CAPTURING PUBLIC VIEWS ON COMPLEX AND UNFAMILIAR GOODS: CHEMICAL WATER POLLUTION IN ENGLAND AND WALES

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of Environmental Policy and Development, at the London School of Economics and Political Science, is solely my own work.

The final word count of this thesis is 54,397.

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Abstract

This thesis (papers submission) focuses on the challenge of using public opinion to value environmental goods that are both complex to understand and unfamiliar to people. The three central papers are introduced by a literature review, which considers recent advancements in methods and knowledge associated with determining values for unfamiliar goods.

The first paper then applies a stated preference choice experiment (using online surveys) and a latent class analysis to determine the value of reducing persistent chemicals from waterbodies in England and Wales. A scientific certainty attribute is included to capture the uncertainties associated with persistent chemical effects, marking a novel contribution to the literature and a development of the precautionary principle for application.

The second paper uses a deliberative approach to investigate how people frame policy options for reducing chemical water pollution in England and Wales (required under the Water Framework Directive), using a representative sample of participants over two consecutive weekend workshops. The key finding here is that stated preference research aiming to be policy-relevant should improve its approach to cost fairness issues.

The final paper uses a contingent valuation approach (using online surveys) to estimate the value of removing metal pollution from waterbodies in England and Wales. This paper applies a split sample to investigate the effect of a social norms information treatment on how convincing and realistic people found the stated preference scenario and payment tasks to be, which increased for the treatment group. The results indicate that the treatment has a weak direct impact on estimated mean willingness to pay (WTP), however a relative measure of WTP precision suggests that such estimates can be improved if people pay attention to the treatment.

The findings from this thesis are of use to social scientists, civil servants and environmental economists interested in: improving approaches to valuing complex and unfamiliar goods; better reflecting natural decision-making in public opinion research; and applying findings from deliberative and survey-based research to create and manage more effective policies.

Table of Contents

List of Tables and Figures **Page**

List of Abbreviations

AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CBA	Cost Benefit Analysis
CE	Choice Experiment
CG	Control Group
CH	Covariance Heterogeneity
CV	Contingent Valuation
CWC	Cold Water Coral
DBDC	Double-Bounded Dichotomous Choice
DCE	Discrete Choice Experiment
DMV	Deliberative Monetary Valuation
DPH	Discovered Preference Hypothesis
DPW	Deliberative Public Workshop
EA	Environment Agency
EU	European Union
GES	Good Ecological Status
HQIC	Hannan–Quinn Information Criterion
IID	Independently and Identically Distributed
LCA	Latent Class Analysis
MNL	Multinomial Logit
NAM	Norm Activation Model
PBDE	Polybrominated Diphenyl Ether
RBMP	River Basin Management Plan
RP	Revealed Preference
RPL	Random Parameters Logit
SNT	Social Norms Treatment
SNTG	Social Norms Treatment Group
SP	Stated Preference
TPB	Theory of Planned Behaviour
WFD	Water Framework Directive
WTA	Willingness to Accept
WTP	Willingness to Pay

1 - Introduction

The opening literature review for this thesis examines recently developed approaches to valuing unfamiliar environmental goods. Economists have for a long time tasked themselves with better understanding how lay people comprehend the benefits of goods that are inherently unfamiliar to the general public. This challenge is set because individual preferences for environmental (and therefore) public services are key to the economic analysis of many future decisions in the public sector.

However, it is only in recent years that research into the valuation of unfamiliar goods has made significant progress. The opening Literature Review in this thesis uses findings from modern valuation methodologies to investigate how practitioners' understanding of unfamiliar good valuation can be improved, using the following central themes: preference formation; deliberation; language; and respondent performance. These themes are used to review recent studies from the relevant literature and – in doing so – highlight future research areas that could prove useful in developing approaches to the valuation of unfamiliar goods and services.

Moving then to the first paper in this thesis, one of the requirements of fully implementing River Basin Management Plans (RBMPs) under the Water Framework Directive (WFD) is the availability of economic benefit estimates for achieving good ecological status (GES) in surface waters (e.g. lakes and rivers). This study aimed to elicit public preferences for, and reveal underlying forms of preference heterogeneity associated with, the removal of persistent chemicals in surface waters. Given the lack of scientific certainty regarding the chemical safety of new persistent chemicals, this variable is explicitly incorporated into a choice experiment (CE) that was administered to a representative sample of the population in England and Wales. This original approach resulted in valuation estimates that integrate the impact of scientific certainty whilst remaining applicable in the policy context of cost benefit analyses (CBAs) under the WFD. This marks an advancement in the methods available to address uncertain environmental impacts and evolves the nature of the precautionary principle in practice.

Other attributes in this CE include the scale of surface waters remediated, remediation time and monetary costs. Categorical and percentage change welfare impacts are estimated for each of the non-monetary attributes using conditional logit models. People preferred policy options with higher chemical safety, widespread aquatic chemical removal and that such action be done in the immediate (rather than distant) future. A latent class analysis (LCA) revealed four distinct groups of people in the sample, with the highest willingness to pay (WTP) values arising from those who were most concerned about human health issues from persistent chemicals in

surface waters. This study provides several helpful contributions to research aimed at valuing complex and unfamiliar environmental goods. In doing so, it delivers an original valuation approach as well as estimates that are highly relevant to policy implementation for persistent chemicals as well as this field of academic research more widely.

The second paper in this thesis applied a deliberative approach to investigate how people frame policy options for reducing chemical water pollution in England and Wales (required under the WFD). Using public views on environmental issues to inform policy decisions is not straightforward, and care is needed if the topics themselves are difficult to understand or new to people. An immediate challenge is to better understand *how* people frame policy responses for environmental problems that involve complex and unfamiliar impacts, so that views on such policy options can be most effectively and correctly applied.

This paper used a participatory and deliberative approach to investigate public views on chemical water pollution, using a representative sample of participants over two consecutive weekend workshops. Three themes of interest were drawn out from these discussions, which all merit close attention when attempting to accurately measure public opinion on complex and unfamiliar goods. The first explored the topic of distributional fairness of costs, and how people's perceptions of this issue might be managed to better capture existing value in surveys. The second looked at the interplay between the extent of people's awareness of an environmental issue and the level of importance that they assign to it. The final theme addressed the matter of establishing optimal conditions for the production and dissemination of effective information.

The key research contribution from this study is that unless cost fairness factors are incorporated into public opinion research then latent interest and WTP will likely remain unaccounted for, allowing for suboptimal policy decisions. The findings from this deliberative study are of use to a range of practitioners interested in: enhancing decision-making via public opinion research; addressing the effect of perceived cost fairness on price acceptability; and using findings from deliberative dialogues to produce more effective policies.

The third and final paper in this thesis is a contingent valuation (CV) study addressing public opinion on the benefits of introducing a management policy to remove metal water pollution from surface waters in England and Wales, which is required in all RBMPs as part of the WFD. Metal water pollution is – for most people – an unfamiliar and complex topic. However reported scenario realism and stated preference (SP) precision can be improved with a social norm information treatment.

This paper used a split sample test to investigate this proposition, in which one half of the respondents received a social norms treatment (SNT) at the end of the learning stage of the SP

survey. This treatment comprised group-learnt descriptive social norms, in the form of expressed views from deliberative public workshops (DPWs) that addressed the issue of metal water pollution in much greater detail than is possible in a typical SP survey. The results show that respondents who received the SNT (but only those who paid attention to that information) were 70-78% more likely to find the survey scenario and payment tasks convincing, coupled with a relative improvement in WTP estimation precision. This is a significant improvement in the quality of preference judgements compared with the control group (CG) and was achieved without persuading respondents to significantly shift their mean WTP in any direction.

Using a double-bounded dichotomous choice (DBDC) approach, this study also estimated a statistically significant ($P<0.001$) mean WTP figure of £73.79 household^{-1} yr^{-1}, for ensuring that all surface waters are free from damaging levels of metal water pollution. The SNT applied in this study presents the foundation of a new approach to valuing complex and unfamiliar goods. In doing so, this paper provides a key original contribution to academic knowledge by applying this new method in an SP survey. This novel application also reduces time and monetary costs associated with recent advances in SP techniques that incorporate social norms. The second key contribution of this paper is to policy, by generating original and relevant valuation estimates for use in planning decisions under the WFD.

In terms of the future policy-relevance of this thesis, it is worth noting that when the UK leaves the European Union (EU), the UK government has committed to maintaining existing environmental standards (Defra, 2018[1]). Consequently, this work should still be highly relevant and applicable to ongoing water management practices in the UK and the EU.

The remainder of this thesis is structured as follows. First, it reviews the relevant literature for recent developments in the valuation of unfamiliar goods. Next, the three core papers described above are presented in turn. These are followed by a critical discussion of some of the findings and reflections from the three papers. Finally, a conclusion provides a summary of the papers' implications for practitioners and policymakers, and suggests some priorities for future research.

[1] Defra (Department for Environment, Food & Rural Affairs), 2018. *Guidance: Upholding environmental standards if there's no Brexit deal*. Accessed 14 September 2018. Available at: <https://www.gov.uk/government/publications/upholding-environmental-standards-if-theres-no-brexit-deal/upholding-environmental-standards-if-theres-no-brexit-deal>.

2 - Literature Review

Recent Developments in the Valuation of Unfamiliar Goods

Contents **Page**

Introduction

Preferences for some public goods and services are often not directly observable in markets, so the CV method – a survey-based technique initially proposed by Ciriacy-Wantrup (1952) and first adopted by Davis (1963) – was developed in order to measure individual values. Since then, SP survey techniques such as CV have been extensively applied to measure individual values of environmental public goods and services (Bateman et al., 2002; Carson, 2012; Kling et al., 2012). With the increased application of such methods in environmental economics, researchers have recognised the need to better understand how lay people comprehend potentially unfamiliar goods or services.

The term *unfamiliar good* refers to any object or service (actual or imagined) that people can derive a benefit from, but that they are unacquainted with. Whilst it is sometimes discussed in absolute terms, familiarity is not a binary outcome, and people can experience degrees of familiarity with an object or service – and this is something that can change over time. SP research is, in some cases, assumed to be able to measure the value of unfamiliar goods, however there are numerous issues with this. This review will address some of those issues and examine emerging methods of handling the complexities associated with unfamiliar non-market good valuation. Though economists have long been interested in people's comprehension of unfamiliar goods (Nelson, 1970), the study of unfamiliar goods, particularly in an environmental context, is a relatively new field.

However, there are a few papers from 2000 and earlier that are worth mentioning briefly, to see how this sort of issue has been looked at in the past. To set the scene, an early mention by Kahneman and Ritov (1994) stated that CV methods "do not usually provide help in the difficult task of expressing an attitude to an unfamiliar good." Shogren et al. (2000) found that people – at least initially – are willing to pay a premium for unfamiliar food goods. Their results indicated that a proportion of a person's WTP for such goods reflects the value of their desire to learn more about the unfamiliar good, which the authors refer to as *preference learning*.

This is a concept that was earlier described by Crocker and Shogren (1991), who outlined a model in which the commodity was well defined, but unfamiliar to respondents. They found that even with ample time to consider the question, respondents systematically overstated their WTP in order to safeguard availability of the good until their learning was more complete. Finally, an even earlier experiment, investigating the disparity between WTP and willingness to accept (WTA), also touched on the issue of unfamiliar goods. In this study, Coursey et al. (1987) found that by using repeated valuation rounds, that allowed respondents to learn about an unfamiliar

good, WTA and WTP estimates can converge (where initially WTA estimates were significantly greater).

Moving to a modern understanding of unfamiliar goods, a central problem in their valuation is made evident in a meta-analysis by McFadden and Train (2017) who found that, as expected, mean bias ratios from valuation experiments for unfamiliar goods are higher than that for familiar goods. Various suggestions have been made to encourage respondents to express their preferences for unfamiliar goods, including improving respondent learning. Kingsley and Brown (2013) achieved this through repeated valuation exercises and measured it by observing reductions in the error variance in a random utility model. Similarly, Lancsar and Louviere (2006) found that responses early in a sequence of choices displayed more variability than later ones, suggesting that this might be a learning effect. It is not uncommon for respondent learning to be addressed in SP studies, for example by taking respondents through sequential choice tasks, and Holmes and Boyle (2005) state that if such respondent learning does occur, then answers to a single question might not best measure preference information. They go on to highlight the importance of developing such methods in SP studies, despite the "age-old issues of statistical efficiency and bias" that this throws up. Another associated suggestion is giving respondents time to think (Svedsäter, 2007; Cook et al., 2012). MacMillan et al. (2006) give an example of this, finding that giving respondents time to think over several rounds of valuation resulted in significantly different WTP estimates (compared to initial estimates) for unfamiliar goods, yet those of a familiar good were not significantly different.

Best practice guidance on ensuring CV markets in general are realistic state that respondents should be reminded to consider substitute goods as well as their budget constraint, and information should be provided on how the policy change of interest relates to other alternative investment opportunities (Mitchell and Carson, 1989; Arrow et al., 1993). A key problem with non-market values is defining the relevant set of substitute goods and alternative investment opportunities which, in some cases, could be very large and difficult or impractical – if not impossible – to identify. This problem also holds for unfamiliar goods, and given the advances in SP techniques more generally, it is surprising that so little progress has been made in developing new and robust ways of uncovering non-market values for unfamiliar goods. People's preferences for environmental or public services are important when assessing policy options in the public sector (Schläpfer, 2017). Accurate estimation of environmental and public values is crucial, given the policy significance of such values, and yet palpable gaps exist in present knowledge. As with other goods in life, such as food, people need to be educated about

unfamiliar things in order for them to adequately assess whether there is interest in them (Tańska et al., 2017).

With these few examples of complications, it is not surprising that accurately measuring non-market values – avoiding the many pitfalls associated with valuing sometimes unfamiliar, distant and complex goods and services – is an enduring difficulty in SP research. Torres and Hanley (2017) even go as far as to suggest that until recently, people's unfamiliarity with goods like deep-sea services is itself a reason for the lack of societal values associated with such topics. That the monetary choice decision typically takes place within a hypothetical market situation, itself an unfamiliar setting for most, further compounds difficulty in such tasks.

This review looks at recent attempts by researchers to approach the problem of valuing unfamiliar public environmental goods. This avenue of assessment is considered important given that "valuing sometimes distant, complex and unfamiliar goods and services, remains arguably one of the greatest challenges in contingent valuation," (Atkinson and Mourato, 2015). People's unfamiliarity with ecosystem services – such as deep sea environments – can in fact represent a greater challenge in terms of assigning economic values to such services and their biodiversity, than the lack of underlying scientific certainty (Wattage et al., 2011; Jobstvogt et al., 2014). We know from experimental and applied SP evidence that people's valuations are predisposed to poor preferences when the hypothetical scenarios involve unfamiliar goods and that people are prone to a range of framing effects and choice heuristics (Bateman et al., 2008a).

Primarily, this review selects literature on complex and unfamiliar good valuation based on the following four themes: preference formation; social influences and deliberation; language and familiarity; and respondent performance. As such, it is not intended as a comprehensive review of all literature or issues associated with complex and unfamiliar goods, but rather as helpful background to some emerging issues in the field and an introduction to some of the matters dealt with in the subsequent papers. As outlined below, the review also highlights topics that could benefit from further research aimed at improving unfamiliar or complex good valuation methods.

Before outlining how the rest of this paper is organised, the issue of valuing goods at the margin should be introduced and discussed in terms of how this relates to assessing large benefit changes (like those typically covered in this thesis' papers). As noted by Sijtsma et al. (2012), valuing environmental goods at the margin means identifying the relative importance of a marginal environmental change at a given moment in time. However, Limburg et al. (2002) note that monetary valuation at the margin can be misleading when ecological thresholds are uncertain (a key theme of the first paper in this thesis). Similarly, Craig (2001) argues that

valuation at the margin has the potential to undervalue intact ecosystems and natural capital, so whilst there is sometimes a disconnect between WTP's underpinning economic theory (which is often developed based on valuation at the margin), this is a less appropriate approach for the very large and aggregated changes in benefits addressed in this thesis. As discussed by Farrell (2000), in the context of valuing benefits or services, multiplying prices and quantities of valuations at the margin does not reflect total values – which is insufficient if the aim is to estimate a total aggregate measure.

The remainder of this literature review is organised as follows. First, it will consider some of the relevant theoretical groundwork regarding people's values for unfamiliar goods, and whether those values are pre-existing or formed in SP surveys. In doing so, the role of familiarity on scale parameters, which relates to the perceived randomness of people's choices, will be looked at. The effect of awareness of one's own level of knowledge (or familiarity) on SP survey responses will be addressed, in addition to considering the role of altruism when valuing unfamiliar goods. The review will then investigate what benefits a deliberative approach can offer, and in doing so what insights the Theory of Planned Behaviour (TPB) can tell us about valuing unfamiliar goods. This will also explore whether people, when valuing unfamiliar goods, express actual preferences or reflections of their attitudes per se. Next, the typically understudied influence of language on SP responses for unfamiliar goods will be explored, offering some useful lessons from recent research in this area. Following this, the theme of respondent performance will be investigated, covering recent insights regarding the role of unfamiliarity on WTP-WTA disparities as well as how unfamiliarity feeds into attribute attendance in CEs. Finally, a short concluding section till draw together some of the key findings from this review. Throughout, this review highlights various areas that would benefit from further research as well as guidance for improvements to future research into unfamiliar goods.

Preference Formation Theory

This section will frame the topic of preference determination by considering what the literature says so far on the matter. To begin with, two important and established interpretations of why responses in SP surveys can violate the neoclassical utility model should be covered (Sugden, 2005). First is the constructed preferences approach (Lichetenstein and Slovic 2006), which assumes that individuals do not possess pre-existing (or stable) preferences for unfamiliar goods and that when completing SP surveys they express attitudes instead. To borrow a phrase from MacMillan et al. (2006), CV methods can act as a "preference engine" when applied to unfamiliar goods, rather than necessarily uncovering underlying and pre-existing preferences. Second is the discovered preference hypothesis (DPH) (Plott, 1996), which is derived from similar empirical findings as the constructed preference approach, but differs in its inference. The DPH assumes that individuals hold true underlying preferences, but that people remain unaware of them until the good is experienced in some way.

