traditionally, stated preference surveys were conducted via mail or face-to-face interviews, but over the past two decades internet panels have been used to a larger extent. As we move away from traditional methods of survey administration it is apparent that we need a better understanding of how "new" survey administration modes influence elicited preferences, particularly when the environmental good under valuation is complex and unfamiliar. Furthermore, it is unlikely that people have well defined preferences over goods for which they have no experience consuming, and evidence suggests that preferences for such goods are constructed during the survey itself. This highlights the importance of information and, by extension, familiarity and knowledge, for people to accurately state their preferences. When analyzing discrete choice data, one of the underlying assumptions is that people are rational utility maximizers, however, mounting evidence show that respondents in discrete choice experiments use simplifying strategies and decision heuristics to reduce the cognitive burden of the choice task. This type of boundedly rational behavior is likely to increase when the environmental good is complex and unfamiliar. This thesis addresses some of the challenges practitioners face when valuing complex and unfamiliar public goods.

In the first paper I compare two identical discrete choice experiments (DCEs) aimed at eliciting the Norwegian population's preferences for increased cold-water coral protection, an environmental good that is considered both complex and unfamiliar. This is the reason why the first DCE was implemented in a series of valuation workshops and why we created videos to secure identical information and provide the same visual impact when conducting the DCE using a probability based internet panel. Our results show that it is possible to use internet panels when the environmental good is complex and unfamiliar, but that practitioners should pay close attention to information provision, emphasize consequentiality and implement procedures to reduce speeding behavior. In the second paper I explore the link between knowledge (familiarity) about the environmental good measured by a quiz on cold-water coral, and the probability that a respondent ignores one or more attributes on the choice card. We find that respondents scoring above the average on the quiz, a measure of high knowledge, is associated with a higher probability of attending to the non-cost attributes (although only significant for one) and a significantly lower probability of attending to the cost attribute, irrespective of whether they knew how well or how badly they did on the quiz. These results show that understanding what type of information affects the degree to which respondents ignore attributes, and in which direction, is crucial to reduce attribute non-attendance behavior and obtain more precise estimates. In the third paper, I identify a group of dishonest respondents who have lied on a follow-up question. I hypothesize that these respondents have spent less effort on the choice tasks and as such have a less deterministic choice process (from a practitioners point of view) and are more likely to ignore attributes. The results show that dishonest respondents are more likely to be in a scale class characterized by a relatively higher error variance and more likely to ignore the non-cost attributes (significant for two out of four). Furthermore, the results suggest that observed difference in error variance between honest and dishonest respondents can partly be explained by different propensities to ignore attributes. As such, this thesis addresses some of the challenges associated with using DCEs to value complex and unfamiliar goods.

**List of Papers**

Paper 1 **Sandorf, E. D.**, Aanesen, M., Navrud, Ståle, Valuing Unfamiliar and Complex Environmental Goods: A Comparison of Valuation Workshops and Internet Panel Surveys with Videos, Ecological Economics (under third stage review)

Paper 2 **Sandorf, E. D.**, Campbell, D., Hanley, N., Disentangling the Influence of Knowledge on Attribute Non-Attendance, Journal of Choice Modelling (under second stage review)

Paper 3 **Sandorf, E. D.**, Accommodating Respondent Dishonesty in Discrete Choice Experiments, submitted

# 1 Introduction

> "Biodiversity in all its dimensions – the quality, quantity and diversity of ecosystems, species and genes – needs to be preserved not only for societal, ethical or religious reasons but also for the economic benefits it provides to present and future generations. We should aim to become a society that recognizes, measures, manages and economically rewards responsible stewardship of its natural capital." – Sukhdev et al. (2010, p. 29)

As the demand for valuation of ecosystem services is increasing (Sukhdev et al., 2010), stated preference methods have been applied to increasingly complex and unfamiliar environmental goods (see e.g. Aanesen et al., 2015; Jobstvogt et al., 2014). Traditionally, stated preference surveys were conducted via mail or face-to-face interviews, but in recent years practitioners have turned to the internet (see Lindhjem and Navrud, 2011, for an overview)[1]. It is apparent that we need a better understanding of how new survey modes influence elicited preferences, particularly when the good under consideration is unfamiliar and complex. This is what motivated the investigations undertaken in Paper I, where we compare two discrete choice experiments[2] (DCEs) aimed at eliciting the Norwegian population's preferences for increased protection of cold-water coral (CWC). One DCE was implemented in a series of valuation workshops,

[1] I provide brief background on survey modes in Section 1.1.

[2] A discrete choice experiment is a stated preference technique in which respondents are asked to choose between two or more alternatives described by multiple attributes taking on different levels. Often respondents are asked to answer several such choice tasks. I discuss the use of stated preference techniques in Chapter 3 and the analysis of such data in Chapter 2.

and the other using a probability based internet panel. One of the challenges practitioners face when attempting to value unfamiliar goods is that it is unlikely that people have well defined preferences over goods for which they have no direct experience consuming, and that preferences for these goods are constructed during the survey itself (see e.g. Schkade and Payne, 1994). Consequently, providing balanced and understandable information about the environmental good and choice task is crucial for people to accurately state their preferences (Álvarez-Farizo and Hanley, 2006). This is the reason why the first DCE was implemented in a series of valuation workshops (Aanesen et al., 2015). To address the issue of information provision[3], we created videos to use in the internet survey to ensure that all respondents received identical information and to give the same visual impact as in the valuation workshops. It is well known that stated preference surveys are susceptible to hypothetical bias[4] and recent evidence suggests that a necessary (but not sufficient) condition for incentive compatibility is the idea of consequential survey questions (Carson and Groves, 2007; Vossler et al., 2012). In our comparison we explore whether respondents in the two DCEs had different beliefs about the consequentiality of the survey instrument. In addition, practitioners are concerned with "professional" respondents and speeders (i.e. respondents who quickly advance through the survey to obtain the incentive offer) in internet panels, which could influence results (see e.g. Börger, 2015; Hess and Stathopoulos, 2013; Windle and Rolfe, 2011). In Paper I we address these issues and further the line of inquiry into survey administration modes and in particular asses the suitability of using internet panels when the good is complex and unfamiliarity is large.

When analyzing discrete choice data, one of the underlying assumptions is that people are rational utility maximizers. However, mounting evidence suggests that people are boundedly rational (Simon, 1955) and tend to fall back on

[3]In Section 1.2 I provide a brief background on the role of information, experience and knowledge in economic decision-making.

[4]I discuss this in more detail in Section 1.3

decision heuristics and use simplifying strategies (see e.g. Hess et al., 2012; Hensher et al., 2005). It is reasonable to assume that this type of behavior is more prevalent when the good under consideration is complex and unfamiliar. In Paper II we take a closer look at the connection between knowledge (familiarity) and the use of one such strategy: attribute non-attendance (AN-A), which is simply to ignore one or more of the attributes on the choice cards (Campbell et al., 2011; Scarpa et al., 2012; Hensher et al., 2005)[5]. Specifically, we hypothesize that knowledge about the environmental good affects the degree to which a respondent ignores attributes. As such, this paper explores one possible reason for why respondents simplify in this manner and adds to this literature (see e.g. Alemu et al., 2013).

As touched upon above, the hypothetical nature of stated preference surveys might lead respondents to over- or under-state their willingness-to-pay, and this bias is the source of much criticism against using stated preference techniques. Recent advances in the pursuit of reducing hypothetical bias has opened up for other interesting hypotheses to be tested. A few studies show that swearing an oath to be truthful and answer honestly prior to the valuation task can be very effective in reducing or eliminating hypothetical bias (see e.g. Jacquemet et al., 2013; Carlsson et al., 2013). One possible reason is that the oath works as a commitment device and induce respondents to spend more effort and deliberate more carefully on their preferences during the valuation task (Carlsson et al., 2013). In Paper III I identify a group of dishonest respondents who have lied on a follow-up question and hypothesize that these respondents have spent less effort on the choice task. While I can only speculate as to why some respondents have lied, I nonetheless hypothesize that these individuals have spent less effort on the choice tasks and as such have a less deterministic choice process (as seen from a practitioners point of view) and are more likely to simplify by ignoring one or more attributes on the choice cards.