Although this thesis doesn't seek to explore this in detail, it is possible to investigate – in limited respects and circumstances – the impact of construction or discovery on eventual preferences. The placebo effect demonstrates the possibility that pre-experience contexts can be carried into the experience itself. Plassmann et al. (2008) conducted an experiment on people's preferences for different types of wine, measured using both respondent reporting and functional magnetic resonance imaging (fMRI) technology. When the same wine was labelled as more expensive, respondents reported increased pleasantness. Interestingly, whilst raising the ostensible price promoted no change in the primary neural taste areas, regions of the brain associated with the computation of experienced utility displayed increased activation. This illustrates that even sensory preferences such as taste are not free from constructive effects, and that empirically distinguishing the latter preference formation pathway from that of discovered preferences is not straightforward. In any case, attempts to test whether value arises from constructed or discovered sets of preferences require careful design and thoughtful consideration of the role of causality.

Under the DPH, experience is thought to help people learn their existing preferences for unfamiliar goods, and research shows that the setting and context of this learning process is very important (Bateman et al., 2008b; Norwood and Lusk, 2011). For example, value convergence usually exists for private goods (through repeated transactions), however when addressing environmental public goods this "preference refinement" (see Brown et al., 2008) is encouraged through repeated interactions, leading to more stable values.

Measuring Familiarity

A recent paper by Matthews et al. (2017) applied repeated CEs over time, for coastal erosion management options. Whilst they found that respondents who reported high certainty in their responses (in the first survey application) had significantly more stable WTP estimates, generally respondent stability did not improve over time with staggered repetitions of the valuation task. Their results imply that either the valuation tasks did not offer adequate feedback to enable preference discovery, or that WTP values were constructed or discovered on the spot. Whilst the relative importance of attributes remained consistent, what their results indicate is that researchers should be especially cautious of SP values for goods or services that necessitate unfamiliar trade-offs like environmental quality. Given the known unknowns with this area of theory, this review will continue on the premise that preference may be either formed or discovered.

Czajkowski et al. (2015) developed a theoretically consistent (and implementable) method of testing and controlling for experience effects on WTP estimates for public goods, which allows preferences to be more deterministic within (and across) subjects as experience with the good increases. They found strong evidence to support their hypothesis that additional experience increases scale, which from the econometrician's perspective makes those consumer preferences more predictable. Their study addressed people's experience with a potentially unfamiliar good – coastal water quality – measured as the reported number of days in which the respondent visited a beach in a year. This experience indicator was assumed to be a good proxy for familiarity as "beach quality is visually observable," a somewhat imperfect assumption. The authors note that their measure of experience is not exogenous and could be correlated with preferences for other amenities. Nonetheless, it is an indicator that does allow for people's experience of perceived quality to be measured, and finding such instruments (for familiarity) is not always straightforward.

Their approach enabled them to both construct a model that was theoretically consistent with Bayesian updating of preferences as well as test the consistency between the model's theoretical predictions and the data. Their results showed that respondents who visited beaches relatively more often had a significantly greater scale parameter, meaning that the magnitude of the error component in their random utility function was lower. These respondents also exhibited lower scale variance, however this result was only significant at the 10% level. Their results do not strongly support the theoretical prediction that heterogeneity in scale across respondents should decrease with familiarity, thus motivating future research in the area.

The Role of Knowledge

LaRiviere et al. (2014) took this idea in a slightly different direction and used an information treatment of which the results implied that WTP estimates for non-market goods are a function of *beliefs* about information states rather than *true* information states. They were interested in exploring evidence from laboratory experiments which suggested that people do not necessarily demonstrate Bayesian updating when provided with fresh exogenous information in new situations (Eil and Rao, 2011; Grossman and Owens, 2012). The paper develops and tests hypotheses addressing the unsolved matter – at the juncture between behavioural economics and SP valuation – concerning how preferences for public goods are affected by exogenously varying respondent certainty about the *quality* of their endogenously acquired information. Their CE design looked at WTP for policies intended to protect cold water coral (CWC) in Norwegian coastal areas and incorporated a measure of respondent knowledge (about CWCs) by quizzing them on scientific information about this public good. As most CWCs exist hundreds of meters below the sea surface they tend to be very unfamiliar to people, and yet are regarded as deep sea biodiversity hot spots providing unique habitats for many different species (Husebø et al., 2002; Freiwald et al., 2004).

Their results showed that high knowledge respondents (those who scored above the mean in the quiz) were willing to pay significantly more for greater CWC preservation, asserting therefore that those with more familiarity with the non-market good possessed higher WTP values. These findings are supported by endogenous preference theory, which states that consumers who possess familiarity with a good may be willing to pay significantly more than those who are unfamiliar with it (Bowles, 1998; Zizzo, 2003; Gowdy, 2004). Their non-causal results found that high knowledge respondents were also associated with a significantly increased scale parameter (i.e. reduced choice randomness).

Additionally, a sample of their respondents received a *treatment* which took the form of their quiz results, thus informing the respondent about their own level of knowledge. The study's results found no significant association between the treatment and the scale parameter and therefore it is stated that such objective signals (of knowledge) have no effect on the scale (or precision) of the public good's estimated utility function. However, the results did indicate that for high knowledge respondents, those who received the treatment declared significantly higher WTP for the level of provision of CWCs (than those not in the treatment group). It is possible that in these cases, trust in one's own knowledge can be a limiting factor in terms of expressing a higher WTP values. As this affect was restricted to high knowledge respondents, the authors infer that the mechanism relates to uncertainty over the correctness of their knowledge as well

as their actual level of knowledge. Put another way, stated WTP for public goods is affected by certainty about the accuracy of a respondent's information.

The paper therefore posits that WTP estimates, for non-market environmental goods, are a function of *true* information states (of the respondent) in addition to their *beliefs* about those information states. This should inspire new research to explore the proportion of estimated WTP that can be attributed to the way in which information provided in surveys can act as an objective signal. It is worth noting too that instability of choices caused by unfamiliarity with a good is not limited to hypothetical SP scenarios, as such effects of unfamiliarity have been observed in real world choices (Carlsson, 2010), so an absence of pre-existing preferences cannot be seen to in itself abrogate the robustness of SP methods.

Time to Consider

Börger (2015) explored how variations in the scale parameter are formed (in a discrete choice experiment). Specifically, the paper was interested in addressing the impact of survey speeders, i.e. respondents who are shown to rush through a survey and therefore not absorb all the presented information adequately. The results indicated that longer response times were associated with larger scale and lower error variance (i.e. less random choices). This positive scale effect (of response time) was non-linear and while response time did not affect welfare estimates, the precision of such estimates was increased by higher response time (i.e. those who were not considered speeders). Sandorf et al. (2016) found that speeders in internet surveys were more likely to be status quo choosers of environmental change options.

Deliberative Approaches

When a significant lack of knowledge (or experience) exists about an environmental good, revealed preference (RP) methods are unlikely to be helpful, as they should only be applied to determine people's preferences for goods that they know are valuable. Indeed, in many cases, the methods of conventional SP approaches may also prove insufficient. As previously mentioned, the effect of respondent consideration time on survey responses is evidently an important driver of preference estimates for unfamiliar goods. However more recent research has addressed the impact of discussion – or deliberation – on survey results. The basic premise behind this approach is that deliberation is a proxy for how people sometimes learn about a topic in real life, which is by talking to people about it. For 'one-shot' surveys, which is the more usual approach (due to time and cost limitations), respondents face the considerably strenuous task of discovering or forming their preferences for unfamiliar goods such as ecosystem services.

Addressing this methodological issue, Lienhoop and Völker (2016) performed a deliberative CE with the intention of producing value estimates for policy advice regarding ecosystem services. Their paper explored the effect of *discussion* and *time to reflect* (two properties of deliberation) on preference refinement and found that deliberation encouraged more comprehensive choice motives as well as a minor increase in choice certainty. Atkinson and Mourato (2015) make clear the need for such "opportunities for learning" to be more widely adopted in SP methods and highlight the potential that such approaches offer in terms of improving non-market value estimates. This is especially so for unfamiliar good valuation, which is prone to a variety of heuristics and framing effects. Sen (2008) makes clear that group deliberation is crucial in contexts where cognitive errors and misunderstandings can exist.

Social Influences

In a recent paper, Börger and Hattam (2017) explored the influence of behavioural determinants of preferences for an unfamiliar (and remote) public good: conservation benefits of a marine protected area on the Dogger Bank in the southern North Sea. Their study investigated the influence of two key psycho-social concepts on respondent behaviour in a discrete choice experiment (DCE). The first concept – the Theory of Planned Behaviour (TPB) – relates to the work of Lichetenstein and Slovic (2006). Their work suggested that where survey respondents are unfamiliar with a good they express attitudes about it (rather than actual preferences), and that attitudes towards particular behaviour (as well as subjective social norms) can predict intentions to carry out such behaviours (Ajzen, 1991). Börger and Hattam build upon applied research into this theory (López-Mosquera and Sánchez, 2012; López-Mosquera et al., 2014;

Liebe et al., 2011; Spash et al., 2009) which has tended to find improvements in model fit when the following TPB components are included: attitudes; subjective norms; and perceived behavioural control. For example, Spash et al. (2009) used these three TPB factors along with ethical statements in a predictive model of WTP for the restoration of river catchment biodiversity. The inclusion of the TPB components was found to vastly improve model explanatory power, thus marking them as significant factors in preference determination.

The second concept – the Norm Activation Model (NAM) – is a model first developed to explain how altruism and motivations influence behaviour (Schwartz and Howard, 1981). In the NAM, norms are activated in the cognitive processes that precede decisions on environmental behaviour, whether friendly or damaging. These can consist of both personal and social norms, which are assessed before making these decisions. Further, the NAM states that personal norms are governed by two elements. First, an awareness that behaving in a particular way has certain consequences. Second, the known responsibility to behave in a particular way. Despite the difficulty in empirically testing the NAM (Liebe et al., 2011), partly due to different components' moderator effects on norms and behaviour, it has been applied for decades to a range of environmental behaviour studies. These have covered specific subjects such as diesel emission reductions from cars (Steg and de Groot, 2010) and recycling behaviour (Bratt, 1999) as well as other more general components of environmentally motivated behaviour (Blamey, 1998; Schultz et al., 2005).

Börger and Hattam show that contributing financially to the positive environmental changes (e.g. the Dogger Bank management plan) was perceived by respondents as a moral obligation. Respondents comprehended the positive effect of the proposed environmental restoration on themselves (aligning with traditional WTP viewpoints), but they also took into account the positive effect of the policy on wider society. This "awareness of consequences" and its impact on WTP indicates that altruistic behaviour also lies behind respondents' stated choices. The inclusion of both TPB and NAM concepts significantly improved the fit of their DCE model, something that previously had only been partly demonstrated using a CV method (see Bernath and Roschewitz, 2008). When tested independently, the inclusion of the NAM concept led to weaker model improvements than the TPB concept, suggesting that TPB possesses stronger explanatory power.

These findings should motivate further investigations into the role of social norms and environmental attitudes as potential mediators of the effects of TPB and NAM, as well as drivers of choice per se. Further studies are needed in order to better understand the impact of TPB on other known preference influencers such as choice certainty (Hensher et al., 2012a). The

findings of Börger and Hattam (2017) also support construct validity of stated choice data when valuing unfamiliar (and remote) environmental goods.

Deliberative Valuation

As with LaRiviere et al. (2014), Aanesen et al. (2015) also addressed the unfamiliar good of CWC in Norway, which is perhaps not surprising given that a considerable number of CWC protected areas have been established around the world over the past decade (Armstrong et al., 2014) and that Norway hosts one of the greatest densities of CWC worldwide (Buhl-Mortensen et al., 2012). In order to derive WTP estimates for improving CWC protection they incorporated a valuation workshop, which is a form of deliberation that enables a greater provision of information (about the good in question) than is usually possible in a typical survey-based SP study. Valuation workshops allow for the collection of data from group settings, sometimes with repeated valuation procedures (i.e. having participants attend two or three workshops, in order to build upon previous knowledge), which allows for much more time to think as well as deliberation of evidence and opinion before any valuation task (MacMillan et al., 2006; Colombo et al., 2013).

Such valuation methods, where they allow opportunities for learning, offer a way of establishing potentially more accurate values for unfamiliar public goods (Atkinson and Mourato, 2015). Aanesen et al. (2015) adopt an individual valuation approach (see MacMillan et al., 2006), with workshop attendees completing choice tasks independently from each other, which was intended to diminish some challenges associated with valuing unfamiliar goods whilst avoiding social desirability bias (Leggett et al., 2003; List et al., 2004). However, it is impossible to say whether this type of bias played a role, as people may still increase their WTP if the preference discovery or formation process is undertaken in a social setting, even if the survey is conducted in private.

Using a Total Economic Value framework, the authors identified both use values (indirect) and non-use values that flow from the CWCs. They stated that they were unable to disentangle respondents' values for CWC habitat benefits from that of CWCs existence benefits, which seems unsurprising given that there is no evidence that people naturally conceptualise such unfamiliar goods in this categorical fashion. Indeed, if they are forced to do so, then it seems reasonable to assume that this might augment any preference engine that might be at play. It should also be noted that the deliberative approach used in the valuation workshops was minimal, with participants simply viewing a 30 minute presentation about CWCs (allowing time

for clarification questions) and then completing just one (i.e. not repeated) set of 12 valuation tasks in a DCE format.

The attributes included in the DCE (in addition to a varying cost level) included: the size of the protected area; usefulness of the area to oil/gas and fisheries activities; and importance of area as habitat for fish. The paper improved on previous valuation research on CWC preservation which – potentially due to a lack of adequate information amount, quality or form – failed to produce significant cost attributes (Glenn et al., 2010). However, the study was relatively expensive (per response) to produce due to the workshop time and money costs, unlike a comparable (though non-social) and cheaper survey which was implemented using informative videos via the internet (see Sandorf et al., 2016). Aanesen et al. (2015) succeeded in showing that people can value unfamiliar goods altruistically (e.g. ensuring that fish have good living conditions) and can simply "derive welfare from knowing that CWC exists".

Language and Familiarity

It has been known for many years that a lack of understanding, about potentially unfamiliar goods like biodiversity, can create obstacles when trying to ensure that people participate effectively in valuation exercises (Spash and Hanley, 1995; Hunter and Brehm, 2003). There is therefore a risk that,

> "*WTP for species that are unfamiliar or undesired by the general public could yield extremely low values despite the fact that these species could be performing indispensable ecological services*," (Daniels et al., 2017).

One of these obstacles relates to understanding the effects of the terminology used in SP surveys, which is important in determining how developing concepts of cultural and social values relate to our economic perspective on ecosystem worth (Chan et al., 2016; Kenter, 2016). For example, it has been proposed that whilst lay people may lack the ability to accurately define the term biodiversity, they nonetheless possess an intuitive awareness and understanding of the word (Buijs et al., 2008), regardless of accuracy. That understanding would likely feed into their preferences over it, however that may not be the type of value that a researcher seeks, and is typically not the one reported from SP research.

Perceptions of Meaning

Research in social sciences has addressed the matter of how lay people perceive and evaluate issues related to biodiversity (Kaczensky et al., 2004; Christie et al., 2006). Mace et al. (2012) distinguished three distinct categories of biodiversity: as a good in itself; as a regulator of ecosystems; and as a final ecosystem service. However the authors fail to provide adequate depictions of these categories for lay people and so it can't be known whether such categories are properly embedded in people's mental constructs about biodiversity concepts in their study.

Relatively little is understood about how public views are formed for potentially unfamiliar goods like biodiversity. It has been argued by ecological scientists that an absence of comprehension regarding biodiversity issues poses a considerable barrier to any such respondent effectively participating in a decision-making processes such as an SP survey (see Fischer and Young, 2007). Building on prospect theory, research on risk perceptions has found that when assessing options with particular risks attached to them people are still influenced by their own perceptions of that risk (Jakus and Shaw, 2003), and this has been explored in valuation studies (Sugden, 2009; Hasund et al., 2011; Lundhede et al., 2013). These papers have found that people have internal reference points for goods and their levels, which come from

their experience with the good (if applicable), the current situation and beliefs about what they consider to be the ideal state of the good. This literature provides some context for the topic of outcome uncertainty and how it affects decisions. This thesis then builds upon this by exploring decision formation not only when the outcomes are uncertain, but also when the policy context itself is depicted by uncertainty over the good in question. So not only is there implicit uncertainty associated with the likelihood that a given policy choice has the expected outcome, but the extent to which the issue in question (chemical water pollution) poses a risk is also brought into focus and explicitly illustrated in valuation choice sets. In doing so, it enables the value of certainty over chemical safety to be measured empirically. In turn (and as will be explored further in the first paper in this thesis) this novel approach allows for modelled uncertainty to assist in implementing precaution through a CBA approach, even where the certainty of impacts can vary.

Glenn et al. (2010) was correct in asserting that "attributes and their levels need to… …be meaningful to the individuals targeted in the survey." Taking this all into account, it is evidently important to characterise lay people's mental constructs of terms like biodiversity if such terminology is to be used in the valuation of associated goods. Particularly where people's knowledge of, and familiarity with, such scientific terms may be heterogeneous or misapplied to the specific good in question and its true faculties.

Bakhtiari et al. (2014) did this and then applied the information to help shape and define the attributes, which is to the best of the author's knowledge the first and only time that such a bottom-up approach has been used to inform survey scenario and attribute design. In doing so they also provide a useful conceptualisation of how lay people relate to unfamiliar goods, focusing largely on the types of terminology used and people's understanding of those terms per se. To illustrate, around two thirds of the sample could give some definition to the term biodiversity, even if some of these were not strictly correct. In addition to the factors normally assumed to be captured under the term, other aspects evidently also formed part of people's personal understanding of the word, such as "the aesthetic value of forest biodiversity". People were also found to include an appreciation of landscapes and wildlife (as well as recreational and educational values) in their individual concepts of biodiversity.

Another dominating characteristic was "peace and quietness" which was particularly emphasised by people who lived in close proximity to forests and is therefore a characteristic that could reasonably be used in future DCE studies as an attribute. Overall, around 96% of the participants were found to include factors beyond purely just the number of species in a given ecosystem as part of their value for biodiversity. The authors stress that in order to improve the

consistency of SP surveys, researchers need to properly understand people's mental constructs about terms like biodiversity and ensure that this knowledge is taken into account when combining terminology with described ecological indicators. They found that whether or not people were familiar with the various ecologic and scientific terms used, they nonetheless had an instinctive comprehension of ecological constructs such as biodiversity (even if they are not rooted in fact). The authors posit that people's attitudes regarding environmental goods (such as forest ecosystems) may therefore stem from their individual mental constructs.

Defining Attributes

Where valuation surveys use strict definitions like *species number* to describe unfamiliar terms like biodiversity, then the methods may not be geared to appropriately reflect the true value of the non-market good and may ignore functionality values. Additionally, researchers should be aware of respondents' perceptions of the 'ideal state of the good' in order to better interpret their expressed preferences. Bakhtiari et al. (2014) found that people's ideals (as a point of departure) do not necessarily match that of a stated scenario, leading people to potentially use incorrect (and heterogeneous) benchmarks to express their willingness to make trade-offs.

Boyd et al. (2015) explore this issue of how environmental indicators that are most useful to the public do not necessarily align with classifications used by scientists or economists. Other authors have attempted to incorporate this understanding in the overt descriptions of attributes, for example Christie et al. (2006) explicitly distinguished between "familiar" and "unfamiliar" wildlife. More recent work by Weber and Ringold (2015) used focus group and interview data to distinguish features of rivers and waterways that were considered important to lay people in an urban area of Arizona in the US. They found that whilst people tended not to possess an attachment to specific species of flora or fauna, they were interested in (and therefore placed value on) categories of environmental goods such as "tall trees", rather than any particular species.

In the context of the National Park Hoge Kempen in Belgium, Jeanloz et al. (2016) offer a structured process for selecting attributes and deciding on associated levels in DCEs which consists of five stages: (1) identify stakeholder study area characteristics; (2) establish the discussion protocol; (3) focus groups and semi-structured (personal) interviews; (4) analyse the semi-qualitative data; and (5) select final attributes and levels. In doing so, they identified and selected the following four attributes (in addition to an entrance fee cost) for their DCE: biodiversity; probability of seeing red deer; environmental education; and air purification. Such approaches will require some fine tuning, but do offer the beginnings of a standardised

approach to attribute selection processes, whilst allowing for the incorporation of understandings regarding people's perceptions of potentially unfamiliar environmental attributes and the terms used to describe them.

Conversance and Respondent Performance

A recent paper by Sandorf et al. (2017) further developed the findings of LaRiviere et al. (2014) regarding the impact of knowledge on WTP for unfamiliar goods (again, on CWCs). More specifically, Sandorf et al. aimed to determine how CWC familiarity affected people's propensity to disregard choice card attributes (in a DCE). This is certainly a worthy endeavour, given that DCEs will likely continue to be used as a primary method of valuing unfamiliar goods and that we already know that knowledge plays an important role in preference discovery or formation. The authors used an ex-ante measure of respondent knowledge by quizzing them on the topic of CWC before the valuation task. They found that those with higher prior knowledge of the good (i.e. those who were more familiar with it) were associated with higher predicted probabilities of attendance.

Attribute Non-Attendance

Attribute non-attendance, in the DCE literature, describes a phenomenon whereby respondents only focus on a subset of attributes when determining their choices. This obviously violates the assumption of fully compensatory preferences when modelling SP data of this kind. Behaviour that is fully compensatory means that respondents make trade-offs between all available attributes in a DCE and have complete knowledge of all the information presented in the choice tasks. The issue is that there are numerous papers showing that it is not uncommon for respondents to disregard one (or more) attributes when making their preferences (Scarpa et al., 2009; Campbell et al., 2011; Hensher et al., 2012b).

Alemu et al. (2013) make clear that attribute non-attendance can arise because of the perceived irrelevance of attributes, or due to coping strategies instinctively aimed at reducing task complexities (and the associated cognitive burden), both of which are feasible phenomena when addressing unfamiliar goods. By empirically demonstrating that familiarity reduces non-cost attribute non-attendance (though the effect is significant for just one of them), Sandorf et al. (2017) shed light on one of the key mechanisms associated with preference elicitation in DCEs that focus on typically unfamiliar goods. Interestingly, their results show that providing respondents with exogenous signals about their knowledge level did not affect attribute non-attendance (though it did increase the probability of cost attribute non-attendance), even though this has been shown to significantly increase WTP per se (LaRiviere et al., 2014). That said, lower WTP estimates were obtained when attribute non-attendance was properly accounted for.

There a numerous reasons why someone might not attend to an attribute (or exhibit non-compensatory preferences). As mentioned above, simplification strategies (to cope with cognitive burdens in complex choice situations) and the perceived unimportance of attributes may lead to attribute non-attendance (Sandorf et al., 2017), and there are other potential reasons too. Some relate to information presentation, for example Hoehn et al. (2010) showed that tabular (rather than text-based) information can reduce attribute non-attendance. Others could be associated with ethical reasoning, where a respondent refuses to make trade-offs between an environmental attribute and money (Hess et al., 2010). Notably, Colombo et al. (2013) found that allowing respondents to state that they 'sometimes considered' an attribute (rather than 'always' or 'never' considering it) meant they could highlight respondents who "ignore an attribute in some of their choices but consider them in others." More widely (beyond money attributes), Hess et al. (2010) offer three alternative explanations for why such non-trading exists. First, that it can be caused by extreme preferences, so whilst a respondent may be acting in a utility maximising fashion, their preferences are so strong that the attractiveness of alternative options is insufficient and therefore overshadowed. Second (relating to the point above about cognitive burden), non-trading may be caused by non-utility maximising heuristics arising from complexity, misunderstanding, boredom or fatigue. For example, decision rules can allow for reduced cognitive effort, meaning respondents may repeatedly choose the most environmentally friendly or cheapest alternative, irrespective of the other attributes (Lusk and Schroeder, 2004). Third, strategic behaviour (or policy response bias) – especially if a respondent believes that their preferences may influence policy outcomes – may result in non-trading. In addition, the stated preference literature also covers the implications of lexicographic preferences, where respondents refuse to accept decreases in a desirable attribute to compensate for increases in another attribute (Rekola, 2003).

Respondent Performance

Research on this topic is rare and certainly more is needed if we are to understand more about how unfamiliarity with goods (and explicit awareness of that) influences the extent to which respondents ignore key components in SP surveys. Taking a wider view, there are additional issues in terms of attribute choice for unfamiliar goods, as it is stated by McFadden and Train (2017) that even mentioning an attribute can give undue prominence to it in a subject's mind than would otherwise occur. As such, researchers should be mindful that informing the respondent about a good whilst avoiding influencing their relative values of attributes is a conflicted practice.

As Schaich et al. (2010) make clear, researchers are faced with many "difficulties in capturing the intangible, cultural benefits of ecosystems." When attempting to do this through SP surveys, it is important to find indicators – or end-points – that sufficiently reflect landscape changes and the meaning that they have to respondents (Barkmann et al., 2008). Similar approaches have been made recently by Boyd et al. (2015), with a focus on "linkage indicators". A recent paper by Rewitzer et al. (2017) applied an explicit ecosystem services approach (as proposed by Barkmann et al., 2008) and found this to "not only reduce unfamiliarity issues in ecological attributes but also helps to communicate [cultural ecosystem service-related] environmental values".

A well-researched area of respondent performance and choice formation is that of the inconsistency between people's expressed WTP and WTA for a given good. For a long time it has been known that, despite theoretical expectations, a significant WTP-WTA disparity can be observed in experimental tests (Coursey et al., 1987; Horowitz and McConnell, 2002). To explore the role that familiarity plays in this phenomena, Kingsley and Brown (2013) used an experimental design (mimicking those covered in Brown and Peterson, 2009) to vary respondents' opportunities for learning, when faced with the task of either paying (or accepting compensation) for a range of goods. They found that without additional learning, respondents displayed a significant value disparity. However, subjects in the learning treatment (consisting of a simple paired comparison exercise) displayed no significant disparity, resulting in preferences more consistently aligned to standard economic theory.

This suggests that valuation survey responses where familiarity is improved – in the strict context of the awareness of their valuations (rather than a respondent's familiarity with the specific good itself) – are less likely to exhibit WTP-WTA disparities. The authors are correct in noting that such experimental designs may be less appropriate for truly unfamiliar goods, such as CWCs or the health effects of polluted air, and that further research would be needed to test the effect of value learning treatments on these public goods.

Conclusion

This literature review has addressed a range of recent findings relating to how unfamiliarity with non-market goods (or terminology used for it) affects how people behave in surveys and how they express preferences. Whilst some headway has been made in determining the effects of unfamiliarity, still much more is needed before these less tangible goods can be properly valued, something that will require deep consideration of *how* people perceive unfamiliar goods, on their terms.

The findings in this review show, amongst other things, that even the very basic issue of whether preferences are formed or unearthed in SP surveys remains unclear. In all likelihood, the mode of preference selection probably varies depending on the situation, stimuluses used by the practitioner and the respondent's familiarity with the topic. Whilst they are far from acting as a panacea for unfamiliarity in SP research, the recent rise of deliberative approaches offers some worthy routes forward if we are to better simulate human learning and enquiry in the lead-up to a valuation task.

The findings from this review also highlight the crucial role of language in expressions of preferences for, and descriptions of, unfamiliar goods. Future researchers are encouraged to both better understand the role of language choice in valuation surveys, but also be open to early feedback from respondents as a means of curating better worded prompts and descriptions. We know that people can ignore information in surveys when the good is unfamiliar, sometimes increasing attribute non-attendance or augmenting WTP-WTA disparities for such goods.

Finally, the evidence makes clear that the selection process for DCE attributes (and levels) can sometimes inhibit the applicability of findings from a study, and that much greater care should be taken (than is typical) to ensure that these attributes are comprehendible to the public. The broad aim of practitioners of SP methods should be towards understanding better how people's prior concepts feed into their assessment of unfamiliar concepts or terminology, which is something that would benefit from a standardised approach. Then we will be better placed to comprehend how people's personal understanding of potentially unfamiliar concepts, like biodiversity, should feed into attribute selection and descriptions that are typically assumed to be limited by their definitions.

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3 - Paper One

Valuing Policy Options for Persistent Aquatic Pollution

Contents **Page**

Introduction

Over the past decades, the flame-retardant properties of halogenated persistents such as polybrominated diphenyl ethers (PBDEs) have resulted in their extensive use in consumer products, from building materials and furniture to electronics and textiles (Shaw et al., 2010; Stubbings and Harrad, 2014). Environmental pollution caused by synthetic, bioaccumulating and persistent organic chemicals (termed *persistents* in this paper), including PBDEs, has become a serious global issue over the last half century. Exposure to such persistents has been associated with endocrine disruption in human bodies, which can lead to a range of human health impacts including birth defects, immunotoxicity, cognitive impairment, reduced testosterone, childhood obesity, reproductive weakening, autism and attention deficit disorders (Martin et al., 2007; Alonso et al., 2010; Bellés et al. 2010; Reverte et al., 2014; Khim et al., 2016). Their widespread use has resulted in ubiquitous human exposure (CDC, 2009; Mitro et al., 2015).

PBDEs (termed *flame retardants* in this paper) are a type of persistent chemical and can form a large proportion of consumer products by weight. The WHO (1994) estimated that plastics can integrate as much as 15% flame retardants by weight, and polyurethane foams even more. Crucially, flame retardants (and many persistents) are not chemically bound to the polymers and other materials where they are applied. Subsequently, varying proportions of these chemicals are emitted to the environment during production, use, disposal, and recycling processes (Domingo, 2012), where they can find their way into surface waters such as lakes and rivers. Their persistent qualities render these substances highly resistant to degradation and therefore they can be transported globally, having been detected in both Arctic polar bears and Antarctic lichens (Muir et al., 2006; Yogui and Sericano, 2008).

Flame retardants and persistents can enter animal and human bodies through water, food and air pathways (Harrad et al., 2006; Frederiksen et al., 2009). In recent years, biomonitoring data indicates that concentrations of flame retardants in animal and human bodies have increased rapidly, with the highest concentrations in North America, Europe and Asia. Flame retardants bioaccumulate in human and animal body tissue (Harrad et al., 2010; Law, 2010; Law et al. 2014), primarily because of their lipophilic characteristics. Whilst international agreements such as The Stockholm Convention have introduced controls on some flame retardants and persistents, they are still routinely observed in pregnant women and their breast-milk (Woodruff et al., 2011; Morello-Frosch et al., 2016). Furthermore, the body burden of flame retardants in infants can be between three and nine times that of adults, due in part to exposure via maternal milk (Linares et al., 2015).

Given water (and consequently food) is a significant exposure pathway for flame retardants and persistents, it provides a suitable means by which to frame this pollution policy problem. Water is vital for ecosystem and human life and ensuring high quality water through chemical decontamination is a major goal of the EU's WFD. Under the WFD, member states must produce RBMPs covering all waterbodies. The planning process around this should also include an economic analysis of all water uses, as well as establishing pressures and impacts on the water environment (Morris, 2007, pp191-205). The WFD has recently listed some flame retardants and persistents as priority substances for control (Vorkamp et al., 2014; EA, 2016), however the practical implementation of the Directive faces a challenge. Much of the WFD's implementation rests upon CBAs in order to determine the advantages (or otherwise) of implementing specific pollution remediation policy options. To do that, not only do the costs associated with chemical removal have to estimated (primarily through water industry knowledge), but so do the economic benefits of chemical removal have to be valued.

One of the central difficulties associated with policy options for persistents is that often their health impacts (on humans and animals) are not known with complete certainty (see Fuhrman et al., 2015). In fact, environmental policy options more generally typically offer uncertain outcomes (Glenk and Colombo, 2011). To address this underlying issue and investigate how SP research can assist with policy problems in a context of uncertainty, this study explicitly incorporated scientific certainty (over the safety of new flame retardants and persistents) into its design. In applying this original approach, it is shown that such certainty has an important impact on the preferences for delivering reductions in persistent pollution. This new method advances the literature, by providing new knowledge relating to people's preferences for uncertain outcomes. However, more importantly, it offers a novel means of incorporating specific monetary estimates for chemical impacts into CBAs whereby the uncertainty over those impacts is explicitly assimilated. As such, it moves beyond simply invoking the precautionary approach for temporary management of possible risks. Further, this research provides the first economic value estimates of their kind for persistent chemical management, a research gap identified by Sørensen et al. (2016).

Although sometimes considered rivals, and indeed there are tensions, the CBA approach and the precautionary principle can work in tandem. Getzner (2008) discusses the CBA approach in the context of European chemicals regulation, emphasizing the issue of fundamental uncertainties and how these can be navigated in actual policymaking contexts. This paper introduces the idea that the CBA can fit into a paradigm of 'post-normal science' (Funtowicz & Ravetz, 1994). In this approach, CBA results can be viewed as a measure of "economic

efficiency", to be used *alongside* other decision tools such as the precautionary approach, stakeholder involvement and public discourse. In fact, the European Commission's own Guidelines (for the Performance of Impact Assessments) contribute little clarification on performing CBAs regarding precautionary measures and in practice the judiciary grants an amount of discretion in such complex situations involving chemicals regulation (EC, 2011). In discussing the EU's REACH[2] regulation, Getzner (2008) illustrates how the regulation's fundamentally precautionary approach also involves economic analyses of net costs and benefits, resulting in a system that "may discover dangerous toxic chemicals earlier than another system would". Similarly, prior to the establishment of REACH, there was a view held by some experts that "existing environmental regulations and other decisions, particularly those based on risk assessment, have failed to adequately protect human health and the environment," (Ashford et al., 1998). In an OECD paper on CBA and the environment, Atkinson and Mourato (2015) discuss how – in the context of risk and uncertainty – a major challenge for CBA is on how to incorporate option values. These are not dissimilar from the certainty values explored in this paper and entail temporal issues that might arise through postponing policy action. Their paper mentions the use of 'probabilistic decision trees' as a potential means of integrating (quasi-) option values in official appraisals.

Environmental regulatory decisions are often based on incomplete information, in part because complete proof of safety or risk can rarely be met. The CBA methodology allows for the incorporation of varying levels of risk aversion built on perceived circumstances and preferences. For example, in a paper of the Stern Review, Weitzman (2007) discusses how the Ramsey equation[3] can include a measure of relative risk aversion, to combine outcome uncertainty with a CBA to implement the precautionary principle. This results in a recommendation (similar to the Stern review) of "insurance", that society should make greater investments today to reduce the possibility of catastrophic climate change, which is a distinctly precautionary concept. Similarly, the quantified outputs from this thesis (associated with modelled risk aversion and outcome uncertainty) can assist in applying the precautionary principle through a CBA, in so far as formally recognising such risk aversion in a CBA implements the principle.

The broader purpose of this study was to estimate the monetary value of benefits expected by the public due to specific reductions in chemical water pollution in England and Wales caused

[2] REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) is a 2006 EU regulation addressing the production and use of chemical substances, as well as their potential impacts on human health and the environment.

[3] The Ramsey equation calculates the social discount rate by incorporating the rate of growth of consumption, the marginal utility of consumption and time preference.

by flame retardants and persistents, using SP methods. In addition to the central issue of scientific uncertainty, this study also addressed people's sensitivity to variations in the magnitude of the environmental changes that they valued, measured by varying the scope of the options across geographical area and time. It is important to consider sensitivities of this kind, as failing to do so can reduce the reliability and applicability of results from studies that are exposed to such underlying realities (Hammitt and Graham, 1999). The effects of scope can be varied, some studies show significant sensitivity to scope (Smith and Osborne, 1996), others a lack of (Svedsäter, 2000) and some with potentially both scope sensitivity and insensitivity (Heberlein et al., 2005). SP methods, such as the WTP approach, are not without their imperfections. However, they do offer policymakers helpful quantified information regarding the benefits of improving environmental conditions. These figures are required in the CBA method, on which the WFD's approach to persistent chemicals such as flame retardant relies.