[5] I cover attribute non-attendance in more detail in Section 1.4

## 1.1 Survey administration mode

The choice of survey administration mode is not a decision to be taken lightly, since each type comes with its own advantages and disadvantages (Bateman et al., 2002). In the remaining part of this thesis, I will make the distinction between self-administered and moderator/interviewer-administered surveys. In the former category, we find surveys sent out by mail using postal addresses or sent out by e-mail using internet panels (opt-in or probability based), while in the latter we find face-to-face and telephone interviews, and valuation workshops. Both mail- and internet surveys are relatively cheap and allow respondents to answer from the comfort of their own homes, but they tend to suffer from low response rates. However, where mail surveys are limited in their use of visual aids in providing information, internet surveys come into their own with the possibility of using enhanced graphics, interactive screens and videos (Bateman et al., 2002; Lindhjem and Navrud, 2011). Face-to-face interviews, on the other hand, are known to be highly flexible, allowing for greater use of visual aids and providing opportunities to probe and motivate respondents. But getting a high enough response rate is expensive and the possibility of interviewer- or social desirability bias could severely affect results (Bateman et al., 2002; Norwood and Lusk, 2011). However, the face-to-face interview was endorsed as the "golden standard" for administering CV surveys used in damage assessment by the NOAA-panel (Arrow et al., 1993). In a valuation workshop, respondents are usually recruited by phone and invited to a central location to participate in a valuation exercise (Álvarez-Farizo et al., 2007; Macmillan et al., 2002). Like face-to-face interviews, valuation workshops are highly flexible and allow for greater use of visual aids, however, it is a time-consuming and expensive way to collect data.

The multitude of available survey modes have prompted researchers to investigate to what degree elicited preferences, and willingness-to-pay, differ between them (see e.g. Lindhjem and Navrud, 2011; Windle and Rolfe, 2011; Olsen, 2009; Bell et al., 2011). In this thesis I will limit myself to focus on a few studies comparing internet panels with more traditional survey administration modes. For example, Olsen (2009) compares a mail-out and an internet survey, and find no significant difference in willingness-to-pay to protect landscape from road-encroachment when building new motorways in Denmark. Windle and Rolfe (2011) compare a paper-based drop-off/pick-up approach with an internet survey, and they too find no difference in WTP for improving the environmental condition of the Great Barrier Reef. These are only two studies, but Lindhjem and Navrud (2011), in their review paper, find that internet surveys tend to elicit equal or lower WTP compared to more traditional survey modes. This is in fact also the result we obtain in Paper I where we find that willingness-to-pay is significantly lower in the internet survey. As I have highlighted elsewhere in this thesis, providing balanced and proper information prior to a valuation task is important for people to accurately state their preferences. The ease of providing information differs between survey modes, which is why the choice of survey mode should take into consideration the complexity and familiarity of the environmental good to be valued. It was the provision of information that was the reason why the first DCE was implemented using a series of valuation workshops, and why we created videos to use online. As such this thesis furthers the line of inquiry into the effect of survey administration modes to provide greater insights into the suitability of using internet panels when the environmental good is unfamiliar and complex.

## 1.2 The role of information

When thinking about the influence of information on stated preferences it is useful, and indeed important, to consider the source of an individual's information set. In this thesis, following the distinction made by Cameron and Englin (1997), we consider exogenous and endogenous information leading to objective and subjective knowledge, respectively. Exogenous information is typically provided by the survey instrument (or moderator/interviewer) and endogenous information is acquired through experience with the good. Input from both sources determines an individual's information set and her knowledge about the environmental good under consideration. The analysis in this thesis makes no attempt at separating the two sources of information, although it is reasonable to assume that the information a respondent has about cold-water corals was provided exogenously by the moderator in the valuation workshops or video online. This is mainly because most cold-water coral live between 200 - 400 meters below sea level, which makes them inaccessible. I cover this assumption in detail in Papers I and II, and in Chapter 4.

The role of information and experience in economic decision-making has been of interest to researchers for decades, and it has also made its way into stated preference research. For an overview of early contributions to this literature, I refer the reader to Munro and Hanley (2001). For example, Cameron and Englin (1997) find that direct experience with fishing, a type of subjective knowledge, significantly increase the willingness-to-pay for a doubling of the trout abundance in the North East United States. A similar result was obtained by Carlsson and Martinsson (2006), who found that direct experience with longer power outages, resulting from a strong hurricane in Sweden, significantly increased the probability of stating a positive willingness-to-pay to avoid power outages in the future. Recently, it has been suggested that people behave consistent with Bayesian updating when new information is made available. In particular, Czajkowski et al. (2014a) find that respondents receiving more complete and positive information[6] about the consequences of a biodiversity conservation program (exogenous information), have a more deterministic choice process as seen from a practitioners point of view. In a different paper, Czajkowski et al. (2014b) find that respondents having experience with water quality (endogenous information), measured as number of trips to the beach, also have a more deterministic choice process relative to those with little or

[6] For example, positive information emphasize more benefits to other species of increased conservation efforts, important part of cultural heritage etc.

no experience. A few studies have explored the role of information on using simplifying strategies. For example, Hensher (2006) varies the number of attributes on a choice card, a measure of information load, and find that it is the relevancy of the information and not strictly the quantity that affects the degree to which attributes are ignored. Kosenius (2013) use a DCE to elicit preferences for water quality improvements in Finland and find that proximity to the water body, a measure of familiarity (experience) is associated with lower levels of stated attribute non-attendance. In Paper II we measure knowledge about cold-water coral by a quiz over the material covered in the presentation given by the moderator in the valuation workshop. As such, our measure of knowledge does not consider the source of the information. We then use this measure of knowledge to explicitly test hypotheses related to the connection between knowledge and attribute non-attendance (this particular simplifying strategy is discussed in more detail in Section 1.4). A different, but related, stream of research on cognitive biases in economic decision-making suggests that individuals with experience trading in a particular market are less prone to the endowment effect (List, 2011; List et al., 2003), the disposition effect (Feng and Seasholes, 2005) and the bias of fixed working hours (Camerer et al., 1997).

## 1.3 Hypothetical bias

Stated preference techniques are often used to elicit preferences, and estimate willingness-to-pay, for non-market public goods. In many cases this implies that the both provision of, and payment for, the public good is hypothetical. The hypothetical nature of many stated preference surveys leads to questions of whether the method is incentive compatible and to what degree the elicited preferences reflect "true" preferences. Indeed, studies show that there is a discrepancy between what people state they would be willing to pay and what they are actually willing to pay (Murphy et al., 2005). This difference is often referred to as hypothetical bias. For many non-market public goods, ensuring incentive compatibility by using real payment experiments is difficult, and hence other methods of reducing hypothetical bias have been proposed.

In a stated preference survey, respondents are often asked to choose between, or vote on, their most preferred option (policy) from among two or more available options, where one is the status quo/choose none option. Carson and Groves (2007) discuss the incentive and informational properties of stated preference questions and introduce the idea of consequential survey questions. A survey question is considered consequential if the following assumptions hold: i) the respondent cares about the outcome of the policy considered, and ii) believe that the answer they provide can potentially influence the policy maker's choice of which policy to implement (Carson and Groves, 2007; Vossler et al., 2012). Vossler et al. (2012), building on the work of Carson and Groves (2007), formulates a set of conditions for when single binary choice and a sequence of single binary choices are incentive compatible. A necessary, but not sufficient, condition for incentive compatibility is that the question is consequential.

A response to a three option DCE (multinomial) only reveals an incomplete preference ranking of alternatives. To see this, consider a respondent choosing between A, B, C. Under the assumption that she chooses A as the most preferred we can deduce that the she prefers A over both B and C, but we do not know anything about the preference ordering between B and C. Another problem when we consider multinomial rather than binary choices is that incentive compatibility disappears (Vossler et al., 2012; Carson and Groves, 2007). In this situation a respondent is choosing between multiple alternatives, e.g. policies, and this opens for strategic adjustments. Central to this is a respondents belief about how the policy maker translates the responses into action and the expectation of how other people will vote (Vossler et al., 2012). For example, if a respondent believes that the policy that most people choose will be implemented, then the choice reduces to a choice between the two alternatives most likely to receive the most votes (expectation of others choices). If a respondent's most preferred alternative is not among these two, then she has incentives to choose her second most preferred (to avoid having the least preferred implemented), which should be among the two in a three option multinomial choice task. This further illustrates that even though the question is consequential, consequentiality is not in itself a sufficient condition for incentive compatibility.

In this thesis I use data from two DCEs where each choice card consists of two alternatives for increased protection of cold-water coral and the status quo. Incentive compatibility conditions for such a situation have not yet been identified, but Vossler et al. (2012) suggest that ensuring compatibility in this situation likely requires additional, perhaps strong, restrictions on which utility functions are allowed and beliefs about the preferences of others (p.168). While the survey questions might be consequential, this does not imply incentive compatibility. Still, the concept of consequentiality does play a central role in Paper I, where we hypothesize that some of the observed difference in willingness-to-pay between surveys is the potential result of different beliefs about consequentiality. We do find that respondents answering the survey online are more likely to perceive the survey as inconsequential.

Cheap talk scripts have been proposed as one way of reducing hypothetical bias in discrete choice experiments. A cheap talk script includes an explicit discussion of hypothetical bias prior to the valuation task, where respondents are made aware of the existence of this bias, that people tend to overstate their willingness-to-pay, they are reminded of their budget constraint, and asked to vote as if the choice task before them was a real referendum (Cummings and Taylor, 1999).

Recently, another approach has been developed to try and address, and reduce, hypothetical bias in stated preference surveys. The oath statement approach has respondents swear an oath to answer truthfully prior to the valuation task. For example, "Do you feel you can promise us to answer the questions that will follow as truthfully as possible?" (Carlsson et al., 2013) or "I undersigned swear upon my honor that, during the whole experiment, I will: **Tell the truth and always provide honest answers**" (Jacquemet et al., 2013). Swearing an oath has been found to eliminate, or reduce, the hypothetical bias in both lab and field settings (Jacquemet et al., 2013; Carlsson et al., 2013; de Magistris and Pascucci, 2014). One possible explanation is that it induces respondents to spend more effort and deliberate more carefully on their preferences (Carlsson et al., 2013). This last approach was a key motivating factor for looking at dishonest respondents in Paper III.

### 1.4 The role of heuristics

One of the basic tenets in economic theory is the idea of a utility maximizing agent with complete information and full knowledge of her preferences. However, acquiring and processing information is costly, and having fully formed preferences over unfamiliar goods is unlikely. Consequently, processing the information presented in a discrete choice experiment, e.g. attributes and alternatives, for then to match this information to one's preferences in order to make an accurate choice is difficult and requires substantial effort. To reduce this effort individuals tend to rely on decision heuristics and simplifying strategies (Gigerenzer and Gaissmaier, 2011). In his seminal paper, Simon (1955) argues that the use of simplifying strategies is *boundedly* rational in light of limited memory and cognitive abilities. As such, using simplifying strategies reduces the cost of making a choice in terms of cognitive burden and effort. In other words, simplifying the choice situation can be rational considering the trade-off between effort and accuracy (Payne et al., 1992).

In a discrete choice experiment, the effort required to make a choice is increasing in the complexity of the choice task and the good under consideration (Caussade et al., 2005; Blamey et al., 2002). Indeed, mounting evidence suggests that respondents adopt a wide range of decision-making strategies, including eliminating- and selecting alternatives based on the level of one or a few attributes (Erdem et al., 2014; Tversky, 1972), using lexicographic decision rules (Hess et al., 2012; Rekola, 2003) and ignoring one or more of the attributes on the choice cards (Hensher et al., 2005; Scarpa et al., 2012; Campbell et al., 2011). In general, this type of boundedly rational behavior is a deviation from random utility maximization, which underpins the analysis of discrete choice data[7], and can potentially lead to biased estimates if we fail to develop models that consider the actual choice process.

While there are many simplifying strategies that individuals may adopt, in this thesis I focus on individuals ignoring one or more attributes on the choice card, also known as attribute non-attendance (AN-A) (Hensher et al., 2005; Campbell et al., 2011, 2008; Scarpa et al., 2009; Carlsson et al., 2010). Two main approaches have been developed in the literature to identify AN-A behavior: *stated* attribute non-attendance and *inferred* attribute non-attendance. The former relies on self-reported measures of AN-A, in which respondents are asked to state which attributes they ignored when making their choices (Hensher et al., 2005; Scarpa et al., 2012). Inferred AN-A, on the other hand, uses probabilistic models, e.g. the equality constrained latent class model, to *infer* AN-A by making probabilistic statements about the use of the strategy (Hole, 2011; Campbell et al., 2011; Scarpa et al., 2012). In this thesis, I use the latter approach. Some authors have called for more research into *why* respondents ignore attributes. Alemu et al. (2013) argues that the standard way of addressing AN-A by forcing zero utility weights on parameters stated to be ignored is incorrect if we fail to consider the reason why the attribute was ignored. For example, if a respondent ignored an attribute because it did not affect their utility, then this represents an actual preference and it is incorrect to impose the AN-A restriction. In this thesis, I maintain the assumption that respondents ignore attributes as a simplifying strategy and explore how knowledge (Paper II) and dishonesty (Paper III) affect the probability of

[7] This is covered in detail in Chapter 2, including how to model attribute non-attendance

attending to attributes on the choice cards.

The rest of the thesis is structured as follows: Chapter 2 gives a general overview of the methods used to analyze discrete choice data as well as those employed here, Chapter 3 provides a brief background on ecosystem services and economic valuation in light of the Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) project, Chapter 4 introduces the data, Chapter 5 summarizes the findings in the papers and Chapter 6 gives a few concluding remarks.

## 2 Methodology

In this chapter we will look at some of the foundations and developments in the analysis of discrete choice data, and in particular how it relates to discrete choice experiments (DCEs). Keeping the discussion general, it serves as a starting point for the investigations undertaken in this thesis. A DCE is consistent with Lancastrian consumer theory in which a good is described in terms of its attributes, and an individual derives utility from the attributes of a good rather than the good *per se* (Lancaster, 1966). Another feature that makes DCEs particularly attractive is that they are well grounded in random utility theory (RUT) (McFadden, 1974). RUT postulates that the utility an individual obtains from the outcome of a given choice is latent and unobserved by the researcher. In other words, the researcher cannot observe what goes on inside a given individual's head. Furthermore, RUT proposes that this latent utility can be decomposed into a deterministic observable component and a stochastic unobservable component. The former comprises all observed characteristics of the choice situation, e.g. attributes of the alternatives, and the latter comprises everything else influencing choices that is not captured by the deterministic component of utility. Because the utility an individual receives from a given choice is random from the researchers point of view it is possible to make probabilistic statements about the chosen alternative. Under the assumption that an individual maximizes utility, we assume that the probability of an individual choosing a particular alternative, from the set of available alternatives, is the probability that the chosen alternative yields the highest utility (McFadden, 1974). This implies that an individual trades off between, and considers, all aspects of each alternative in all choice tasks.

Consequently, the basis in RUT gives DCEs behavioral implications, which are necessary to estimate indirect utility functions (Louviere et al., 2010).

It is possible to derive different discrete choice models by assuming different distributions for the stochastic component of utility (Train, 2009). Typically, assuming that the stochastic component of utility is *i.i.d.* type I extreme value (Gumbel) distributed leads to the conditional logit (CL) model (McFadden, 1974). The models discussed here and those used in this thesis are all based on this basic model. Since its development, the CL model has been the workhorse in discrete choice analysis due to its ease of implementation and practical closed form solution (McFadden, 1974). We need to note at this point that in any choice model derived based on RUT the deterministic and stochastic component of utility is linked by a scale parameter (Train, 2009). That is, the deterministic component of utility is scaled by a factor that is inversely proportional to the variance of the stochastic component of utility. This implies that if the variance is large, the deterministic component of utility becomes small and the choice process, as seen from the researchers point if view, is seemingly more random. Conversely, if the variance is small, the deterministic component of utility becomes large and the choice process is seemingly more deterministic. To identify the model we need to normalize the scale of utility. In most applied work the scale parameter is assumed constant and equal to unity (Train, 2009). The purpose of many discrete choice experiments is to derive willingness-to-pay or welfare measures for a particular good, service or proposed policy. Willingness-to-pay is defined as the negative of the ratio between the non-cost attribute of interest and the cost attribute. In the CL model this calculation is relatively straight forward since it is the ratio of two point estimates. Another thing to note about WTP is that it is a "scale-free" measure because the overall scale of utility cancels out.