This paper contributes to the aquatic chemical valuation literature by applying CE and LCA valuation methods to a case study in England and Wales. The applied purpose of this study was to provide policymakers with much needed information on the economic value of the benefits generated by reducing chemical water pollution (caused by flame retardants and persistents) in this region. To the best of the author's knowledge, this is the first SP study to specifically investigate EU chemical water pollution from flame retardants and persistents. The economic value of flame retardant and persistent pollution reduction was estimated using data from 1,143 households in England and Wales – the extend of the Environment Agency's (EA) remit – using internet-based SP CE surveys. In doing so, several areas in the supporting literature are expanded on, particularly preference formation under scientific uncertainty.

The results reveal that overall the public in England and Wales obtain positive and significant benefits from aquatic chemical remediation policy options. However, beyond simply understanding such relationships for the average person, it is often helpful to explore how different types of people respond to SP surveys, particularly if reliant policies seek to accommodate variations in people's preferences. The LCA approach is well suited to classifying respondents into groups, based on the patterns of individual choices in SP surveys. The good in question, chemical pollution remediation, contains a lot of unknowns – a problem that is compounded by it being unfamiliar and complex to people. Consequently, it is important to tease out how different types of people respond to this relatively complicated policy issue, and the LCA applied shows a considerable level of heterogeneity in the public's preferences for these chemical remediation benefits, as well as what drives those preferences.

There are alternative ways of incorporating preference heterogeneity in stated choice models, beyond the LCA approach. For example, the Random Parameters Logit (RPL) (or mixed logit) model has been used in discrete choice modelling (McFadden and Train, 2000), as well as the Covariance Heterogeneity (CH) model. Whilst the latter offers some advantages, for example when seeking to investigate issues of scale factors, this was not the purpose of this paper and therefore an LCA approach was chosen. The LCA performs well in terms of welfare estimation (a key intended output from this paper) and (along with the RPL method) focuses on the deterministic component of utility. This approach assumes constant error variances, in line with many published articles (see Colombo et al., 2009), and assumes that heterogeneity is best captured through the systematic (rather than random) utility component. Colombo et al. (2009) also note that whilst LCA models can be less flexible than the RPL in structure (due to fixed attribute and covariate parameters in each class), they allow "clearer" narratives around segment heterogeneity in the data (another key intended output from this paper).

An associated issue is scale heterogeneity, which relates to differences in choice behaviour randomness. Although not a focus of this paper, it can be important when addressing differences in subgroup preferences (from a wider sample) which can be caused by choice consistency (Vass et al., 2018). In a paper comparing LCA models with more traditional multinomial logistic (MNL) regression models, Flynn et al. (2010) note the unpopularity of logit models in modelling scale heterogeneity, and state that whilst the LCA approach avoids needing to parameterise heterogeneity, it still models it in terms of means (not variances). Davis et al. (2016) explore more developed models that can account for heterogeneity in error variance, such as 'scale extended' or 'scale adjusted' LCAs. However, Greene and Hensher (2010) provide some evidence to suggest that ignoring (or failing to account for) scale heterogeneity may not be of great importance (compared with preference heterogeneity) when measuring WTP. However, this will arguably have some impact on the clearness of the narratives around segment heterogeneity covered in this paper. Further definitions on scale assumptions are given later in the Econometric Models section of this paper.

The key research contributions relate to the value placed on scientific certainty over chemical impacts, providing an original approach to incorporating such (un)certainty in CBAs. Additionally, the study provides novel remediation scale figures that are applicable at the national level, as well as insights regarding people's time preferences regarding persistent chemical removal from surface waters.

The rest of the paper is organised as follows. The next section describes the relevant supporting literature. The CE design and administration methods are then described. The results of the

econometric analyses are reported in the next section, followed by a discussion of the findings and their implications. The final section concludes the paper.

Literature Review

In setting the background for this paper, this literature review draws upon evidence from a range of topics. First, the concept of SPs will be presented, followed by some examples of where such methods have been used in the context of valuing benefits associated with water management options. After these underpinning sections, this review then examines – in turn – the relevant literature associated with the three non-cost attributes used in the CE.

Stated Preferences

When evaluating the merits of different water policy options, it can be helpful to quantify the estimated public benefits associated with those different choices. Those can provide useful estimates in CBAs or be used to develop focused legislative proposals (Thaler et al., 2014). SP and RP methods are commonly used to estimate such policy option values. RP techniques rely on the assertion that a person exhibits behaviours that reflect their objective of maximising their own utility, or quality of life. The cost that that individual knowingly suffers, in the pursuit of utility maximisation, reflects the minimum value that they place on the good or service that they expect in return. The applicability of the RP method is constrained to cases where people make direct use of a good and are aware of it, the UK Treasury's Green Book states that such methods "cannot estimate the value placed on an asset by people who make no direct use of it. In these circumstances, stated preference methods may be useful," (HM Treasury, 2014, p58).

One type of SP method is the CE, and it can be used to measure respondent interest in different hypothetical policy option scenarios, which can include non-use values. The trade-offs that respondents make between the different attributes and non-use values that describe those scenarios (and their varying levels) can be analysed to estimate the relative and quantified values that people place on them (Tonsor et al., 2009). Consequently, the CE method is also well-suited to valuing environmental issues (such as policy options) that are multi-dimensional in nature whilst enabling trade-offs to be made between attributes (Atkinson et al., 2018). However, it can impose a higher cognitive burden on respondents compared with other SP methods, requiring them to make multiple choices for sometimes complex and unfamiliar non-market goods. This can encourage satisficing behaviour to overshadow utility maximising conduct, potentially introducing more errors and biases (Hanley et al., 2001). SP valuation, as a field of study, never will be that of a perfect science, however it remains a widely applied means of estimating economic values for policy decisions. This justifies the improved understanding and refinement of SP methods, which is what this paper seeks to do.

Finally, unlike standard MNL models that are used to assess CEs, LCAs can detect respondent heterogeneity by identifying multiple (latent) preference classes, or groups (Boxall and Adamowicz, 2002; Greene and Hensher, 2003). It is difficult to observe respondent heterogeneity in an MNL model (Louviere et al., 2000), because it would require *a priori* respondent characteristic interaction terms. CEs use empirical observations to identify respondent heterogeneity and can estimate individual choice probabilities for each class. Consequently, it is applicable in welfare analyses by enabling aggregate welfare benefits by individuals of specific classes to be estimated (Shen and Saijo, 2009).

Valuing Changes in Water

The EU adopted the WFD in 2000, with an original intention of restoring all EU waterbodies to GES by 2015. The definition of GES is multifaceted, simultaneously addressing biological factors (e.g. aquatic species abundance) and chemical elements (e.g. nutrient status and the concentration of specific pollutants including priority substances such as persistents), amongst others. If successfully implemented, the WFD should generate considerable non-market benefits (Bateman et al., 2006; Brouwer, 2008). The ecological status of waterbodies is categorised into five ordinal classes: High (class I), Good (class II), Moderate (class III), Poor (class IV) and Bad (class V).

To date, many SP studies[4] addressing the non-market benefits of meeting WFD targets have used broad classes such as these to signify the overall non-market benefits to be valued by respondents in the associated surveys. For example, Metcalfe et al. (2012) used three levels of ecological status (low, medium and high quality). Their study employed a large-scale SP survey to value the benefits of WFD implementation for waterbodies in England and Wales. Hanley et al. (2006) addressed the practicalities of using valuation techniques for environmental management. Their study used three attributes to represent the concept of GES under the WFD: river ecology (including fish, plants and invertebrates); aesthetics (e.g. the amount of litter in the river); and bankside quality (in terms of vegetation and erosion). A study by Glenk et al. (2011) investigated the impact of the WFD in Scotland and differentiated between varying waterbody types (descriptions of the impacts on rivers and lochs were distinct). As with the two previous studies, this paper also used an ecological status level approach to value water quality change.

[4] See Birol et al. (2006) for a discussion on the application of economic valuation techniques in the context of the WFD.

Thaler et al. (2014) suggest that, where possible, all benefits of environmental policies should be more thoroughly investigated than normal practice. They suggest that some specific environmental factors could be better characterised by focusing less on the systems level. This paper seeks to focus the economic valuation on the level of specific chemical policy impacts. It is the first time that economic values for removing persistent chemicals, in the context of improved surface water quality under the WFD, have been estimated in the UK. With a 2012 European Commission survey finding that "EU citizens… …cite chemical pollution as the biggest threat to water resources," the issue is worthy of such closer study. In the UK specifically, 81% of survey respondents cited chemical pollution as the main threat to the water environment (EC, 2012).

Certainty and Safety

A meta-analysis of 45 chemical valuation studies by Sørensen et al. (2016) provides one of the key motivations for this paper. This analysis, prepared for a range of Nordic governmental chemicals agencies, showed that for most specific chemicals or substance-groups, studies which produce monetary valuations are rare. Those that focus on flame retardants were specifically identified as a gap in the existing research. A fundamental problem with valuing policy options associated with such emerging and persistent substances is that the scientific evidence regarding their impacts on human health is typically uncertain (Martin and Voulvoulis, 2009).

Environmental economics is a discipline well suited to investigating the framing of decision-making for uncertain environmentally-associated scenarios (for recent examples see: González-Cabán et al., 2017; Bujosa et al., 2018). For decades now, SP methods have been used to value uncertain environmental improvements (Johansson, 1989; Macmillan et al., 1996). Past SP research has demonstrated outcome uncertainty in various ways, and its inclusion in respondent choice options offers the potential to improve the approximation of choice behaviour in non-hypothetical situations (Roberts et al., 2008).

In recent years, SP techniques have been used to measure the value of improved chemical safety in goods. Many studies have focused on the quality and safety of food where large WTP premiums are indicated for food safety, risk perceptions and reduced chemical use in production (Mørkbak et al., 2011; Probst et al., 2012; Bai et al., 2013; Owusu and Anifori, 2013; Wu et al., 2015; Lai et al., 2018). A common theme in these studies, discussed by Pouratashi (2012) in a meta-analysis of consumers' WTP for chemical-free food production, is that whilst people are often willing to pay a premium for product safety, their knowledge and awareness of the products' chemicals varies remarkably.

There are less chemical-safety WTP studies focused on non-food products (such as electronics and clothes), though results similarly show that people are generally willing to pay a premium for improved chemical safety or management (Afroz et al., 2013; Tian et al., 2016; Holmquist et al., 2018). However, these chemical safety WTP outputs are, as with the food-focused studies, customarily associated with certificate issuers and labelling attributes. Whilst this approach is helpful in specific case study applications, it does not provide value estimates that can be more widely utilised. This study is the first to estimate changes in a chemical safety attribute that can be expressed as a quantified percentage change in safety.

Few environmental impact probabilities are known with absolute certainty, and this is commonly caused by scientific uncertainty over those impacts (Langsdale, 2008). Much previous research on this topic has focused on the issue of climate change (Viscusi and Zeckhauser, 2006; Akter and Bennett, 2012). Some papers have investigated how subjective perceptions about policy uncertainty affect SPs (Cerroni et al., 2013; Lundhede et al., 2015) whilst others have focused on addressing the impact of alternative ways to measure choice behaviours (Glenk and Colombo, 2013; Rolfe and Windle, 2015). Other SP studies have focused on what Torres et al. (2017) term *inherent uncertainty*, the element of uncertainty stemming from the stochastic characteristics of ecosystems – as opposed to that of scientific uncertainty per se. Overall, predicting environmental changes is difficult (Berkes, 2007), and most of these previous studies show that people are risk-averse, which is consistent with economic theory. This paper does not attempt to address the issue of preference uncertainty, which is typically identified by assessing how confident individuals are when stating their preferences (Martínez and Lyssenko, 2012).

As mentioned above, one of the key difficulties associated with implementing the kind of studies identified as lacking by Sørensen et al. (2016) is the unknown certainty around the impacts of emerging persistent chemicals like flame retardants – rendering end-point impact scenarios difficult to construct. To address this problem, this study explicitly incorporated a varying attribute on scientific certainty over the safety of the chemicals in question (termed *Chemical Safety*), which also enabled people's preferences regarding these varying levels of safety to be measured. Estimating people's preferences for aquatic chemical pollution remediation in the context of uncertainty could provide interesting results, as well as policy implications, where scientific certainty is typically viewed as a prerequisite for environmental policy decisions (Sethi et al., 2005; Torres et al., 2017). This study intends to contribute to the SP literature by examining the effects of scientific uncertainty around persistent chemical safety for surface waters in England and Wales.

This approach to the issue of scientific uncertainty for persistent chemical effects offers a means of furthering the standard precautionary principle, which is typically simply invoked for the interim supervision of potential risks (Martin and Voulvoulis, 2009). Whilst the outputs from this study can be used in that respect, the original contribution of this paper enables the extent of existing caution (i.e. the degree of scientific certainty over chemical impacts) to be explicitly reflected in the estimated economic value that people place on water management options. To date, there exists no widely accepted risk assessment paradigm for endocrine disrupting chemicals like flame retardants and other persistent chemicals, primarily due to the scientific impact ambiguities (Rhomberg, 1997; EFSASC, 2013; Honkela et al., 2014; Fuhrman et al., 2015). The findings from this paper provide a new means of valuing the impact of such chemicals, ahead of their health impacts being fully understood.

Because the attributes in this study provide some variation in scale, any insensitivity to scope can be assessed. The latter issue has been linked with SP studies and debated for over 30 years (Kahneman, 1986; Carson, 1997). Further, a substantial volume of psychological research suggests that people depict weak considerations of probability scale differences (Kahneman and Tversky, 1973; Baron, 1997) and respondents can commonly be observed to value variations in probability in a way that is inconsistent with expected utility theory (Anand, 1995). For example, in a meta-analysis of 25 studies on WTP for health risk reductions, Hammitt and Graham (1999) found that mean WTP estimates for health changes are often much less than proportional to the underlying probabilities.

Whilst sensitivity and insensitivity to scope have both been found to occur in SP research (Smith and Osborne, 1996; Svedsäter, 2000; Heberlein et al., 2005), Brouwer (2009) suggests that insensitivity to scope can occur when respondents are led to constructed preferences due to a lack of familiarity in hypothetical markets. Further, it is worth distinguishing between *weak* and *strong* sensitivity to scope. Taking forward the ideas of Hammitt (2000), and for the purpose of this paper, weak sensitivity to scope means WTP increases as the size of the good increases, whilst strong sensitivity to scope denotes situations whereby WTP increases almost completely proportionally to the change in magnitude of the good. The latter situation's sensitivity of WTP to scope suggests that in such cases, expected utility theory would represent a suitable model for valuation, as mentioned by Leiter & Pruckner (2009). However, such proportionality need not hold for theories of decision making like prospect theory (Kahneman and Tversky, 1973), which allow for thresholds in how people evaluate probabilities. Further to this, the WTP literature typically finds that where sensitivity to scope does occur, it is weak and not in line with what strict theory predicts (Lindhjelm et al., 2011; Desvousges et al., 2012; Andersson et al.,

2016), suggesting that nonstandard models could be appropriate. Where non-proportionality does occur, this could be due to a failure in the survey instrument, however this would imply that a 'correct' instrument does exist which would eliminate non-proportionality, which may – in practice – be difficult to demonstrate. Although it depends on the context in question, the chosen model is often a likely candidate for inhibiting a 'correct' interpretation of results. Certainly, more research is needed in order to better understand the role of model choice (and flexibility) in how we interpret apparently non-proportional responses.

Temporal Benefits

The context of persistent chemicals is partly formed by their continual impacts across temporal variations. Outside of the health literature, many time-associated WTP studies have focused on the benefits of reducing travel time (Amador et al., 2005; Tsamboulas and Nikoleris, 2008; Small, 2012). To the best of the author's knowledge, no SP studies have been conducted specifically on the value of reducing the potential exposure time to chemicals. It is important to assess persistent chemicals in this context as their concentrations in the environment can increase over time. They therefore create inter-temporal pollution impacts, which demand specific attention. Further, CBAs applied to water resource management options may consider different implementation times into the future, which necessitates the valuation approach taken in this paper. The method applied in this paper is also in line with recommendations by Gabbert and Hilber (2016), that chemical impact valuations should adequately capture temporal aspects associated with pollution from persistent chemicals.

It has been long established that people commonly value costs and benefits in the future at a discounted rate to those that occur immediately (Olson and Bailey, 1981). Psychological research shows that people's intertemporal preferences can depend in a large part on the context in which they are studied (Zauberman and Urminsky, 2016), such as perceptions around the time horizon relevant to the choice itself. Discounting functions in environmental studies are mixed, some finding that hyperbolic or quasi-hyperbolic discounting occurs (Viscusi et al., 2008; Richards and Green, 2015), whilst others find that environmental valuation data can be better accommodated by an exponential specification (Meyer, 2013). The purpose of this study is not to determine a specific discounting function, but more straightforwardly to address whether people's behaviour is consistent with non-constant discount rates. In the health literature, Attema (2012) reviewed various theoretical and empirical developments for time preferences and warns that falsely assuming discounting across time can result in unintended policy prescriptions.

Scale of Remediation

Whilst there are various ways in which practitioners have included spatial characteristics as attributes in CE scenario designs (e.g. accessibility, surrounding land-use and distance to site), for this study the most relevant was the size of the treated area itself. This has a direct theoretical relationship with consequential pollution reduction, but it is of interest to water planners who have to make decisions around the extent to which new water treatment plants should be built around the country. CEs using the size of the area undergoing environmental change as an attribute were first applied in the 20th century (for an early wilderness area application see Adamowicz et al., 1994). More recently, preferences have been elicited for a wide range of environmental changes from freshwater nature reserves to coastal areas or urban locations, by varying the size of the area affected (Johnston et al., 2001; Mallawaarachchi et al., 2006; Bateman et al., 2011).

In one of the first relevant applications of incorporating spatial aspects of environmental change in the CE literature, Brouwer et al. (2010) assessed preference heterogeneity for the spatial distribution of water quality improvements under the WFD. Their study found that people attach higher values for improved water quality in their own local regions (providing it is for the highest level of improvement).