## 2.1 Preference heterogeneity

While the CL model is widely used it has a limited ability to describe observed and unobserved heterogeneity. For instance, we assume that preferences in the population for a particular attribute can be described by a single parameter and that the scale parameter is constant and equal to unity. This implies that people are “preference clones”. Although convenient, it is hardly realistic in most cases. Here we focus on a few approaches to address this issue with particular relevance to the models used in this thesis. We can introduce observed preference heterogeneity by allowing the preference part-worths to be interacted with socio-demographic variables. For example, if we believe that women have a different mean marginal utility for biodiversity conservation, then we can estimate a separate mean parameter for women to uncover the marginal effect of being a woman relative to the average. As such, we reveal heterogeneity in preferences between men and women. Now I will introduce two approaches to uncover unobserved preference heterogeneity. First, I will discuss the mixed logit model, and this will be followed by the latent class models.

A mixed logit model is powerful in that it allows for the modeling of flexible preference structures using continuous distributions to describe how preferences vary in a population (Revelt and Train, 1998; Train, 2009). When applying a mixed logit model, the researcher assumes that preferences for a particular attribute follow a pre-specified distribution, and estimates the population parameters describing this distribution. In general, any distribution is possible, but the most common are normal and log-normal, but uniform and triangular have also been used (Train, 2009). Deciding on which distribution is appropriate to describe preferences in the population remains a challenge. When deciding which distribution to use a researcher can use economic theory as a guide. For example, if preferences are assumed to have the same sign for all people, e.g. cost, then the log-normal or constrained triangular are reasonable choices.

Both distributions have advantages and disadvantages in terms of describing preferences. The constrained triangular, for example, is symmetric around the mean and bounded by the spread, which is constrained to be less than or equal to the mean. This tends to give well behaved willingness-to-pay functions that have defined moments, but the behavioral realism of such a distribution of preferences can be questioned. The log-normal distribution is perhaps the most popular choice for the cost attribute. This distribution is unbounded and as such can lead to extreme coefficients for some individuals and in some instances force a large mass of the distribution close to zero that might cause rather large willingness-to-pay estimates. Choosing distributions for attributes other than cost also requires a researcher to think about the choice of distributions. For example, if some people are likely to gain utility from an attribute whereas others might have a loss of utility from that attribute, then a distribution with support over zero might be more appropriate. Again, using an unbounded distribution like the normal does come with the risk of predicting extreme values for some individuals. As such, thinking about the distributions and testing different assumptions is prudent. Another question that arises when estimating mixed logit models is whether the distributions of the random parameters should be independent or correlated. In situations where a researcher suspects that preferring one attribute is correlated (positively or negatively) with another, it could be worthwhile investigating this possibility. For a set of parameters assumed to be normally distributed, a researcher can allow the distributions to be correlated by estimating the off-diagonal elements of the lower triangular Cholesky matrix. Ultimately, which distributions to use, and whether they should be correlated, comes down to behavioral realism, model fit and a researcher's judgment.

Calculating willingness-to-pay from a mixed logit model is slightly more complicated since the distribution of WTP is a ratio-distribution of two independent distributions. If we assume, as some do, that the cost parameter remains fixed, then WTP follows the same distribution as the non-cost attribute. However, as discussed above, assuming that everybody has the same marginal utility of money is behaviorally restrictive and assuming a distribution is more appropriate. For some distributions assumed for cost; the ratio distribution has undefined moments (Daly et al., 2012). For example, if cost follows an unbounded normal distribution then the distribution of willingness-to-pay has undefined moments[1]. To see this, the normal distribution has support over zero, which means that at some point the denominator in the WTP measure is zero. A perhaps more serious problem with a normally distributed cost parameter is the behavioral aspect that some people actually prefer to pay more to paying less, which is contrary to economic theory. One advance, which has gained popularity is to re-parameterize the utility function such that the estimated parameters are willingness-to-pay rather than preference weights. This is termed utility in "willingness-to-pay space". It allows the researcher to specify the distribution of WTP directly rather than rely on the ratio distribution from a model estimated in "preference space" (Train and Weeks, 2005; Hensher and Greene, 2011). It is also possible in this case to allow the distributions of willingness-to-pay be correlated.

In a latent class model, we assume that there is a finite number of distinct types of people in a population and that each type is characterized by a distinct set of preferences. The researcher cannot observe any given individual's preference structure, but she can make probabilistic statements about the likelihood of a given individual being in a specific class described by a particular utility function. Usually, homogeneity is assumed within a class and heterogeneity is captured by variations in the probabilities of individuals being in a particular class (Greene and Hensher, 2003). One of the benefits of a latent class model is that it does not require the researcher to make any distributional assumptions regarding preferences, but rather rely on a finite number of support points. One of the challenges facing researchers using the latent class model is to find the appropriate number of classes. Theory is not necessarily a guide and often the process is one of "trial and error" to identify the optimal number of classes,

[1] Daly et al. (2012) derives proofs for when the willingness-to-pay distribution has defined moments and provides a list in Table 1 covering the most common distributional assumptions

which is determined using a type of information criteria (e.g. AIC or BIC). To gain insights into what characterizes the individuals predicted to be in a given class, the researcher can let socio-economic variables enter in the class probability functions. This provides an idea of whether e.g. men are more likely to be in class X relative to Z. Latent class models can be particularly useful if one is interested in identifying particular groups of users of a national park or consumers of a particular product. A recent development by Greene and Hensher (2013) relaxes the assumption of homogeneity within classes. They propose to use mixed logit models to describe preferences within each class to reveal additional layers of heterogeneity.

The models outlined is this section do not have the convenient closed form solution that the CL has. Instead, we approximate the integrals using simulation techniques (Train and Weeks, 2005). In the case of the "willingness-to-pay space" and latent class models, the simulation process might end up in a local maximum. To overcome this particular problem it is prudent to estimate the models multiple times with starting vectors chosen at random to increase the certainty of reaching a global maximum. As indicated by the discussion above, each of the models have their strengths and their weaknesses, and ultimately the choice of models is at the discretion of the researcher and should depend on the hypotheses she wishes to test. In Paper I we estimate a model in "willingness-to-pay space" and allow for relative scale differences between datasets to consider possible unobserved differences that might arise when combining different sources of preference data (Train and Weeks, 2005; Louviere et al., 1999).

### 2.2 Scale heterogeneity

The focus on developing models to capture preference heterogeneity, outlined above, has resulted in researchers largely ignoring scale heterogeneity and kept the convenient assumption that scale is constant and equal to unity (it has not been completely ignored, see e.g. Louviere et al., 1999; Louviere and Eagle, 2006, and references therein). If this assumption is violated then the preference weights vary systematically with error variance and we have a confounding between the preference part-worths and scale (Swait and Louviere, 1993; Louviere and Eagle, 2006). Remember that the deterministic component of utility is scaled by a factor equal to the inverse of the variance of the error term (Train, 2009). Mathematically, as the variance of the error term approaches infinity, the scale parameter limits to zero and the probability of choosing a particular alternative becomes equal across all alternatives, i.e. the choice process appears random. As such, the scale parameter is not just a statistical assumption, but carries behavioral implications (Train and Weeks, 2005; Louviere and Eagle, 2006). In fact, it is unlikely that error variance is constant and that unobserved factors do influence utility differently for different people or groups of people (Swait and Louviere, 1993; Louviere et al., 1999; Louviere and Eagle, 2006). It has even been argued that much of the observed heterogeneity in preferences uncovered in latent class and mixed logit models are caused by differences in unobserved factors, i.e. scale heterogeneity, rather than differences in the underlying preference structure (see e.g. Louviere et al., 1999; Louviere and Eagle, 2006).

In a latent class framework the preference-scale confound can be particularly problematic. Here the preference weights can only take on a finite number of values, and the researcher makes probabilistic statements about the likelihood that a given individual's preferences are described by a particular utility function. Keeping in mind that the estimated parameters confound scale and preference part-worths, a researcher runs the risk of misclassifying individuals with equal preference part-worths into different latent classes because they differ in error variance. Magidson and Vermunt (2008) proposed an extension of the traditional latent class framework that allows subgroups of respondents within classes to differ in error-variance, and hence consider scale heterogeneity within a latent class framework. In Paper III I use a slightly different approach and introduce latent scale classes where I probabilistically classify individuals into classes that differ in scale. Recently, practitioners have developed models that attempt to separate scale- and preference heterogeneity, for example, the generalized multinomial logit model(see e.g. Fiebig et al., 2010; Greene and Hensher, 2010). Hess and Rose (2012) argue that these model developments fail to fully consider the confounding between scale and preference part-worths in a linear-in-parameters specification of utility, and as such the result is a more flexible distributional form and not a separation of scale- and preference heterogeneity.

### 2.3 Attribute processing heterogeneity

While there are many simplifying strategies individuals may adopt, in this thesis I focus on individuals ignoring one or more of the attributes on a choice card, also known as attribute non-attendance (AN-A). For example, individuals might ignore an attribute in order to reduce the cognitive burden or because it is irrelevant to her in the choice situation (see e.g. Hensher et al., 2005; Campbell et al., 2011; Scarpa et al., 2012). The idea is that if an individual ignores an attribute, then that attribute had no bearing on the choice made, and as such does not influence utility. Typically, this is accommodated by restricting the parameter on the ignored attribute to zero when estimating the indirect utility function (Hensher et al., 2005). As mentioned previously, in this thesis I focus on *inferred* AN-A. Early attempts at inferring AN-A from the data used the equality constrained latent class model and assumed that the underlying preference structure could be described by a multinomial logit model. However, this approach fails to consider preference heterogeneity, which could result in an over-prediction of AN-A because researchers run the risk of misclassifying individuals with low preference part-worths into classes in which an attribute is ignored Hess et al. (2013). To avoid this possible identification problem, in both Papers II and III I use a mixed logit model to describe the underlying preference structure. To accommodate the full set of possible combinations of attributes being ignored and attended to we need $2^k$ classes, where $k$ is the number of attributes. For example, with four attributes, we need sixteen classes. In order to infer attribute non-attendance from the data we need to include an equality constraint for the parameters across all classes and specify the non-attendance indicators to be different across classes. In other words, we assume a common underlying preference structure and only allow variations of attributes being attended to or ignored between classes. Then we can interpret the probability of being in a given class as the proportion of respondents adopting a particular processing strategy (Hole, 2011; Campbell et al., 2011; Scarpa et al., 2012). If an attribute in a particular class is ignored then the utility weight is restricted to zero, while the attended attributes are estimated and take the same value across classes, i.e. the equality constraint (Scarpa et al., 2009).

# 3 A background on ecosystem services and economic valuation

## 3.1 Ecosystem services and the Millennium Ecosystem Assessment (MEA)

The deep sea[1] comprises 90 percent of the oceans in volume and is the largest ecosystem on Earth (Ramirez-Llodra et al., 2011, 2010). Explorations over the last century and a half have revealed a great diversity in organisms and habitats, e.g. sea mounts, whale falls, cold seeps, cold-water corals and hydrothermal vents. Still, this “final frontier” for research and resource extraction remains the least understood biome on the planet (Ramirez-Llodra et al., 2010). In addition to being a highly bio-diverse ecosystem, the deep sea provides important ecosystem services such as nutrient cycling, pollution absorption and temperature regulation (Armstrong et al., 2012). Though remote, the deep sea is still affected by human activities, which could threaten its ability to provide the same services in the future. For example, deep water fishing and ocean acidification caused by climate change pose a threat to cold-water corals (Ramirez-Llodra et al., 2011; Freiwald et al., 2004), and ocean dumping and other pollution can affect large areas and as it degrades into micro-particles that are taken up in the food chain (Ramirez-Llodra et al., 2011). This has led some to call for establishing deep sea marine protected areas (MPAs), also outside of the exclusive economic zones (EEZs), and that in the face of uncertainty regarding lost ecosystem functions and services, we should adopt

[1] The deep sea is generally considered anything below the shelf break, usually about 200m below the surface (Ramirez-Llodra et al., 2011).

a precautionary approach (Barbier et al., 2014). It is important to recognize that the economic system is dependent on the natural system, and that nature through its various functions provides important inputs to the economy, which if degraded or lost might demand costly mitigative or adaptive action.

In 2001, the United Nations (UN) launched the Millennium Ecosystem Assessment (MEA) program to assess the status of the world's ecosystems and the services they provide (Millennium Ecosystem Assessment, 2005). Ecosystem services are defined as the flows of goods and services from ecosystems to humans, in other words: how ecosystems contribute to human well-being. The MEA framework broadly categorizes these benefits into four groups: *Supporting services*, *Provisioning services*, *Regulating services* and *Cultural services* (see Figure 3.1). The assessment suggests that as much as 60 percent of the 24 ecosystem services examined, are used unsustainably or being degraded, and that this could continue unless significant changes are made in current policy, institutions and practices (Millennium Ecosystem Assessment, 2005).

Because of their very nature, many of these ecosystem services are non-marketed and essentially "free" inputs into the economy. As a consequence, the benefits of their existence or loss from their degradation, are not always considered when individuals, private firms or policy makers make decisions. Sukhdev (2011) calls this "the economic invisibility of nature". Consider a policy maker deciding on a land reform to either regulate an area for development or establish a reserve to protect it. This decision involves a trade-off between jobs created and revenues accrued, and the potential loss of ecosystem services such as bio-diversity, habitats, recreational values and other amenities. If the policy maker decides in favor of development, she has implicitly put a value on the ecosystem services lost, which are judged lower than the direct benefits from employment opportunities and increased revenues. This is implicit valuation on an ordinal scale. Sometimes identifying these opportunity costs are enough, but by putting a value on the lost ecosystem services we are making the trade-off the policy maker faces explicit. Let us consider an example. In Thailand, mangrove

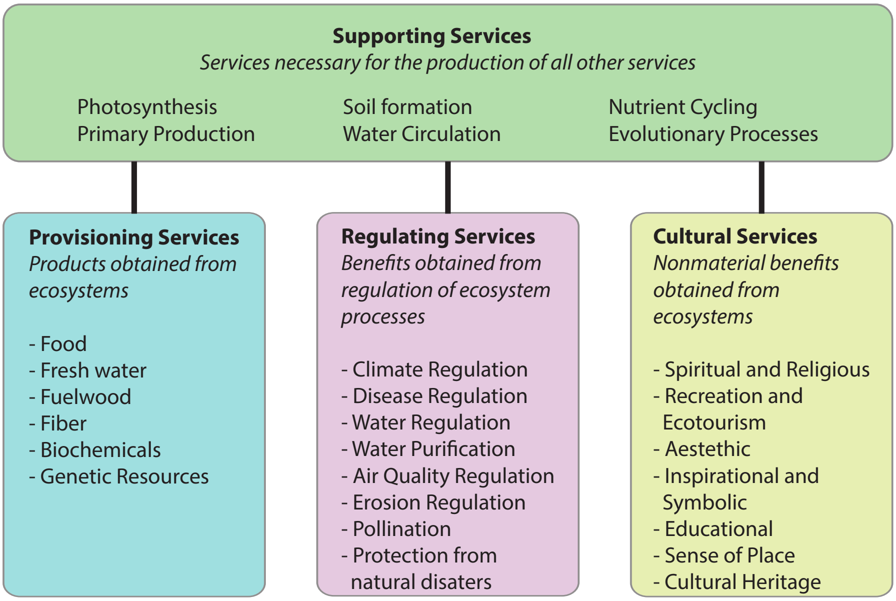



Figure 3.1 - The Ecosystem Services Framework

forests are converted into shrimp farms that provide local communities with income and job security. However, it comes at the cost of lost ecosystem services such as flood- and storm protection, and nursery grounds for fish species that are important for near shore fisheries (Barbier, 2007). Because these ecosystem services are provided for free, the cost of their loss does not factor into the shrimp farmer's decision to convert a mangrove area into a shrimp farm. Barbier (2007) shows that by estimating the benefit, or value, of the mangrove forests, the benefits of preserving them exceeds the net return to the shrimp farmer. It is argued that not valuing these ecosystem services, or inputs, creates incentives for over-exploitation and consequently becomes a contributing factor to ecosystem degradation, which in turn results in loss of ecosystem services (Sukhdev et al., 2010).

## 3.2 Putting a value on nature - The Economics of Ecosystems and Biodiversity (TEEB)

Over the past two decades we have seen increasing attention being drawn to the value that ecosystems have for human well-being, and the value of the goods and services they provide. In 1997, Costanza et al. (1997) estimated that the average value of all the world's ecosystems and natural capital was US$ 46 trillion[2] per year (2007 US$), a number which was updated to US$ 125 trillion per year (2007 US$) in 2011 (Costanza et al., 2014). This type of valuation exercise, though controversial (see e.g. McCauley, 2006; Norgaard et al., 1998; Pearce, 1998), is still useful as it represents a push to move from the "economic *invisibililty* of nature" to the "economic *visibility* of nature".