A limit to the application of most previous studies is their use of localised geographical sizes, rather than nationally applicable metrics. The latter offers a means of assessing macro-level policy implications, and such metrics have not before been studied in the literature covering economic valuations for the benefits of reducing persistent chemical water pollution. In doing so (although it is not a central aim), this paper will also investigate the marginal effects of magnitude changes, where typically the marginal utility is expected to decrease as levels of change increase (Arrow et al., 1993; Carson and Mitchell, 1993).

Methods

Survey Design

Discussions were held with subject specialists and economists from the EA and Defra[5] between January and March 2016, with the objective of identifying end-points and subsequent WTP measures that would be most appropriate for informing the next round of RBMPs under the WFD. The survey focused on pollutants (using both flame retardants and persistents as examples). Various focus groups were held throughout February, March and April, in order to test the survey and its content. Two of these consisted of eight people in each[6] who were professional survey takers and these focused heavily on the online survey material, its presentation format (including the CE design) and how the questions were phrased. These latter focus groups took place in London and consisted of equal female and male members[7] across ages 24-65.

An internet-based pilot survey (100 respondents) was completed in March 2016, the results of which were used to determine coefficient priors for the CE attributes (using Choice Metrics, 2012). Other feedback from the pilot was also used to improve and finalise the survey, which was administered online from April 2016.

Survey Structure

The final survey consisted of four sections and was designed to take no longer than 15 minutes to complete. The first section asked about respondents' attitudes, knowledge and behaviour regarding risk, societal issues, the environment and chemical water pollution. Posing questions of this type can enable respondents to think carefully about their expressed preferences as well as provide internal tests for response credibility where they predict respondent behaviour (Arrow et al., 1993; Wilcock et al., 2004). The primary purpose of the second section was to educate respondents on the subject matter, ensuring that they understood the drivers of persistent chemical water pollution and its potential effects. This section covered: the various sources of the type of chemical in question; characteristics of the chemical type; effects that the chemical type can have in the natural environment (covering specifics regarding animal, plant and human health); and the expected consequences of remediation policy options. Due to respondents' unfamiliarity with – and the complexity of – the subject matter, short tests were interspersed throughout this section of the survey, in order assess how well the respondents

[5] Department for Environment, Food & Rural Affairs.
[6] So 16 in total.
[7] Recruitment was organised by a professional recruitment firm, PureProfile.

understood the topics and the SP scenarios. The third section of the survey centred on the main CE and its contextual scenario. A series of typical follow-up questions was then used to gauge respondents' reasoning and confidence in their answers, as well as to highlight protest votes. The final section was mostly comprised of questions relating to respondents' socio-economic characteristics and personal habits.

Survey Scenario

The common scenario for the survey had a business-as-usual (or status quo) baseline in which flame retardants/persistent chemicals that are now banned or controlled would continue to exist in surface waters (e.g. rivers and lakes) for at least 50 years and uncontrolled (often more recent) flame retardants/persistents would continue to exist in the environment indefinitely. At this baseline, no surface waters would be treated, and respondents would not be required to pay anything extra on their monthly water bills. Furthermore, the scientific certainty regarding the impacts of more recent (and uncontrolled) flame retardants/persistents was marked as unknown.

In addition to the 'Take No Action' (status quo) scenario option, each choice task provided two additional scenario options, which varied from task to task in terms of the levels assigned to the attributes. Images and photographs were used throughout the survey to help depict the background learning and scenario. Manipulated photographs have been used in SP studies to depict actual landscape changes and reduce respondent judgement error (Bateman et al., 2009; van Zanten et al., 2016). However, it proved difficult to clearly reflect the varying attribute levels in this way, so for the CE scenarios simpler images were used instead (see Figure 1a) to ease the cognitive burden on respondents and facilitate their comprehension of the choice tasks (Hope, 2006; de Ayala et al., 2015). These were developed in part and tested during the focus groups. A practice round was also used to familiarise the respondents with the CE concept.

It was explained that to tackle the problem of flame retardant/persistent chemical pollution, the government is thinking about improving some waste water treatment systems to remove these chemicals from surface waters. This is all the information that was given to respondents regarding the consequentiality of their responses. As such, the approach assumes that respondents knew that the proposed government action *could* take place, but not that it *would*, and therefore responses were not necessarily expected to impact on policy outcomes. Respondents were informed that to help pay for the improvements and necessary upkeep of these waste water treatment systems, water bills for households and businesses would permanently increase. The majority of the respondents already had experience with this

payment vehicle, thus improving plausibility (Morrison et al., 2000). Several other payment vehicles were explored in the focus groups and water bills were chosen by those members as the most likely to produce meaningful and reliable responses.

Before describing the four attributes applied in the CE tasks, it is worth making clear that whilst the primary attribute of interest – *Chemical Safety* – incorporates an uncertainty element, the others are all assumed to be certain in themselves and their delivery uncertainty is assumed away by presenting these end-points with absolute clarity. In doing so, this research aims to assist the literature's understanding regarding the context of uncertainty for this type of policy problem. Whilst the above assumption of certainty over the surface cover and remediation time attributes is not entirely dependable, it was considered appropriate given the intention to not overcomplicate the choice tasks. Incorporating further information, such as a recognition that respondents should consider variances in the deliverability of remediation cover and time, would compound the variables in play and lead to either overly-complicated choice sets or the necessary removal of other attributes (thus limiting the insights from the study). In addition, in a follow up question[8], less than half of the respondents stated that they were unsure that the proposed policy options would have the results described. This is not an insignificant proportion, however the follow up question did not disaggregate this 'sureness' to the attribute level, so further comments on its relevance in this context cannot be made.

There were four attributes used in the CE tasks (and an example of a choice task is given in Figure 1a):

1. **Chemical Safety** – the stated level of scientific certainty over whether uncontrolled (newer) flame retardants/persistent chemicals are safe (or if they potentially could cause harmful impacts on human and animal health, as with banned or controlled (older) types). These chemicals were marked with the following levels: *probably not safe (25% chance)*; *maybe safe (50% chance)*; or *probably safe (75% chance)*.
2. **Remediation Time** – the time taken for banned or controlled (older) flame retardants/persistent chemicals to be cleaned-up in surface waters, with levels set at either: *10 years*; *20 years*; or *30 years* into the future.
3. **Surface Cover** – the percentage of surface waters that would be cleaned-up of all flame retardants/persistent chemicals (banned/controlled and uncontrolled). Due to limits on where *waste water treatment* and *land* management systems can be placed, the

[8] "How sure are you that the proposed new pollution policy for 'waste water treatment' systems would have the results described (e.g. that the government and water companies would act efficiently and as instructed, resulting in a reduction in Flame Retardant water pollution)?"

scenarios never offered complete clean-up of surface waters, and so the levels were set at either: *some (30%)*; *half (50%);* or *most (70%)*.

4. **Cost** – the permanent increase in monthly household water bills, with levels set at: *£0* (zero increase); *50p*; *£1*; *£3*; *£8*; or *£16* (with annualised amounts shown alongside).

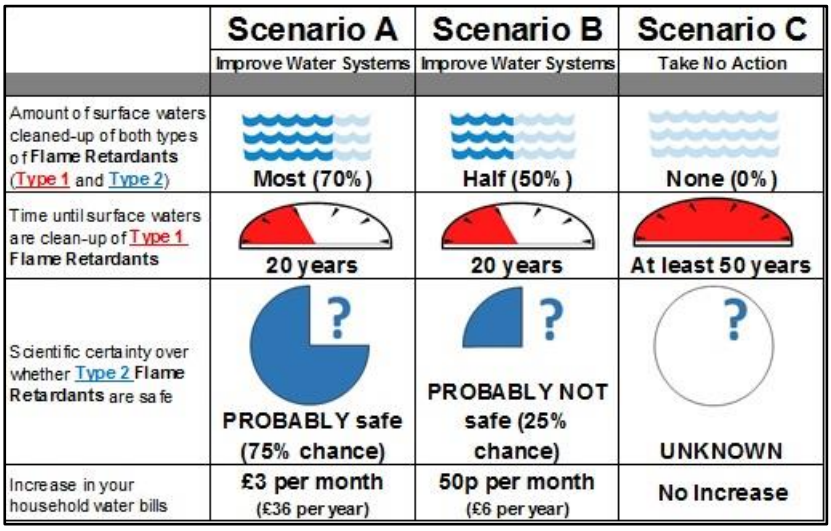

Figure 1a. Example Choice Task.

There were 162 combinations of attribute levels (3x3x3x6) so an optimal design was obtained by developing a fractional factorial design, using model results from the pilot survey as priors for that design. A total of 40 paired scenario option tasks were generated, which were optimally split into five blocks of eight CE tasks (using Choice Metrics, 2012), with each respondent being randomly assigned to one of these blocks. This more limited number of tasks (compared with the full 40) was shown to each respondent to reduce tiring which can lead to mental fatigue (Bateman et al., 2002). Each CE task had, in addition to the two management options, a third 'Take No Action' option which represented the status quo baseline (described above). This gave respondents the option of paying nothing (resulting in no environmental change), thus providing a baseline that is consistent with demand theory (Louviere et al., 2000; Hanley et al., 2001).

Part-whole bias is a phenomenon that has been recognised as an issue in SP literature for a long time (Bateman et al., 1997). Furthermore, the EA and Defra wished – in the interests of ensuring the most correct application of the valuation estimates – for this study to incorporate some method of measuring this bias. Specifically, it was important to determine whether people distinguish between the remediation of persistent chemicals as a suite of substances and the remediation of flame retardants per se. To establish whether or not respondents made this distinction, three survey splits were employed. The first split sample (n=337) was only given information regarding flame retardants (and asked to value the benefits of reducing pollution

from flame retardants). The second split sample (n=404) was given information regarding persistent chemicals (including flame retardants and other chemicals) but was only asked to value the benefits of reducing pollution from flame retardants per se (i.e. not tackling the other pollutants). The third split sample (n=402) was given information regarding persistent chemicals (including flame retardants and other chemicals) and was asked to value the benefits of reducing pollution from all types of persistent chemicals.

Distribution

The survey was designed to be completed over the internet to avoid interviewer bias issues, reduce financial and time costs and allow respondents more time to think (Hudson et al., 2004; MacKerron et al., 2009). Online surveys can also reduce data input errors and allow implementation flexibility (Atkinson et al., 2018), such as response filtering and split samples. Furthermore, internet-based SP studies have been shown to produce more conservative WTP estimates (Marta-Pedroso et al., 2007). Olsen (2009) found no significant difference in WTP estimates between internet and postal surveys and it is assumed that the internet method used in this study did not in itself produce any significant bias in the final SP figures.

The pilot and final survey were distributed via a professional survey firm[9], using their probabilistic panel of the English and Welsh population. Quotas were set to encourage the respondents' ages (minimum 18) and genders to reflect the target population. Due to the use of a distributing survey firm, there is certainly some bias relating to self-selection by respondents, a common issue with internet-based studies. Additionally, around 1 in 7 households in Great Britain do not have access to the internet (ONS, 2014a), so a sizable portion of the general population has been excluded from this study. This raises an issue regarding representation as people without internet access in the UK are likely to be less educated, have lower incomes or be retired (Dutton and Blank, 2011).

Econometric Models

The CE analysis used a conditional logit model which allowed for estimation of the coefficients associated with each attribute (McFadden, 1973). An LCA was also employed to investigate respondent heterogeneity. Latent class models offer greater flexibility, in identifying preference heterogeneity amongst respondents, whilst overcoming potential collinearity issues. The latter

[9] PureProfile.

may otherwise arise from interacting multiple highly correlated independent socioeconomic characteristic variables with the alternative specific constants in an MNL model. Additionally, as discussed earlier, the LCA approach does not require *a priori* assumptions regarding potential sources of heterogeneity. Instead, latent class models assume that a number of *a priori* unknown groups (or classes) exist in a given population, each with differing preference drivers (Meyerhoff et al., 2010). The LCA estimates, for each individual, the posterior class-membership probabilities (referred to as *class probability*) via observed individual characteristics. Information criteria including the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Hannan–Quinn Information Criterion (HQIC) are used in this study to help determine the optimum number of latent classes. The CE and LCA model regressions were undertaken using version 6 of the NLOGIT statistical package (NLOGIT, 2018), except for the conditional logit model that handled categorical data (see Table 3a), which used version 15 of the Stata statistical package (Stata, 2018).

The attribute-based CE approach is based on random utility theory (Arrow, 2001) and consumer theory (Lancaster, 1966), which assume that utilities for goods or services can be separated and assigned to their various component attributes. A basic supposition is that people act as utility maximisers when faced with alternative choices. The likelihood of an individual selecting a given alternative will be greater if the utility gained by that alternative is the highest of all the available choices.

The utility of a choice for an individual (U) can be modelled as the sum of both a deterministic element (V) and a random error term (ε). The random part of a random utility model can be interpreted as the unobserved tastes or characteristics of a given individual, therefore capture imperfectness of information. Formally, an individual h's utility of choice i can be specified as:

$$U_{ih} = V_{ih} + \varepsilon_{ih} \quad (1)$$

where the error term implies that the true utility remains unobservable, but that the rest of the utility function can be modelled. Taking this further, the probability that individual p selects choice i from a set of options J comprising j alternative choices can be specified as:

$$P_{ih} = P(U_{ih} > U_{jh};\ \forall\ j(\neq i) \in J) = P(\varepsilon_{jh} < \varepsilon_{ih} + V_{ih} - V_{ih} - V_{jh};\ \forall\ j(\neq i) \in J) \quad (2)$$

If the random error terms are assumed to be independently and identically distributed (IID) across alternative choices and observations, the conditional logit model is reached (McFadden, 1973). When the residuals are IID (following a Type I extreme value distribution) then the difference in error terms has a logistic distribution (Maddala, 1986). In this model, the choice probability from Equation 2 can be given as:

$$P_{ih} = \exp(\mu V_{ih}) / \sum_{j=1}^{J} \exp(\mu V_{jh}) \quad (3)$$

The deterministic component of utility can be assumed to be linear and additive in parameters ($V_{ih} = \beta' X_{ih}$), hence the probability in Equation 3 can be expressed as:

$$P_{ih} = \exp(\mu\beta' X_{ih}) / \sum_{j=1}^{J} \exp(\mu\beta' X_{jh}) \quad (4)$$

where μ is a parameter determining the utility scale (usually normalised to 1.0 in MNL models) and, in determining the utility, β denotes parameters that weight exogenous variables associated with the matrix X_{ih}, which are explanatory variables of V_{ih}.

Observing respondent heterogeneity in MNL models is challenging (Louviere et al., 2000), due to interaction terms needing to be correctly selected by the analyst. As described above, LCAs can be used to counter this limitation of the standard CE approach, where the choice probability of individual *h* of class *c* can be specified as:

$$P_{ih|c} = \exp(\mu_c \beta'_c X_{ih}) / \sum_{j=1}^{J} \exp(\mu_c \beta'_c X_{jh}) \quad c = 1, \ldots, C \quad (5)$$

in which μ_c is the class-associated scale and β'_c are utility parameters. Taking this further, the probability of individual *h* in class *c*(T_{hc}) can be given (Boxall and Adamowicz, 2002; Swait, 2007):

$$T_{hc} = \exp(\alpha\lambda'_c Z_h) / \sum_{c=1}^{C} \exp(\alpha\lambda'_c Z_h) \quad (6)$$

in which α is a scale factor (typically normalised to 1.0), λ'_c is the parameter vector in class *c*, and Z_h represents a collection of individual-determined characteristics that in turn establish the classification probability. Finally, by combining Equation 5 (conditional choice) and Equation 6 (membership classification), an unconditional probability of selecting choice *i* can be specified as:

$$P_{ih} = \sum_{c=1}^{C} P_{|ih|c} T_{hc} =$$

$$\sum_{c=1}^{C} [\exp(\mu_c \beta'_c X_{ih}) / \sum_{j=1}^{J} \exp(\mu_c \beta'_c X_{jh})] [\exp(\alpha\lambda'_c Z_h) / \sum_{c=1}^{C} \exp(\alpha\lambda'_c Z_h)] \quad (7)$$

Following this, the number of classes must be determined by the analyst. Various information criteria (mentioned above) were used to assist with selecting the model with the best fit (as recommended by: Louviere et al., 2000; Boxall and Adamowicz, 2002; Morey et al., 2006; Swait, 2007). These information criteria are constructed as follows:

AIC (Akaike Information Criterion) = $-2(\log L - K)/n$

BIC (Bayesian Information Criterion) = $-2(\log L - K\log K)/n$

HQIC (Hannan–Quinn Information Criterion) = $-2(\log L - K\log(\log n))/n$

where log*L* is the Log-likelihood function, *K* is the number of estimated parameters and *n* is the number of observations (note, this can be greater than the number of respondents if multiple choice tasks are completed by each respondent).

The random parameter logit model is an alternative method of accounting for individual heterogeneity (Shen and Saijo, 2009), however a couple of primary advantages exist with the LCA approach. First, specific assumptions about parameter distribution across individuals are not needed, because it is semi-parametric (Greene and Hensher, 2003). Second, the probabilities in each class are given, meaning uncertainty is taken into account regarding a respondent's class membership, even though each respondent can be expected to belong to just one class.

Additional Notes and Data Handling

Several methods were used in the SP scenarios and questions to encourage realistic and reliable answers. First, a one-month period was chosen for the payment phase, to emulate the most common type of water bill payment period. Second, respondents were asked in an earlier part of the survey to state or estimate how much their household normally spends on water bills and respondents were reminded of these amounts immediately prior to answering the SP questions. Third, the annual equivalents appeared in brackets next to the monthly bill increase amounts. Fourth, cheap-talk bullet points were displayed before the CE, including reminders of budget constraints (Cummings and Taylor, 1999). Finally, answer-prompts and minimum time limits were applied to avoid nonresponses and survey rushing, respectively.

Protest bids and other invalid responses can occur for various reasons. They do not represent genuine economic values and therefore should not be used to calculate SP values (Jorgensen, et al., 1999). Using guidance in Bateman, et al. (2002, pp145-147), such responses (less than 4% of the pre-analysis total) were identified using WTP follow-up questions and subsequently removed from the analysis. After this process, the remaining surveys totalled 1,143.