The total economic value (TEV) framework provides a lens through which we can study the different dimensions of value (Perman et al., 2011). This framework recognizes two distinct sources of value: use- and non-use values, each with its own sub-categories (Figure 3.2). The utility we get, or value we derive, from ecosystems encompasses much more than direct use values such as food, fresh water and genetic resources. It also includes indirect use values like pollination, cultural heritage and protection from natural disasters. In addition, people might derive utility from knowing that a species or ecosystem exists regardless of their current or future use[3]. Option values refers to the potential future uses or benefits we might have from the ecosystem and can be either use- or non-use.

When economists value ecosystem services they typically use either revealed-

[2] 1 trillion $= 1 \times 10^{12}$

[3] It is argued that intrinsic value judgments also need to be considered (Millennium Ecosystem Assessment, 2005). However, this refers to a species or ecosystem having a value in and of itself, regardless of its contribution to human well-being. Under the utilitarian paradigm, on which economic theory rests, only humans have moral standing and only human preferences count, as such intrinsic values does not enter into the equation (Spash et al., 2009). It only matters insofar as it contributes to human well-being.

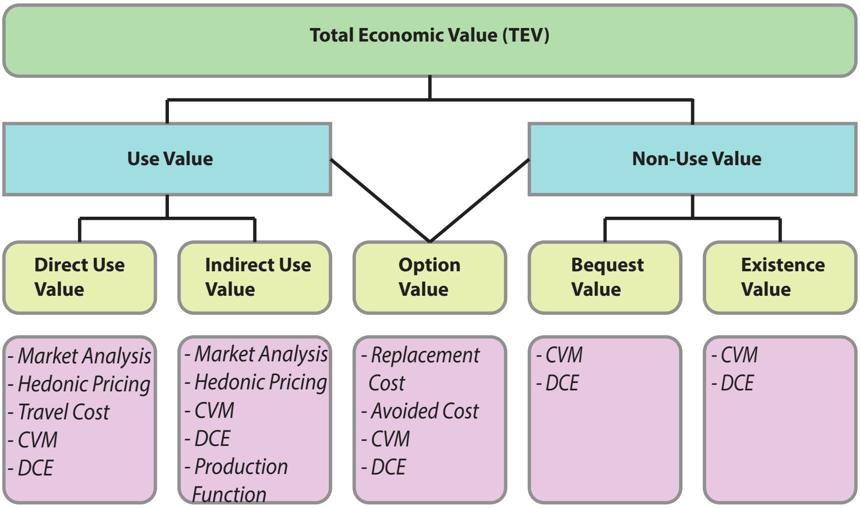



Figure 3.2 - The Total Economic Value Framework

or stated preference techniques[4] (Hanley and Barbier, 2009). The revealed preference (RP) techniques, as indicated by the name, make use of existing market data and observed behavior to infer preferences, i.e. people "reveal" their preferences through their actions. Common RP techniques include travel cost and hedonic pricing. For example, using the travel cost method, a researcher can observe the distance traveled to visit a national park, fuel costs and entrance fees paid, and use this "cost"-information to infer willingness-to-pay (Hanley and Barbier, 2009). Hedonic pricing works differently. Consider two identical houses that only differ in their proximity to a noisy highway. Using the hedonic pricing method you would infer that the difference in price for these two houses is the willingness-to-pay for noise reduction (Hanley and Barbier, 2009). RP techniques are limited to elicit preferences for direct and indirect use-values and would be inappropriate if one is interested in non-use or option values (see Figure 3.2).

[4] To avoid any confusion, I will, as far as possible, use the common nomenclature proposed by Carson and Louviere (2011)

Stated preference (SP) techniques, on the other hand, make use of hypothetical markets and have people state their preferences for a particular ecosystem service. In addition to capture use-values, SP techniques can be used to capture non-use and option values. The two most common SP techniques are contingent valuation (CV) and the discrete choice experiment (DCE) (Bateman et al., 2002). In a CV study, a respondent is presented with a detailed description of a change in the provision of a public good resulting from a proposed policy (Carson and Louviere, 2011). For example, if the proposed policy leads to a decrease in the provision of the public good in questions, the CV study could be framed as a willingness-to-pay to avoid the decrease or a willingness-to-accept compensation to be indifferent towards the decrease. The question could be framed as an open-ended maximum willingness-to-pay or a minimum willingness-to-accept, or a single binary choice whether to accept/reject a proposed amount. This latter way of posing the question was endorsed by the NOAA panel, when using CV studies as the basis for damage assessments (Arrow et al., 1993). In a DCE a respondent is faced with the choice between two or more alternatives described by multiple attributes taking on different levels, where the attributes describing the alternatives vary systematically across individuals.

Many of the ecosystem goods and services of the deep sea are non-marketable and include values that are distinctly non-use. Therefore, stated preference techniques are required. For example, Jobstvogt et al. (2014) estimate the Scottish population's willingness-to-pay for additional deep-sea marine protected areas (MPAs). These deep-sea MPAs were to be included in the UK's biodiversity conservation strategy. Given that many of the ecosystem services provided by the deep sea are predominantly non-use, they focused on option- and existence values. Option values were captured through an attribute describing the potential for new medicinal products and existence values through number of protected species. Results of the study shows that the average willingness-to-pay for the "best" option was in the range of £70 to £77 per household per year (Jobstvogt et al., 2014). Aanesen et al. (2015) focus on the

Norwegian population's preferences for additional MPAs to protect cold-water coral (CWC) habitat[5]. They focus on existence- and habitat values of CWC as well as potential industry impacts from increasing the size of the protected areas. They find that the average willingness-to-pay to increase protection is in the range of €274 to €287 (Aanesen et al., 2015). In this thesis, I use data from two DCEs aimed at eliciting the Norwegian population's preferences for increased cold-water coral protection. The studies and data are discussed in detail in in Chapter 4.

[5]The data from this study is also used in this thesis. Cold-water corals and the discrete choice experiment are covered in detail in Chapter 4.

# 4 Empirical Case Study: Cold-Water Coral in Norway – An Unfamiliar Public Good

Cold-water coral (CWC) reefs are among the largest biological structures in the world. These deep sea ecosystems are considered biodiversity hot spots and are unique habitats for a number of species (Hovland and Mortensen, 1999; Husebø et al., 2002). Although research on the ecosystem functions of cold-water coral is still limited, some research suggests that they may have important nursery and refuge functions for some species of groundfish (Stone, 2006; Edinger et al., 2007). In Norway, the stone coral *Lophelia Pertusa* is the only known reef-building coral. Large-scale exploration of the sea-bed within the Norwegian exclusive economic zone, by both research institutions and oil companies, has revealed the largest known density of cold-water coral reefs and occurrences in the world, which at the last assessment numbered almost 1100 (Institute of Marine Research, 2012). These corals have been discovered in waters as shallow as 39m and as deep as 3 383m, but most are found between 200m - 400m (Freiwald et al., 2004; Fosså et al., 2002). As such they are inaccessible to most people. Foley et al. (2010) identify ecosystem services associated with cold-water coral, for example nursery and refuge functions for fish, and existence values. Despite cold-water coral reefs' apparent beneficial ecosystem services, their existence is threatened by bottom trawling, oil- and gas activity, waste disposal and dumping, and other pollution (Fosså et al., 2002; Freiwald et al., 2004; Ramirez-Llodra et al., 2011). An early study estimated that 30 - 50 % of known reefs in Norwegian waters were damaged or impacted by human activities (Fosså et al., 2002). Unlike tropical corals, CWC grows very slowly, only 4 - 25mm per year (Freiwald et al., 2004), making such impacts irreversible. Consequently, under the precautionary principle, increasing protection for these ecosystems is important. Currently, under Norwegian law, it is illegal to destroy cold-water coral reefs and some areas are closed to certain types of fishing activities (Armstrong and van den Hove, 2008). In that regard, eliciting people's preferences for increased protection is of interest to policy makers.

## 4.1 Data

The work in this thesis is based on two separate, but related, studies, both of which explore the Norwegian population's preferences for increased cold-water coral protection. Both studies make use of a discrete choice experiment (DCE) to elicit preferences. In the DCE, each respondent was faced with a sequence of 12 choice tasks. Each task contained 2 hypothetical alternatives for increased protection and a status quo alternative, which meant no increase in the protected area at zero additional cost.

The attributes and levels describing each alternative were selected based on a review of the literature and expert interviews. Based on the large review and identification of ecosystem services associated with cold-water corals conducted by Foley et al. (2010) it was decided that "size of the protected area" to represent existence values, "raw material in medicinal products" to represent direct use and option values, and "habitat for fish" to represent indirect values should be included in the survey. Two of Norway's largest exports are fish and oil- and gas, and these industries operate along the entire coast. It is likely that increasing the size and number of protected areas would impact these industries. In addition, the aspect of impact on off-shore industry was also considered in the study by Glenn et al. (2010). Consequently, it was decided to include "attractive for industrial activities" to capture the social cost of increased protection, and finally a private cost attribute was included, which was a lump-sum increase in annual federal taxes. This version of the DCE was tested in focus groups with experts and the general public to make sure that the attributes and levels were understandable and conveyed the correct information (Aanesen et al., 2015). The three focus groups with experts were conduced at the Institute of Marine Research with ecologists, biologists and oceanographers, Tromsø University Business School with economists and marketers, and the Norwegian College of Fishery Science with resource economists, marine biologists and sea-food scientists. The two focus groups with the "general public" consisted of individuals with various backgrounds. While none of the groups opposed any of the attributes, in general, the focus groups found the choice tasks complex and the outcome of the discussions was a reduction in the number of attributes (from five to four) and a reduced number of levels, and as such a reduction in complexity. The attribute "raw material in medicinal products" was considered speculative by focus groups, contained a high degree of uncertainty, and it was difficult to convey the concept of an option value. Consequently this attribute was not included in the final survey. In the final survey, each alternative was described by four attributes taking on a limited number of levels. The attributes and levels are described in Table 4.1.

To reiterate slightly and emphasize each of the attributes, the first attribute: "Size of the protected area" represents the total size of the protected area if the policy alternative is implemented, and as such represents the existence value of cold-water coral. The second attribute: "Protected area attractive for industry" captures the social cost of the proposed policy. The two industries that are likely to have the largest impact on CWC, and to be impacted by larger areas being protected, are the fisheries and the oil- and gas industry. The third attribute: "Protected area important habitat for fish" picks up whether the proposed protected cold-water coral reefs are an important habitat, a possible indirect use value[1]. The final attribute: "Cost" is measured as a lump-sum

[1] Given current scientific knowledge it is not proven that CWC is an important habitat for fish, but scientists have observed that fish congregate on some reefs and not others (Costello et al., 2005). This attribute, the way it is displayed, reflects this uncertainty in that some reefs might be important and some reefs are not.

Table 4.1 - Attributes and attribute levels (adapted from Aanesen et al., 2015)

| Attribute Level | Size of protected area | Protected area attractive for industry | Protected area important habitat for fish | Cost of the management scenario[i] |
|---|---|---|---|---|
| Status Quo | 2.245 $km^2$ | Partly | Partly | NOK 0 |
| Level 1 | 5.000 $km^2$ | Attractive for the fisheries | Not Important | NOK 100 |
| Level 2 | 10.000 $km^2$ | Attractive for oil and gas | Important | NOK 200 |
| Level 3 | | Attractive for both | | NOK 500 |
| Level 4 | | Not attractive to either industry | | NOK 1000 |

[i] NOK 1 = €0.1028 (http://www.xe.com – 12-01-2016)

increase in annual federal taxes per household per year. We show a sample choice card in Figure 4.1. The DCE uses an efficient design, where Bayesian efficiency was determined based on minimizing the d-error (Scarpa and Rose, 2008). The design was optimized for the multinomial logit model and updated based on two pilot studies to get more precise priors.

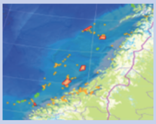
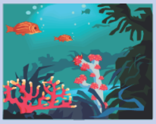
| Attribute | | Alternative 1 | Alternative 2 | Alternative 3 (SQ) |
|---|---|---|---|---|
| Size of the protected area |  | 10 000 sq. km. | 5 000 sq. km. | 2 500 sq. km. |
| Attractive for the industry |  | Attractive to oil and gas | Attractive to the fisheries | Somewhat attractive to both |
| Improtant habitat for fish |  | Important | Not Important | Somewhat Important |
| Cost per household per year |  | NOK 200/year | NOK 500/year | NOK 0/year |
| I prefer | | | | |

Figure 4.1 - Sample Choice Card – Cold-Water Coral Study

### *4.1.1 A DCE implemented using valuation workshops*

The first study took place between February and May in 2013 and was conducted in a series of valuation workshops (Aanesen et al., 2015). The valuation workshop format was chosen because the environmental good to be valued was complex and unfamiliar to respondents. A valuation workshop gives the researcher a structured environment in which to provide good and proper information, which is crucial for respondents to accurately state their preferences (see e.g. Álvarez-Farizo and Hanley, 2006). In addition, it provides an opportunity for respondents to ask questions, and for the researcher to quiz and question them to gauge their understanding of the subject matter (LaRiviere et al., 2014). A professional survey company recruited valuation workshop participants to be representative on age and gender within the selected municipalities. The 22 selected municipalities are considered a representative sample of municipalities within Norway with regards to characteristics such as urban and rural, coastal and inland as well as general location within Norway. Two days prior to the valuation workshop, the survey company, based on public phone records, randomly contacted respondents by phone and asked if they were willing to participate in a 2-hour workshop on marine resources and that they would be compensated NOK 500[2] to participate. The valuation workshop itself took place in a central location within the municipality. Once respondents arrived they were seated in a classroom-type setting. Each valuation workshop was led by a moderator and an assistant. The moderator was an economist familiar with the discrete choice experiment methodology and the assistant was a trained biologist. A power-point presentation and a script was created to ensure that in each workshop respondents received the same information. The presentation (and script) was based on conversations with researchers at the Institute of Marine Research and relevant literature (see for example Foley et al. (2010), Armstrong and van den Hove (2008), Armstrong et al. (2012), Freiwald et al. (2004), Hovland and Mortensen (1999)), and included information such as what are cold-water corals, where can we find them, current status of the ecosystem, mapping and exploration, current protection and legislation, and threats facing them. The step-by-step process of conducting the valuation workshops are described in Table 4.2. Included in the second step was a quiz containing eight questions about cold-water coral. All information required to obtain a perfect score was covered in the presentation given by the workshop

[2] NOK 1 = €0.1028 (http://www.xe.com – 12-01-2016)

moderator. Embedded in this stage was a field experiment where respondents were randomly allocated into two groups, one group received their score prior to filling in the choice cards and the other group did not (LaRiviere et al., 2014). After completion of the discrete choice experiment, participants took part in a study unrelated to the answers given on the choice cards.

Table 4.2 - The steps in the valuation workshop and internet survey

| | **Valuation Workshop** | **Internet** |
|---|---|---|
| Step 1 | Power-point presentation about CWC | Video presentation about CWC |
| Step 2 | Fill in first part of of the questionnaire including a quiz over the material covered in the presentation | Fill in first part of of the questionnaire including a quiz over the material covered in the video |
| Step 3 | Power-point presentation about the DCE | Video presentation about the DCE |
| Step 4 | Fill in the choice cards | Fill in the choice cards |
| Step 5 | Fill in the demographic questions | Fill in the demographic questions |

### *4.1.2 A DCE implemented using an internet panel*

The internet discrete choice experiment took place one year later in August of 2014. Respondents were recruited from a probability based internet panel[3] to be representative with regards to gender, age and geographic location. We employed a sampling quota of 500 respondents[4] and the survey company

[3]We used the internet panel run by Norstat AS, which is the largest of its kind in Norway, with 80 000 registered members.

[4]3462 individuals were invited to participate, 761 clicked on the link and 500 completed the survey.

recruited these via e-mail addresses of registered panel members. The e-mail invitation was generic and included an invitation to participate in a survey that would last 25 minutes and that they would receive compensation in the form of 50 reward points. Reward points can be exchanged for gift certificates or donated to charity[5]. To facilitate comparison between the two DCEs we needed to ensure that information was provided in a manner that was as similar as possible to the valuation workshop. We ended up creating two information videos to give the same visual impact of a class-room type presentation and used the same script as in the valuation workshop to ensure that internet respondents received identical information. The DCE itself was also identical to the one provided in the valuation workshop. Clicking the link in the recruitment e-mail took respondents to the first page of the survey with the first video presentation. Once the survey was begun, it followed the same process as in the valuation workshop (see Table 4.2).