Household SP values were sought (instead of individual values), as they are most appropriate when aggregating estimated values countrywide (Strand, 2007; Lindhjem and Navrud, 2009).

For analysing the CE data, the status quo unknown scientific certainty was coded as 50%. Respondents who did not provide information on their household income were coded as having the average annual household income level (before tax), which was £36,000.

Results

Descriptive Statistics

The online survey data for this study was collected from April 2016 and consists of responses from 1,143 individuals (after removing protest responses) living in England and Wales. Quotas were used to ensure the sample was broadly representative of the population by age (minimum 18) and gender. In terms of socio-economic and demographic representation, Table 1a compares the sample mean with the regional population average, for a selection of descriptive statistics. Overall, the sample appears to be a good representation of the regional population. Exceptions are that people of White/Caucasian ethnicity were slightly oversampled, as were people who were married or in civil partnerships (at the expense of those who were single) and people who had some form of educational degree. The estimated average annual household water bill (£361) was notably close to the UK average of £389.

Table 1a: Descriptive Statistics.

Variable	Type	Study Sample (n=1,143)	Target Population
Gender (%)	Female Male	51.4 48.6	50.8 49.2 (ONS, 2013a)
Household income[10] (£k)		36.0	38.1 (ONS, 2014b)
Living location (%)	Urban Rural	79.8 20.2	79.9 20.1 (World Bank, 2013)
Ethnicity (%)	White/Caucasian Asian Black/African Mixed Other[11]	92.0 4.2 0.9 0.8 2.1	87.2 6.9 3.0 2.0 0.9 (ONS, 2011a)
Marital status (%)	Single Married[12] Widowed Divorced[13]	25.7 60.8 4.0 9.5	35.6 48.1 7.0 9.3 (ONS, 2011b)[14]
Respondent education[15] (%)	School[16] College Undergraduate Postgraduate	30.1 29.2 32.0 8.7	46.0 21.9 24.9 7.2 (DfE, 2007)[17]
Average household size (people)		2.4	2.3 (ONS, 2011c)
Respondent Employment (%)	Employed Unemployed Inactive/Other	59.7 2.9 37.4	59.6 4.2 36.2 (ONS, 2014c)
Living situation (%)	Homeowner Rent and Other	66.9 33.1	64.0 36.0 (ONS, 2013b)[18]
Average age (years)[19]		51.8	48.5 (ONS, 2016)[20]
Average annual household water bill (£)		361.0 (estimated)	389.0 (Water UK, 2017)[21]

[10] Mean average annual household income before tax.
[11] Includes 'Prefer not to say'.
[12] Includes Civil Partnerships.
[13] Includes people who are separated.
[14] England and Wales only.
[15] Highest level of education completed by the respondent.
[16] Includes people who stated 'Other'.
[17] For individuals in England only, excluding those with 'no qualifications'.
[18] England and Wales only.
[19] Excludes people <18 years old.
[20] UK data.
[21] UK data.

Choice Experiment Model

An initial analysis of the responses found that respondents did not distinguish between addressing flame retardants or persistent chemicals more generally, in terms of the value that they placed on each CE attribute. Consequently, the three survey splits were combined for all models, and some discussion on this observation is given later in the paper.

Attribute interactions were tried for a range of variables – including age, household income and gender - though none produced significant results, so these have not been reported. As expected, when interactions were performed with the six variables used to determine the latent class probabilities (see below), these produced some significant interaction outputs. However, these are more meaningfully interpreted via the latent class model so have not been reported separately.

The results in Table 2a below show that the conditional logit model produced highly statistically significant parameters for all CE attributes (using robust standard errors clustered by respondent). This model used data coded as interval integers, thus providing specific percentage change WTP estimates for the three non-bill attributes. The second reported conditional logit model (see Table 3a) used categorical attribute data (except for the bill amount attribute), as depicted in the CE scenarios. Whilst the outputs from this second model are less widely applicable (due to their restricted interpretation), they do provide some interesting insights regarding people's framing of the policy options as they are more strictly related to the CE scenarios. For example, people did not distinguish between 30 and 50 years into the future for the time taken to remove older flame retardants/persistents from surface waters.

As mentioned previously, for analysing the CE data, the status quo unknown scientific certainty was coded as 50%. When this status quo attribute was coded categorically and distinctly from the other levels, then respondents still exhibited a significant preference for any level of known certainty over chemical safety. Whilst this may suggest that coding it as 50% in the models is not correct, when asked what they thought the unknown level of certainty was in the status quo option, in follow-up questions, the average was 46%, which justifies the use of the 50% coding.

Table 2a: Conditional Logit Model (interval data).

Attribute	Coefficient	St. Error	Welfare Impact Scenario	Annual household WTP (£)
Monthly Bill Increase	-0.1151***	0.0036	n.a.	n.a.
Chemical Safety	2.1972***	0.0932	1% increase in scientific certainty over chemical safety of new flame retardants/persistents	2.29 [2.10-2.48]
Surface Cover	0.8021***	0.1057	1% increase in the amount of surface waters cleaned up of all flame retardants/persistents	0.84 [0.62-1.05]
Remediation Time	-0.1459***	0.0197	Reducing the time taken to remove old flame retardants/persistents from surface waters by one year (from a baseline of 50 years)	1.52 [1.12-1.92]

** p < 0.1, ** p < 0.05, *** p < 0.01. Log likelihood value of -8409.46172. WTP 95% confidence intervals in square brackets.*

All WTP estimates given to three significant figures. All other figures given to four decimal places.

All welfare impact figures shown in this table are treated as follows: Bill Increase figures were monthly, so have been multiplied by 12 to estimate annual amounts; Chemical Safety figures were for scientists being 100% sure that new flame retardants/persistents were safe, so have been divided 100 to estimate values for a 1% change in certainty over safety; Surface Cover figures were for 100% surface water being cleaned up of old and new flame retardants/persistents, so have been divided 100 to estimate values for a 1% change in surface waters treated; and Remediation Time figures were for decennial periods of time until surface waters were cleaned up of old flame retardants/persistents, so have been divided 10 to estimate annual amounts.

Table 3a: Conditional Logit Model (categorical data).

Attribute	Coefficient	Odds Ratio	Welfare Impact Scenario	Annual household WTP (£)
Annual Bill Increase	-0.0096*** (0.0004)	0.9905	n.a.	n.a.
Chemical Safety 50% chance	0.6906*** (0.0393)	1.9949	Increasing scientific certainty over chemical safety of new flame retardants/persistents to 50% (maybe safe) from 25% chance (probably not safe)	72.11 [64.06-80.16]
Chemical Safety 75% chance	1.0800*** (0.0558)	2.9446	Increasing scientific certainty over chemical safety of new flame retardants/persistents to 75% (probably safe) from 25% chance (probably not safe)	112.78 [101.35-124.20]
Surface Cover 30%	1.5001*** (0.0814)	4.4824	Increasing the amount of surface waters cleaned up of all flame retardants/persistents to 30% (some) from 0% (none)	156.66 [140.00-173.32]
Surface Cover 50%	1.6663*** (0.0772)	5.2923	Increasing the amount of surface waters cleaned up of all flame retardants/persistents to 50% (half) from 0% (none)	174.00 [158.20-189.80]
Surface Cover 70%	1.7946*** (0.0855576)	6.0173	Increasing the amount of surface waters cleaned up of all flame retardants/persistents to 70% (most) from 0% (none)	187.41 [169.89-204.92]
Remediation Time 10 years	0.2473*** (0.0433)	1.2805	Reducing the time taken to remove old flame retardants/persistents from surface waters to 10 years (from a baseline of 50 years)	25.82 [16.97-34.68]
Remediation Time 20 years	0.1446*** (0.0393)	1.1555	Reducing the time taken to remove old flame retardants/persistents from surface waters to 20 years (from a baseline of 50 years)	15.09 [7.04-23.15]

** p < 0.1, ** p < 0.05, *** p < 0.01. Log likelihood value of -8395.7242. Standard errors in parentheses. WTP 95% confidence intervals in square brackets.*
All WTP estimates given to two decimal places. All other figures given to four decimal places.
All welfare impact figures shown in this table are treated as follows: Bill Increase figures are annualised; Chemical Safety used the 25% safe level as the reference baseline; Surface Cover used 0% cover as the reference baseline; and Remediation Time used 50 years as the reference baseline. Note that the categorical 30 years level depicted in the CEs has been omitted, as it displayed collinearity with the baseline 50 years level, so cannot be meaningfully interpreted beyond this.

Latent Class Model

For the latent class model, the choice probabilities of selecting preferred scenarios were regressed on bill increase costs and the other three scenario attributes (coded as interval data): chemical safety, surface cover and remediation time. The other regressors are largely dummy variables and the model was estimated in NLOGIT (2018) using maximum likelihood estimation procedures.

Number of Classes

For LCAs, analysts must specify the number of classes prior to applying the technique. Six different LCAs were run for this paper, using two to seven classes in each. There are various available approaches to choosing the best number of classes and several information criteria are given in Table 4a to assist with this (and discussed in the Methods section above). Such criteria can assist in selecting the model with the best fit, identified by the AIC, BIC or HQIC value that is closest to zero (allowing for positive Log likelihood functions). For these six models, the number of classes is consistently negatively correlated with the AIC, BIC and HQIC[22] (the opposite was consistently the case for the models' McFadden R^2 values, which are not reported). When applying five classes or more, respondents representing 45% of the average class probabilities (across two classes) showed attribute non-attendance for the bill amount (with p-values ranging 0.1358-0.2728), thus limiting the usefulness of these models in calculating WTP. In fact, it is not uncommon for the AIC to over-estimate the optimum number of classes (Meyerhoff et al., 2010).

In such cases, the decision to determine the best number of classes should be based on interpretability (Swait, 1994; Scarpa and Thiene, 2005; Geiser, 2011), rather than solely on statistical measures. Consequently, the best number of classes was deemed to be four, as that model ensures: all classes show responsiveness to the bill attribute; all classes have at least two significant non-attribute explanatory variables; and no class makes up less than 5% of the sample by probability. Whilst this latter *no small class rule* is associated with interpretability, it has also recently been shown to hold some theoretical justification (Nasserinejad et al., 2017).

Table 4a: Information Criteria (to determine optimum number of latent classes).

Number of Classes	2	3	4	5	6	7
Number of Parameters	17	29	41	53	65	77
Log likelihood function	-7207.342	-6845.121	-6733.059	-6592.287	-6532.527	-6433.727
AIC*	1.580	1.504	1.482	1.453	1.443	1.424
BIC*	1.581	1.506	1.487	1.462	1.455	1.439
HQIC*	1.579	1.501	1.478	1.449	1.437	1.417

All figures given to three decimal places.
**Divided by n(9144).*

[22] Note the Log likelihood function statistical test suggests that six is the best number of classes for this model, however due to the associated interpretability issues cause by insignificant variables (for models with five or more classes), this model is not selected.

Class Definitions

Table 5a explains the descriptive variables used to determine class probabilities. Amongst the numerous variables recorded in the full survey, these were found to have a strong relationship with how different people responded to the CE attributes. Put another way, depending on how people responded to the descriptive variables described, they were likely to fit into a particular group which behaved uniquely in the CE tasks. Consequently, these variables were central to determining the groups (or classes) of people that acted in distinct ways. Some initial analyses explored the role of further variables in determining class membership, however they were not as significant (or interpretable) as those described in Table 5a, so are not reported.

Table 5a: Descriptive Variables (for latent class probability identification).

Variable Name	Variable Type	Variable description	Sample Average (n=1,143)
Opinion	dummy	Positive if respondent stated that they viewed the issue of climate change and the environment as either “important” or “very important”.	61.0% positive
Society	dummy	Positive if respondent answered either “supported” or “strongly supported” to the following question, “If 'waste water treatment' systems across the country were improved, to remove flame retardants/persistents from the environment and food chain, do you think this would be supported or opposed by the public overall?”	64.5% positive
Concern	dummy	Positive if respondent answered either “concerned” or “very concerned” to the following question, “How concerned are you about human health issues from flame retardants/persistent chemicals in our rivers and lakes?”	57.6% positive
Aptitude	dummy	Positive if respondent said they found it either “easy” or “very easy” to complete the eight stated preference choice tasks.	39.7% positive
Risk	interval	Self-reported measure of how much of a risk taker the respondent rated themselves, when asked the following question, “In general, how willing or unwilling are you to take risks? Use a scale from 0 to 10, where a 0 means you are "completely unwilling to take risks", and a 10 means you are "very willing to take risks". Coded as 1–11.	4.46/10.0
Knowledge	dummy	Positive if respondent correctly answered “lakes and rivers” to the following question, “What are surface waters?”	60.1% positive

The following class descriptions use the fourth class, labelled the *Bill-Focused Class*, as the reference class (which is described last). The class (or posterior) probabilities are given in Table 6a.

Class 1 - Concerned

The largest class, representing 62.5% of the class probability, is labelled the *Concerned Class*. People in this group were more likely to be concerned with persistent chemical impacts and most strongly viewed climate change and the environment as important. Similarly, this group thought that the public would support persistent chemical remediation improvements. Uniquely, these members described themselves as risk-takers, using a risk question adapted from Dohmen et al. (2006) and described in Table 5a. It was also the only class who found the eight SP choice tasks significantly harder to complete than the reference class.

Class 2 - Knowledgeable

The second class, forming 21.6% of the class probability, is labelled the *Knowledgeable Class*. Like the *Concerned Class*, they were likely to view climate change and the environment as important and think that the public would support persistent chemical remediation improvements. However, respondents in this class had the highest probability of correctly answering the surface waters knowledge question. Unlike the *Concerned Class*, this group were unlikely to find the eight SP choice tasks difficult to complete.

Class 3 - Safety

The third class, constituting just 8.6% of the class probability, is labelled the *Safety Class*. As with the previous classes, this group were likely to view climate change and the environment as important and think that the public would support persistent chemical remediation improvements (though the latter was to a lesser extent for this class). However, what distinguished this class from the others was that (in addition to the bill increase attribute) this group only responded significantly (p-value <0.05) to the safety attribute (see the Welfare Impacts section below).

Class 4 - Bill-Focused

The fourth (and reference) class, representing the remaining 7.3% of the class probability, is labelled the *Bill-Focused Class*. Compared with the other classes, these members were not likely to view climate change and the environment as important nor think that the public would support persistent chemical remediation improvements. Characterisation of this class is furthered by assessing how its members responded to the SP choices, as they only responded significantly (p-value <0.05) to the bill increase attribute.

Class Stated Preference Responses

The results of the latent class model with 4 classes are presented in Table 6a.

Table 6a: Latent Class (LC) Model.

	LC 1 - Concerned		LC 2 - Knowledgeable		LC 3 - Safety		LC 4 - Bill-Focused	
Variable	Coefficient	St. Error	Coefficient	St. Error	Coefficient	St. Error	Coefficient	St. Error
Monthly Bill Increase	-0.073***	0.005	-0.795***	0.049	-0.178***	0.043	-4.184***	0.885
Chemical Safety	2.678***	0.142	2.879***	0.382	3.536***	0.938	0.976	0.860
Surface Cover	1.161***	0.147	2.828***	0.416	-0.076	0.553	-0.116	0.875
Remediation Time	-0.258***	0.190	-0.396***	0.070	0.177*	0.094	-0.153	0.190
Opinion	1.8221***	0.3808	1.4755***	0.4064	1.4660***	0.4521	Ref. cat.	Ref. cat.
Society	1.1289***	0.3407	1.5781***	0.3653	0.9349**	0.4303	Ref. cat.	Ref. cat.
Concern	1.7463***	0.3769	0.4229	0.4059	0.8977*	0.4780	Ref. cat.	Ref. cat.
Aptitude	-0.9622***	0.3033	-0.4956	0.3254	-0.5772	0.4742	Ref. cat.	Ref. cat.
Risk	0.1636***	0.0595	0.0655	0.0651	0.1411*	0.0783	Ref. cat.	Ref. cat.
Knowledge	0.4769	0.3182	1.3040***	0.3432	-0.1277	0.4349	Ref. cat.	Ref. cat.
Class Probability	0.625		0.216		0.086		0.073	

** p < 0.1, ** p < 0.05, *** p < 0.01. Log likelihood value of -6733.05907. All attribute figures given to three decimal places. All descriptive variable figures given to four decimal places.*
Latent Class 1 was the least likely group to select the status quo alternative of taking no action, followed by Latent Class 2 and then Latent Class 3 (Latent Class 4 did not give a significant coefficient for the status quo alternative).

Welfare Impacts

Table 7a provides the welfare impact estimates from the latent class model with 4 classes (see Table 6a).

Table 7a: Welfare Impacts of Attribute Scenarios for the Latent Classes (LCs).

	LC 1 - Concerned	LC 2 - Knowledgeable	LC 3 - Safety
Scenario	Annual WTP (£)	Annual WTP (£)	Annual WTP (£)
1% increase in scientific certainty over chemical safety of new flame retardants/persistents	4.40***	0.435***	2.38***
1% increase in the amount of surface waters cleaned up of all flame retardants/persistents	1.91***	0.427***	0.0510
Reducing the time taken to remove old flame retardants/persistents from surface waters by one year (from a baseline of 50 years)	4.24***	0.598***	1.19*

** p < 0.1, ** p < 0.05, *** p < 0.01. Latent Class (LC) 4 (Bill-Focused) has not been included as all the attribute coefficients, except Bill Increase, were insignificant.*

All WTP estimates given to three significant figures.

All welfare impact figures shown in this table are calculated from figures in Table 6a, and treated as follows: Bill Increase figures were monthly, so have been multiplied by 12 to estimate annual amounts; Chemical Safety figures were for scientists being 100% sure that new flame retardants/persistents were safe, so have been divided 100 to estimate values for a 1% change in certainty over safety; Surface Cover figures were for 100% surface water being cleaned up of old and new flame retardants/persistents, so have been divided 100 to estimate values for a 1% change in surface waters treated; and Remediation Time figures were for decennial periods of time until surface waters were cleaned up of old flame retardants/persistents, so have been divided 10 to estimate annual amounts.

Discussion

The Value of Safety

The results in aggregate (see Table 2a and Table 3a) show significant and intuitively correct respondent behaviour in relation to the CE attributes, as well as significant differences between the resulting categorical WTP estimates, as the 95% confidence intervals do not overlap. Respondents were willing to pay more for scenarios in which the scientific certainty over the safety of new flame retardants/persistents (the *Chemical Safety* attribute) was greater. Whilst this attribute was couched in terms of scientific certainty, it can also rightly be interpreted as an SP for chemical safety. This places the results in-line with previous studies on WTP for increased safety in the food sector (Mørkbak et al., 2011; Wu et al., 2015; Lai et al., 2018) as well as from electrical waste (Afroz et al., 2013) and clothing (Holmquist et al., 2018).

Interestingly, the most knowledgeable group identified in this paper (the *Knowledgeable Class*) expressed the least WTP for chemical safety (excluding the *Bill-Focused Class*). Although not directly comparable, this finding contrasts with those of Pouratashi (2012), who notes that in the case of chemical-free food production, only consumers who are knowledgeable about such products are willing to pay a premium. The *Knowledgeable Class's* identity comes from their understanding of the background scenario in the CEs, rather than of the product/chemical itself, however this highlights the importance of the LCA approach in drawing out nuances in sample data. It also identifies a potential problem associated with the application of WTP estimates relating to chemical-safety, as respondent knowledge (which might otherwise be assumed to be absolute or homogenous) has direct and large impacts on expressed WTP values. As with Pouratashi's meta-analysis, people's knowledge of the underlying chemicals is considerably varied.

The results from this study go some way to filling the research gap identified by Sørensen et al. (2016) and provide a unique and practical contribution to research which targets chemicals (or associated impacts) for which the effects are associated with scientific uncertainty (such as pollution from microplastics, pharmaceuticals and agrochemicals).

Given this study's percentage change WTP estimates for safety are the first of their kind, further similar studies are needed to meaningfully corroborate the accuracy of them. Unlike many previous studies on WTP for safety, the outputs are not restricted to specific certificates or product labels. Further, due to respondents' conformity across the three sample splits, the estimates obtained in this study can be broadly applied to a range of persistent chemicals, providing they host similar qualities and impacts to those in this study. A further discussion on this sample split conformity is given later in this discussion.

Pragmatic cautiousness associated with persistent substance control legislation has, in a large part, been driven by the scientific uncertainty around the impacts of these chemicals (EFSASC, 2013; Honkela et al., 2014; Fuhrman et al., 2015). As discussed by Torres et al. (2017) in the context of climate change, scientific certainty is typically regarded as a precondition for policy action. This study's contribution to the field of valuation economics provides a prototype vehicle for applying CBA-applicable and remediation-associated economic estimates for emerging or otherwise poorly-understood persistent chemicals. This contribution to the literature also provides a means of advancing – in the context of persistent chemicals – Paragraph 15 of the 1992 Rio Declaration:

> "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*" (UN, 1992).

The precautionary principle, usually invoked for interim management of potential risks (Martin and Voulvoulis, 2009), can now be applied with an empirical understanding of the degree to which scientific certainty (over chemical safety and impacts) relates to the value of implementing pollution policy options. This contribution also goes some way to enabling the establishment of the standardised risk assessment paradigm for endocrine disrupting persistents called for by Fuhrman et al. (2015), ahead of their health impacts being better understood. Of course, there remains an unanswered question, relating to exactly how clearly defined unit values can be best applied in real world situations (where precision in physical end-points is not known). Future research on this application aspect must consult current practices used by, and seek advice from, European environmental and chemicals agencies. In relation to the precautionary principle, what this research demonstrates is that people can value goods, even when they are uncertain.

As discussed in the Literature Review section, insensitivity to scope is a common occurrence in SP research (Kahneman, 1986; Carson, 1997; Hammitt and Graham, 1999). However, the odds ratios shown in Table 3a depict remarkable and strong respondent scope sensitivity towards the safety attribute. On average, people were two times as likely to choose scenarios in which the new flame retardants/persistents were 50% likely to be safe (compared with a baseline of 25% likely to be safe). Further, they were three times as likely to choose scenarios in which the new flame retardants/persistents were 75% likely to be safe (compared with a baseline of 25% likely to be safe). This provides fresh contrasting evidence to previous psychological research which shows people to have weak understandings of probability scale differences (Kahneman and Tversky, 1973; Baron, 1997). Similarly, this is a rare occurrence of strong sensitivity to scope,

unlike that which is typically found in the WTP literature (Lindhjelm et al., 2011; Desvousges et al., 2012; Andersson et al., 2016).

Scope insensitivity is common in surveys when the scope of policy changes is small (see Atkinson et al., 2018). However, the type of scope sensitivity described immediately above is for relatively large changes. Potentially, people found it comparatively easier to compute as the proportions in question were great enough for respondents to subjectively feel the difference and wish to act (Dickert et al., 2015). In any case, these results provide some assurance that the WTP estimates associated with this attribute in this study are reliable. In turn, this offers some justification for using the percentage change version of this WTP estimate in a policy context, providing it is kept within the boundary of the categorical attribute levels (i.e. only applied when there is no considerable scientific certainty, either way, over a chemical's safety).

The Value of Time

Respondent reactions to the time attribute suggest that people could have viewed it in terms of the potential exposure time, as well as the more typically investigated uncertainty associated with the future (or discount rate). Interestingly, the class that self-identified as risk-takers (*Concerned Class*) expressed a considerably higher WTP to reduce the future chemical remediation time. This may be driven by this group's risk-taking characteristics allowing for easier selection of higher bid amounts, however it is possible that it was driven instead by this class's relatively high levels of concern with persistent chemical impacts. Primarily, the findings from this aspect of the study make clear that there are potentially large societal benefits if governments or water companies implement early action on aquatic chemical remediation. Before moving on, it is worth briefly discussing further the association between self-confessed risk takers and respondents in the *Concerned Class*. Typically, one might expect that people who dislike risk would be willing to pay more to avoid it, yet those in the *Concerned Class*, expressed the highest WTP values. Whilst the results provide no absolute explanation, it is possible that people who are willing to take risks are also more willing to part with cash for a good that is inherently uncertain. Certainly, more research would be needed to tease out the *type* of riskiness that these people self-identified with.

As discussed in the Literature Review section, most SP research which addresses WTP for variations in time has concentrated on reductions in travel time (Amador et al., 2005; Tsamboulas and Nikoleris, 2008; Small, 2012). This study is the first example of the time-cost associated with policy inaction on aquatic pollution remediation efforts being estimated. Whilst further studies to compare with the estimates from this study are greatly encouraged, the time-associated valuation estimates obtained are relevant to CBAs where the policy implementation

date itself is part of the consideration (rather than simply the binary choice of whether to enact a policy or not).

The conditional logit model that used categorical attribute data (see Table 3a) provides some time-associated results that are particularly useful in understanding respondent behaviour on this topic. On average, people were 16% and 28% more likely to choose scenarios where the remediation time for older flame retardants/persistents was reduced from 50-plus years to 20 and 10 years, respectively. This preference is broadly in accordance with expectations for this attribute. Interestingly, people did not distinguish between the baseline time horizon and one of 30 years. So, whilst the respondents displayed clear, significant and rational behaviour for short-term time frames, they ceased to distinguish between times that were greater than 20 years in the future. Consequently, when using the annualised WTP estimates for this attribute, applications should be restricted to a 20-year time horizon into the future. Further caution is needed for such use, as the 95% confidence intervals overlapped across these two category levels, suggesting the presence of collinearity.

This discounting of preferences across time is, in part, in accordance with longstanding knowledge around people's preferences for distant benefits (Olson and Bailey, 1981). However, considering the context of this paper (Zauberman and Urminsky, 2016), it is perhaps perfectly logical for people to perceive no difference in long-term policy impacts, as by then any health effects on the individual respondent would be in motion, due to the bioaccumulating nature of persistents. This evidence satisfies the recommendation of Gabbert and Hilber (2016) that valuation estimates for chemical impacts should capture associated temporal characteristics. Although further research is recommended on these time-associated findings (particularly if any specific discounting function is to be identified), they do suggest that if water managers are considering persistent chemical remediation policies that are time-dependent, then focusing on options that deliver in the short-term could maximise value.

The Value of Quantity

The findings from the spatial attribute in this study provide a unique addition to the existing literature on the value of varying sizes (spatially) of environmental change (Johnston et al., 2001; Mallawaarachchi et al., 2006; Bateman et al., 2011). Crucially however, what this study provides is a nationally applicable metric for aquatic persistents remediation at the percentage point level (across all surface waters). This is both a reasonable approach, given the pervasive nature of persistents (their impacts are not localised), and a practical one, given the national (or even international) focus that serious remediation efforts on persistents necessitate. As such, the

outputs from this study take forward previous research that applies CEs and LCAs, but that are otherwise restricted largely to local implications (such as Brouwer et al., 2010).

People clearly preferred more remediation over less, however as expected (Arrow et al., 1993; Carson and Mitchell, 1993), respondents exhibited some degree of diminishing marginal returns as the level of remediation cover increased. Using the results in Table 3a, we can see that on average respondents' household WTP to treat 30% surface waters (compared to a baseline of 0% treated) was £5.22 yr^{-1} for each percentage point increase. This drops to £3.48 yr^{-1} and £2.68 yr^{-1} for each percentage point increase for 50% and 70% surface waters being treated in total, respectively. It should be noted, however, that this outcome holds limited significance for policy implications as respondents were not suitably educated on the relative merits of these different coverage-associated policy options. Further, the WTP 95% confidence intervals overlapped across all category levels for this attribute, albeit only slightly at the extremes, meriting further caution for policy use. As with much of the background data regarding the potential health impacts of emerging persistents, the available evidence regarding the impacts of variations in remediation cover (as depicted in this study) are non-existent. That said, in a policy context, the results from this attribute will be of some use to the EA and Defra in future price controls. However further research to validate the results from this study are strongly recommended.

It is important to note, as with the other attributes, that the model estimates that use interval data for the attributes should only be interpreted for the range in which they were given in the survey (i.e. remediation cover interpretations should be limited to a maximum of 70% surface waters).

Attribute Non-Attendance

The *Bill-Focused Class* exhibited attribute non-attendance for all non-monetary attributes. Similarly, the *Safety Class* showed attribute non-attendance for the surface cover and remediation time attributes. This phenomenon arises when respondents do not respond to all attributes when deciding their choices, thus producing non-significant results for at least one attribute. It is not an uncommon occurrence in SP research (Scarpa et al., 2009; Campbell et al., 2011; Hensher et al., 2012), and it can happen due to a variety of reasons. Sandorf et al. (2017) suggest that such non-attendance may be due to respondent unfamiliarity with the scenario, which is very possible given the nature of persistents as both unfamiliar and complex substances. The latter issue, their complexity, may have also led to this attribute non-attendance, and Börger (2016) states that allowing more time to think can increase the likelihood of a respondent considering more attributes in choice tasks. That said, minimum time limits were employed in this survey (as explained in the Methods section), so the likelihood of this effect was limited.

Alemu et al. (2013) suggest that attribute non-attendance can result from perceived attribute irrelevance, which may well have been the case for the *Bill-Focused Class*, if indeed they were only interested in the price. This potential explanation would require further investigation, however given this class's relative lack of interest in climate change and the environment, perhaps this is a justified rationale. This highlighted lack of interest in associated issues suggests that perhaps the respondents in the *Safety Class* simply didn't care enough about the matter to attend to all attributes. However, as with the suggested explanations above, without further evidence of what drove this class's behaviour (for example, through additional follow up questions), certainty around the interpretations is not possible.

One class (*Safety Class*) only showed attendance for this safety attribute (as well as the bill increase). Without further examination, or follow-up questions with people who are most likely to fall into this class, it is difficult to speculate with any accuracy why this behaviour occurred. It is possible that, given the survey's emphasis on scientific uncertainty and chemical safety, this group were overly-focused on this attribute. However, with the overbearing importance of this attribute (compared to the other non-bill attributes) in terms of determining whether chemical impacts (for newer flame retardants/persistents) are negative or not, it is reasonable to focus only on this aspect if safety was truly their main concern.

Flame Retardants or all Persistents

As mentioned previously, respondents displayed conformity across the three sample splits, and so the three groups were combined for all models. This outcome relates to the part-whole bias, which has for a long time been recognised as a phenomenon in SP research (see Bateman et al., 1997). It is possible that if the same individual were asked to value the different sample focuses, then they would distinguish between them. If that were the case, then it would suggest that respondents in this study paid little attention to this scope aspect, instead providing nominal responses which were broadly the same irrespective of the probability level (Carson, 1997). This type of starting point bias could have formed a portion of this part-whole bias, particularly given respondents could have viewed whichever level they were assigned as normal, giving little thought to alternate levels of scope. As it stands, the outputs from this study are better applied to persistent aquatic chemicals as a whole, which is the more conservative approach.

A similar issue exists regarding the realistic interpretation of the welfare estimates. For example, the WTP estimates presented in Table 3a suggest that households would be happy to accept significant increases in their water bills, in order to ensure that scientific certainty over new flame retardants/persistents moves up to 75% (from 50%). However, in reality people may not be willing to pay such a premium (a >50% bill increase) for this perceived benefit. For example,

they might prefer to spend their money on other things (if given the choice) or simply not be able to afford it – in any case none of the choice tasks proposed this specific attribute and cost change in isolation – so care should be taken if using these results in a policy context.

Conclusion

This study applied an original CE design to elicit non-market welfare estimates for water quality improvements under the WFD in England and Wales, focusing on persistent chemicals. The study introduced an explicit attribute for scientific certainty around chemical safety, meaning that the benefit of scientific certainty itself could be valued monetarily. This provides an original contribution to how CBAs can be conducted when dealing with substances for which the impacts are not known with complete certainty. Furthering the standard precautionary approach, the novel contribution of this paper allows for the degree to which caution exists (i.e. the extent of scientific certainty over chemical impacts) to directly reflect the extent to which society values associated policy options. Additionally, this is the first valuation study of these chemicals in the context of water pollution.

An LCA was implemented to investigate preference heterogeneity for this attribute, as well as attributes for surface water remediation scale and time (as well as a cost attribute). Non-localised spatial attributes are rarely considered in SP, and the associated results are applicable at the macro-policy level. Analysis of the time attribute showed that people, on average, preferred shorter remediation times, but did not distinguish between time-frames that were more than 20 years in the future.

The LCA results showed that the largest group of people (*Concerned Class*) formed the majority and produced the highest WTP values for aquatic persistent chemical pollution remediation, and that these people were the most concerned about human health impacts from these substances. A similar but smaller group (*Knowledgeable Class*) were more likely to have understood the SP scenario, found it easier to complete the CE tasks and were willing to pay significantly less for environmental improvements. The remaining two classes were largely influenced by either the chemical safety or bill increase attributes.

This paper offers several unique contributions to the academic literature concerning uncertain environmental impact valuation, public preferences regarding scope variations in policy outcomes and the benefits of temporal differences in policy delivery. Additionally, the valuation estimates obtained in this study are of interest to governments and water companies conducting CBAs (and considering decisions) for aquatic persistent chemical removal policy options, given they provide the first of such figures for persistent chemical removal in the EU.

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4 - Paper Two

A Deliberative Study of How People Frame Policy Responses to Complex and Unfamiliar Environmental Impacts

Contents **Page**

Introduction

The overarching motivation for this paper was to improve the understanding of how people frame policy responses for environmental problems involving complex and unfamiliar impacts. A suitable vehicle for doing so was to explore public perceptions around the importance of reducing chemical water pollution in England and Wales, as necessitated by the WFD. Hering et al. (2010) argues that of all European legislation in the water sector, the WFD is the most important piece. Previous research has focused on estimating public economic values for taking such remedial action, however none has specifically addressed the structural components in the water sector that shape people's fundamental attitudes.

First, this study addresses the research question of how perceptions of cost fairness impact on people's willingness to support environmental improvement projects. Given that many environmental improvement endeavours are state or socially funded, the research contributions from this are highly useful to civil servants and monopoly utility companies, respectively.

The second theme in this paper is the interplay between the awareness of environmental issues and people's perceptions regarding their importance. Whilst awareness and perceived importance can be jointly determined, it's also possible to be reasonably aware of an issue and not consider it important. Similarly, it is possible to place substantial importance on something – rightly or not – whilst retaining a low familiarity (or knowledge) about it. Indeed, as this paper will determine, learning identical information can lead to polarised views in terms of importance and previously held opinions have a distinct role to play in regulating perceived importance. This has connotations for any actor (be it a government, policy researcher or social scientist) wishing to understand more about the ways in which importance is determined and how topic saliency interacts with expressed interests or WTP over time (MacMillan et al., 2006; Czajkowski et al., 2016).

The final theme explores how information can be most effectively designed to inform the public about environmental issues like chemical water pollution, and what types of information are most trusted. Insights from this last area of discussion will likely be of interest to water companies, utility managers and relevant government departments, and perhaps also to corporate social responsibility teams in publicly facing firms.

Primarily, this paper contributes to the literature's knowledge of how cost fairness perceptions affect latent willingness to accept costs that may lead to improvements for complex and unfamiliar public goods. These unique insights offer a variety of improvements to policy decision-making. Further, all three themes provide some useful guidance for the SP literature, as well as an empirical underpinning where researchers are seeking to understand more about

how information acquisition and type influence people's SPs for environmental goods. The lessons gained from this research should help environmental economists to construct more effective and meaningful SP scenarios, ultimately resulting in more accurate and applicable value estimates that can effectively reflect cost fairness issues that exist in the *real world*. In doing so, quantified price estimates obtained by taking such phenomena into account will better reflect the value that those figures purport to represent. If value is conceived within the mind of an individual observer then the instruments used to measure that value must consider how the mind comprehends value in the *real world*. In this way, perceptions of cost (and benefit) distribution fairness will feed into how people determine the value of a particular option.

Further to this, the findings from this paper offer potentially useful practical guidance for researchers aiming to reduce incidents of protest votes in surveys, thus increasing their effective sample size (see Meyerhoff et al., 2014).