[5] 1 reward point = NOK 1

## 5 Summary of the Papers

### 5.1 Paper I: Valuing Unfamiliar and Complex Environmental Goods: A Comparison of Valuation Workshops and Internet Panel Surveys with Videos

Traditionally, stated preference surveys in general, and discrete choice experiments in particular, have been administered by mail or face-to-face interviews. Over the past two decades practitioners have increasingly used internet panels to administer such surveys even for complex and unfamiliar goods. As we move away from traditional methods of survey administration, it is becoming apparent that we need a better understanding of how "new" survey modes influence results. In this paper, we compare two identical discrete choice experiments (DCEs) aimed at eliciting the Norwegian population's preferences for increased protection of cold-water coral (CWC). Seeing as CWC is an environmental good that is both complex and unfamiliar to most people, the first DCE was implemented in a series of valuation workshops. However, this is an expensive and time-consuming way to gather data. The second DCE, was implemented using a probability based internet panel and allows us to explore how suitable such panels are when complexity and unfamiliarity is large. To facilitate proper information provision, we created videos to secure that internet respondents received identical information and the same visual impact of information presentation. Our results show that estimated WTP in the internet survey is significantly lower compared to estimated WTP in the valuation workshop survey. We identify a large number of status quo choosers (SQ-choosers) in the internet survey that partly explains this result. A SQ-chooser is a respondent who chooses the reference alternative (status quo) with no increase in the protected area at no additional cost in all choice tasks. Furthermore, we find that respondents scoring below the average on the quiz on cold-water coral (an indication of knowledge about the environmental good), respondents who speed through the survey questionnaire, and respondents believing the survey to be inconsequential are significantly more likely to choose the reference alternative in all choice tasks. Inspection of the conditional WTP distributions suggests that part of the observed difference in WTP between survey modes are caused by these respondents. Taken together, these results suggests that it is possible to use probability based internet panels to value complex and unfamiliar environmental goods, but that practitioners should pay close attention to information provision, emphasize consequentiality and implement procedures to reduce speeding behavior.

## 5.2 Paper II: Disentangling the Influence of Knowledge on Attribute Non-Attendance

Over the past few decades respondents using simplifying heuristics and strategies when responding to discrete choice experiments have received increasing attention. The main problem is that failing to consider non-utility maximizing behavior could lead to biased estimates and wrong inferences drawn regarding preferences and ultimately willingness-to-pay. In this paper we use data from a discrete choice experiment on cold-water coral protection and seek to disentangle the influence of knowledge about the environmental good under consideration on a respondent's propensity to ignore one or more of the attributes on the choice cards, i.e. attribute non-attendance (AN-A). The data was gathered in a series of valuation workshops. In the valuation workshops, respondents received a presentation about the environmental good followed by a quiz over the material covered. We use the number of correct answers on the quiz as a measure of knowledge. Specifically, we test two hypotheses: One, that the knowledge about the environmental good affects the probability of attending to the attributes, and two, that receiving an external signal about how well you did influences the probability of attendance. Our results show that scoring above the mean on the quiz, a measure of high knowledge, is associated with a higher probability of attending to the environmental and ecological attributes and a lower probability of attending to the cost attribute. This result was only significant for two out of four attributes, and holds irrespective of whether a respondent received his or her score. In general, being told your score causes mixed directional effects on the probabilities of attendance, but these are all insignificant, indicating that knowing your score does not influence the degree to which you attend to or ignore attributes. Finally, considering attribute non-attendance leads to significantly lower willingness-to-pay estimates, a result which conforms to the majority of findings in the literature. Our results imply that information, which translates into knowledge, does influence the degree to which respondents ignore attributes, but at the same time highlights that more research is needed to know what type of information influence the degree to which respondents attend to attributes and in which direction. Understanding this is crucial to reduce attribute non-attendance behavior and obtain more precise estimates.

## 5.3 Paper III: Accommodating Respondent Dishonesty in Discrete Choice Experiments

While stated preference techniques in general, and discrete choice experiments in particular, are largely considered an accepted method of preference elicitation for unfamiliar non-marketed goods and services, practitioners are increasingly concerned with data and response quality. In this paper, we use data from an online discrete choice experiment aimed at eliciting the Norwegian population's preferences for increased cold-water coral protection. We identify a group of dishonest respondents who have lied on a follow-up question. Recent evidence suggests that taking an oath to be honest and answer truthfully prior to a hypothetical choice task reduces hypothetical bias. It is suggested that taking an oath works as a commitment device and induces respondents to reflect more carefully on their preferences indicating more effort is put into the choice task. As such, we hypothesize that respondents lying on the follow-up question have spent less effort answering the choice tasks and as a consequence are characterized by a more stochastic choice process and are more likely to ignore attributes on the choice cards. Using a combined modeling framework to simultaneously address preference-, scale - and attribute processing heterogeneity, we find that respondents classified as dishonest are more likely to be in a scale class characterized by a relatively more stochastic choice process, and are significantly more likely to ignore two out of three non-cost attributes. Furthermore, our results suggest that observed differences in error variance between honest and dishonest respondents can partly be explained by different propensities to ignore attributes. Looking at willingness-to-pay (WTP), we find that considering attribute non-attendance leads to substantially lower estimates, and that dishonest respondents, on average, have lower WTP compared to honest ones.

## 6 Contributions and Limitations

The explorations in this thesis have shed some light on the potential challenges using discrete choice experiments (DCEs) to elicit preferences for complex and unfamiliar public goods. I have used data from two DCEs aimed at eliciting the Norwegian population's preferences for increased cold-water coral protection. In Paper I we set out to explore how suitable probability based internet panels are when the good is complex and unfamiliar. We considered the importance of information provision and created videos to ensure that internet respondents received the same information as valuation workshop respondents. Our results show that using a probability based internet panel is possible, but that practitioners should pay close attention to information provision, emphasize consequentiality and implement measures to reduce speeding behavior. Even controlling for this, we found that some differences remained. One possibility, which we discuss in Paper I, is the presence of a social desirability effect in the valuation workshop. Although, respondents filled in the questionnaire individually and anonymously, they were still in a group setting. An interesting extension would be to include a rigorous test of social desirability bias in the valuation workshop setting to try to quantify this effect.

Recently, respondents using simplifying strategies and heuristics have received increasing attention from practitioners. In Paper II we hypothesize that respondents are more likely to use simplifying strategies when the environmental good under consideration is unfamiliar and complex. Specifically, we explore the connection between a respondent's knowledge about the environmental good, measured by a quiz, and the probability of ignoring one or more attributes on the choice cards. We find that scoring above the average significantly increases the probability of attending to one of the three non-cost attributes, and significantly decreases the probability of attending to cost, irrespective of whether a respondent received his or her score. These mixed results answer a few questions, but open up others. First, it highlights the importance of providing information prior to a DCE since information, and by extension knowledge, affects the probability of attending to the attributes. At the same time, it underlines that more research is needed into what type of information affects attribute attendance (non-attendance) and in which direction. Understanding this connection is crucial to reducing attribute non-attendance and obtain more precise estimates. It will allow practitioners to implement *ex-ante* measures rather than rely on *ex-post* modeling techniques. We also need to consider that this investigation was undertaken in the context of a very unfamiliar good, and it might be that a clearer relationship could be obtained in a context more familiar to respondents.

In Paper III I am concerned with another type of underlying behavior: dishonesty. Motivated by findings that swearing to be honest and answer truthfully prior to the valuation task induces respondents to spend more effort and reflect more carefully on their preferences, I hypothesize that dishonest respondents have spent less effort and as such have a less deterministic choice process and are more likely to ignore attributes. This is in fact what the results show. However, while dishonesty is interesting, the way I identify it here it cannot be cleanly disentangled from speeding or a "decision" to be uninformed. This provides two clear avenues for further investigation. One, to use a different measure of dishonesty to see if the results obtained here generalize to a wider range of measures, as well as beyond the current study; and two, although oath statements motivated this exploration of dishonesty, within the current study it is not possible to say that it is indeed the flip-side of the coin. An interesting extension is to combine the two approaches and run a split sample where one group does take the oath and another does not. That way, we can truly see if the oath in fact reduces dishonesty, i.e. fewer people lie on the follow-up question, and whether honest respondents are more likely to attend attributes relative to dishonest ones, in the context of being primed to act honestly and truthfully.

As such, this thesis explores some of the issues related to valuing unfamiliar and complex environmental goods as it relates to choice of survey mode, and attribute non-attendance seen in connection with knowledge and dishonesty.

> "Prediction success and good model fits do not equal understanding, and understanding is unlikely to come from pedantically overly complex statistical models that demonstrate mathematical and statistical ability but little understanding of theory and substance."
> – Louviere et al. (1999, p. 216)

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