As will be explained in more detail at the end of the Methods section, this study was inspired by Hajer's (1995) *argumentative* approach to discourse analysis, to identify the three themes for discussion. This approach allowed for these policy- and research-relevant themes to emerge from a guided process focused specifically on determining public opinion around the complex and unfamiliar topic of chemical water pollution in English and Welsh waterbodies. The continued use of public views in environmental decision-making demands we take a closer look at how people form opinions on such matters. This is particularly important for complex and unfamiliar goods, a typical combination in emerging environmental issues. One of the central factors when trying to determine the value that people might place on policy options is to understand how people perceive fairness and the impact of those perceptions on their value judgements. It has been decades since economists first began discussing issues regarding fairness, which previously had been largely assumed to be irrelevant. For example, Kahneman et al. (1986a) demonstrated that individuals sometimes resist unfair transactions and that public perceptions regarding fairness can provide incentives for profit-maximising firms to act in accordance with these social norms.

When estimating the nonmarket benefits of potential improvements to the natural environment – especially when such projects are likely to involve a mixture of personal (e.g. water bills), private (e.g. water company investments or bond issuance) and public (e.g. government spending) expenditure – then the distributional fairness of costs should be addressed. This issue, and public perceptions of it, have been shown to affect people's stated WTP for environmental improvements (Dresner et al., 2006; Bicket and Vanner, 2016; Drews and Van den Bergh, 2016). Consequently, economists should seek to measure the impacts on value estimates that are

driven by respondent perceptions regarding the distribution of costs and benefits (e.g. profit, sustainability and health). To do this in any meaningful way, it is necessary to first understand public perceptions regarding the specific environmental improvement in question, in this case chemical water pollution. This paper endeavours to uncover, for the first time, informed public opinion regarding chemical water pollution in England and Wales. More specifically, it focuses on the issue of cost fairness, what that means to the public and how perceptions regarding cost fairness form people's WTP for environmental improvements or support for strong policy responses.

The empirical evidence in this paper comes from a public and deliberative consultation that was held on the topic of chemical water pollution in England and Wales, in which three arising structural components of the interplay between the water sector and public realm were explored: cost fairness; awareness and concern; and communication and trust. The recorded public views on these three themes are explored, alongside relevant evidence in the existing literature, to uncover previously undocumented public opinion behaviours and reveal opportunities for improving a range of public opinion research.

The deliberative consultation workshops covered two distinct types of chemical water pollution affecting the environment and people in England and Wales. The first was that of *local level* pollutants, using metals as a case study. Metals have multiple sources, including domestic and trade effluent, but can also exist naturally in the environment or because of past industrial activity, and can lead to local environmental risks to animals and wildlife if their levels exceed environmental quality standards (EQSs) set under the WFD.

The second is that of *distant scale* pollutants, and this study primarily used flame retardants as a case study to explore this pollution type (but also addressed other persistent pollutants). Flame retardants (and many other persistent chemicals) can lead to animal *and human* health concerns (unlike metals) arising from food chain accumulation, often caused by historic use of the chemicals in consumer goods. Unlike most local level pollutants, distant scale pollutants like flame retardants bioaccumulate and so: can cause impacts far away from the source; can persist for a long time; and the scientific certainty over their impacts is significantly lower. The WFD mandates that member states use citizen and stakeholder participation in the preparation and updating of their RBMPs, which detail how 'good water status' will be reached in waterways.

The 'mandated participatory planning' approach (Newig and Koontz, 2014), previously untried by authorities in England and Wales in the context of chemical water pollution, offers an excellent test bed for exploring relevant issues arising from a participatory environmental governance approach. By promoting active public involvement in the planning stage, the

European Commission encourages an instrumentalist rationale for public contribution that is reflected in participation guidance on the WFD: “public participation is not an end in itself but a tool to achieve the environmental objectives of the Directive,” (EC, 2003). Whilst there is no prescription on how such participation should be designed (e.g. who should be involved, at what stage and how), allowing member states much leeway (Newig et al., 2014), public participation is nonetheless viewed as central to WFD planning and an important success factor for the Directive's execution, as portrayed in its Preamble 14.

From a regulatory perspective, these substances are managed against an EQS, typically using end of pipe treatment. However until now, we have lacked non-quantified evidence to illustrate public opinion regarding these types of chemical pollution, what management options and outcomes are preferred, and how those preference are formed. Assessing the value of such action is important if future management decisions are to consider the opinions of the public and this study provides empirical evidence to support the inclusion of factors such as cost fairness in valuation studies.

The rest of this paper is organised as follows. First, the relevant academic literature will be explored, in doing so the academic contribution that this new research provides will be further demonstrated. Following this, the methods used to deliver the deliberative workshops and analyse the outputs are explained. The three arising themes of the workshops are then described before being discussed, followed by some concluding remarks. The purpose of this paper is not so much to report the findings of these public deliberative workshops, but to learn from them about: how such techniques can help researchers; how people frame policy views for complex and unfamiliar environmental problems; and what we can learn about qualitative valuations of this kind in the context of the three themes explored.

Literature Review

Cost Fairness

Cost fairness can be defined as the perception of whether the distribution of costs of a given good is right or unjust (Campbell, 2007). We have known for a long time that perceptions regarding the fairness of a change in price (typically an increase) can strongly influence consumer reactions (Etzioni, 1988). In fact, many early studies exploring the impact and acceptance of price changes on consumer behaviour were largely rooted in the concept of price fairness (Campbell, 1999b; Kahneman et al., 1986a; Kahneman et al., 1986b). More recent research by Campbell et al. (2015) has investigated consumer acceptance regarding higher prices for which the increased costs were due to a company's corporate socially responsible (CSR) activities.

This study builds upon the dual entitlement principle, which is the idea that whilst consumers may feel entitled to a particular reference price, so too are private companies entitled to reference profits (see Haws and Bearden, 2006). This principle supports the concept that if the reference profit of a given company is at risk of being reduced (for example, paying for an environmental project), then increasing prices to protect rather than create profit, may be acceptable to the public even if this increase comes at the expense of consumers (Vaidyanathan and Aggarwal, 2003). Indeed, research by Herrmann et al. (2007) shows that people's satisfaction judgments can be influenced by both price per se, as well as indirectly through perceptions of price fairness. Campbell et al. (2015) found that the effects of the dual entitlement principle even hold true for pro-active private investments and CSR activities, and that price increases do not have a negative impact on purchase behaviour when they are caused by fair trade commitments, which are perceived as fair. Based on this evidence, people seem generally willing to pay a premium if they feel that the extra amount can be justified as fair.

The drivers of behaviour identified in the paper by Campbell et al. (2015) are restricted in terms of what we can learn, not least because they are limited to the context of price changes for coffee purchases. A related study by Iyer et al. (2016), found that "green products" can go mainstream if producers can convince consumers that the premium cost reflects a greater value compared to non-green alternative products. Their study also has limitations in that it only addressed one category of green products: cosmetics and personal care products. Their results indicate that perceptions of price fairness are driven by environmental and social consciousness, and that in turn perceptions of price fairness guide subsequent green purchase decisions. The authors claim that this is the first study to use price fairness to look at green products in terms

of both the economic and altruistic benefits realised, and it found that the purchase of green products is still largely determined by "values anchored in altruistic benefits".

We know from Kahneman et al. (1986a) that people sometimes resist costs that are perceived as unfair, a phenomena that can incentivise profit-maximising firms to align their practices with these social norms. Social scientists have since argued that resistance to unfair costs, often represented by protest bids, may vary not only with the type of good being valued or the elicitation format, but also the interaction between these elements and other external factors (Jorgensen et al., 1999).

Amongst other drivers, more recent research by Meyerhoff et al. (2014) addressed the effect of fairness aspects on protest responses in a meta-analysis of 10 different SP surveys. The authors note that whilst cost fairness, policy context and payment vehicles have been mentioned in the existing literature, "many of these aspects have yet to be empirically investigated." Such findings are highly valuable to researchers wishing to understand and apply insights regarding how cost fairness perceptions drive behaviour, public opinions and WTP. Dixit et al. (2015) also highlight this research gap in the context of marketing and firm reputation. They note that "to date there has been limited empirical investigation of environmental factors" including the idea that in some circumstances the perceived fairness of a price (or an increase) may affect customer WTP.

Awareness and Importance

The merits of public consultation in environmental decision assessments have not been overlooked by environmental economists and researchers, indeed there is a considerable and ever-mounting literature on quantified environmental valuation. In addition to estimating quantified applications for CBAs, the outputs from environmental change valuation exercises should sometimes seek to provide adequate insights into the underlying drivers of public opinion for sometimes complex and unfamiliar goods – such as the role that awareness plays in determining importance. If public opinion research – whether quantitative or qualitative – is to be most appropriately applied, then we need to ensure we have a reasonable understanding of how people frame policy responses for environmental problems involving complex and unfamiliar impacts. Often public opinion or SP research tends not to address *how* or *why* people develop (or possess) the views that they have on the environment, focusing instead on what those views are and how they affect value statements. However, in some cases the role of framing a policy response and the reasons behind people's views can be strong and considered, and therefore worthy of investigation. Recent research on the conceptual framework of the Intergovernmental Platform on Biodiversity and Ecosystem Services presents the justification

for valuing nature's contributions to people in decision-making (Pascual et al., 2017). This research tackles the tricky objective of integrating values, especially where they are derived from incommensurable value dimensions, covering the following methods: integrated modelling; multi-criteria decision analysis; narrative approaches; and deliberative valuation. So whilst integrating different *types* of value is not straightforward, it can be done, and such integration should be considered where the issue itself requires a more than conventional approach in order to capture relevant values.

Chan et al. (2014) provide a simple hypothesis for the formation of importance (or concern with an environmental issue), describing it as a "linear progression of environmental knowledge leading to environmental awareness and environmental concern", all of which can influence ecological behaviour. Kollmuss and Agyeman (2002) define awareness as "knowing of the impact of human behaviour on the environment". Their analysis provides a more helpful view than Chan et al., by making clear that the formation of pro-environmental behaviour cannot be described through a single framework, due to the many underlying complexities. By focusing on chemical water pollution (a complex and unfamiliar good), this paper will explore some of the mechanisms that drive people's opinions through awareness building. This is not a straightforward objective, and Kollmuss and Agyeman make clear that an individual's willingness to act environmentally can be compromised by cognitive limitations, including the slow progression of many ecological problems and their complexities.

In a study by Gelcich et al. (2014), when asked to think about marine environments, the single most important matters were those relating to "pollution"[23], with a third of respondents noting this issue amongst their top three areas of concern. The expressed levels of concern, or importance, were closely associated with the level of informedness for the different impacts covered. However, those for which respondents were likely to be more familiar with (at least conceptually), such as oceanic pollution and habitat destruction, were associated with higher levels concern (relative to their perceived level of informedness) compared with concepts that were probably more unfamiliar such as aquaculture and jellyfish blooms. Similarly, respondents' informedness and concern (for all assessed impacts) increased with the frequency that they visited the marine areas.

[23] Including "water cleanliness", "water pollution" and "water quality".

Effective Information and Trust

The basic concept behind cost fairness is that a shared benefit – whether that be made of social gains or an environmental improvement – often requires an investment, which in turn should be shared fairly amongst the recipients of the benefits. A related topic is that of trust, and it has been demonstrated that people are significantly more likely to accept a given policy if they trust the institution overseeing that policy (Keramitsoglou and Tsagarakis, 2013; Drews and Van den Bergh, 2016). Further, a study by Adaman et al. (2011), looking at WTP for expected CO_2 emission reductions due to power production improvements in Turkey, found that people's willingness to make financial contributions is significantly inhibited by their beliefs regarding fellow citizen contributions, as well as the general level of trust in the governing institutions.

To date, the interplay between public acceptability and trust has broadly been argued in two ways. First is that of policy certainty, which is the confidence placed in an institution to effectively deliver a given change or good. Typically, higher levels of public trust are placed on policies perceived to be more effective, such as that described by Drews and Van den Bergh (2016) in their examination of why citizens either support or reject policies associated with climate change.

Another recent paper, by Fairbrother (2017), used survey experiments to investigate which conditions improve people's willingness to pay taxes on polluting activities in the UK. Consistent with results from qualitative focus groups, their study suggests that public hostility towards increased environmental taxation is largely driven by political distrust. Similar results have also been found in relation to environmental taxes in Canada whereby a pre-election recession meant that voter interest in the economy triumphed over that of the environment, and people were judged to have voted for the party they trusted most to manage the economy (Harrison, 2012).

Finally, a study by Gaunt et al. (2007) looked at the 2005 Edinburgh referendum on introducing a long-discussed road user charging scheme in the city. Their analysis found that the schemes lack of voting support was driven in part by strong public distrust regarding the perceived effectiveness of the charging scheme. The second argument typically covered by researchers, in relation to public acceptability and trust, is whether transparency over institutional motives is sufficient. This also links to how perceptions regarding improved distributional fairness of costs and procedural fairness are sometimes associated with higher public acceptability (Dresner et al., 2006; Zvěřinová et al., 2014; Drews and Van den Bergh, 2016). A study by Kallbekken and Sælen (2011) estimated that most people in Norway would like to decrease the existing fuel tax by at least 20%. However, the motivation for this was predominantly driven by the extent to

which the policy was perceived to be fair (environmental consequences as well as beliefs about the consequences to others), rather than self-interest or personal cost. This is perhaps more reflective of true personal values, properly incorporating our natural altruistic mentalities. Indeed, shifting opinions towards the common good can move people's focus onto solutions to the problem at hand (rather than personal interests) and matters that can benefit society and the environment (Webler and Tuler, 2000).

Whilst these two arguments regarding public acceptability and trust are useful to researchers, they rarely are derived from consultation with typical members of public, which is usually difficult unless they have been educated enough to respond meaningfully in focus group environments. Insights from such settings can provide the empirical support for future research into these effects, as well as providing novel understandings previously missed by economists and social scientists. Fairbrother (2017) makes clear that future "research would benefit from exploring how the relationship between political trust and willingness to pay environmental taxes may differ across different kinds of political/cultural contexts". This research gap will be addressed in this paper, by encouraging the workshop participants to discuss the effect of trust in information and institutions, and how this feeds into their interest in supporting environmental improvement projects.

Deliberative Dialogue Methods

When addressing environmental issues for which the public has a low initial understanding or awareness of – and especially when the topic is complex (such as chemical water pollution) – the deliberative approach can be well suited if trying to determine public opinions. It can provide empirical evidence to support future academic work, from social perceptions studies to SP scenario and information design. Participatory deliberative methods are not without their flaws, and we will cover some of these later in this section. But crucially, for the issue of chemical water pollution, it is an approach that can help to identify how people frame policy responses for environmental problems involving complex and unfamiliar impacts.

A primary purpose of the deliberative dialogue approach is to amend traditional arrangements of knowledge, thus permitting society (or scientists) to take a fundamental role in policy deliberations (Pieczka and Escobar, 2013). Support for such public engagement in legislative processes has the capacity to change the nature of policymaking regarding the governance of technological advancements (Chilvers and Burgess, 2008). Robinson and Nolan-Itu (2002) undertook a comprehensive international analysis of methods for public dialogue and found that best practices centre on government agencies genuinely cooperating and involving the public in

the process of policy pre-evaluation. Additionally, improved community understanding "can only be achieved by creating the opportunity for members of the public to play an integral and valued role in the… …decision-making process." In UK environmental decision-making, the use of public dialogue approaches is growing, where there is "clear evidence that where developers… … grasp the benefit of early engagement with local communities, [then] this is reflected in lower costs, fewer delays and less uncertainty in the planning process," (DTI, 2007: 259).

Looking at an urban river restoration project in the UK, Petts (2006) found that if the right conditions for listening, sharing, and reflection are provided, then community advisory groups can produce practical and collective agreements on policy recommendations. This concept is related to the citizens' jury (CJ) approach, a method to assist public bodies with the decision-making process, broadly based on the concept of a legal jury. As Garnett and Cooper (2014) note, many deliberative activities found in the literature have applied such methods with the purpose of "understanding public perceptions and attitudes to more controversial science (e.g. stem cells and synthetic biology)," and insights have been discovered more recently regarding participation in environmental governance through comparative analysis of such approaches under the WFD (Kochskämper et al., 2016). The methods applied in this paper take these concepts further, by incorporating different knowledge types (e.g. from policy and chemical experts) to complement that of the public sample, which has previously been shown to foster improved understanding of varying participant perspectives and the development of views through critical reflection (Armitage et al., 2008; and Connick and Innes, 2003).

The topic of public participation benefits in the water sector has been recently covered in some respects (Benson et al., 2014; Ballester and Mott Lacroix, 2016), and this work makes clear that this method is well suited to exploring public views and management option preferences regarding complex (and previously unfamiliar) environmental issues such as chemical water pollution, which can contribute to a better decision-making process (Jonsson et al., 2011; Fritsch and Newig, 2012). However unlike with typical CJ methods, this study does not necessarily intend to find consensus positions amongst participants.

Public deliberative dialogues, using a CJ type model, have the capacity to stimulate public engagement (simultaneously increasing the civic knowledge base), improve the foundation of decisions with publicly supported opinions and values, identify common interests and vastly improve the legitimacy and acceptance of policy decisions (Joss and Bellucci, 2002; Petts, 2008; Bull et al., 2010; Acland, 2012). The deliberative approach was used in this fashion, by establishing a type of CJ in the form of non-expert citizens, to provide relevant conclusions and

recommendations for decision-making regarding the reduction of chemical water pollution in England and Wales. In the process, this study also aimed to meet all six of the 'social goals' identified by Beierle (1999), to get the most out of the public participation. These cover: educating the public; incorporating public values, assumptions, and preferences into decision-making; increasing the substantive quality of decisions; fostering trust in institutions; reducing conflict; and making decisions cost-effectively.

The choice of the deliberative approach, as a means of exploring public views regarding chemical water pollution in England and Wales, was made to prevent typical problems that can arise in decision-making procedures for policy development, including: an absence of public knowledge around complex environmental issues; insufficient incorporation of public opinions and preferences; and trust issues between the public and experts (Beierle, 1999). This study also aimed to broadly follow the three stages of 'framing', 'assessing' and 'management/action' as identified by Chilvers (2007). The 'framing' stage covers the process of defining the issues and shaping the policy issue, predominantly on the first workshop day. The 'assessing' stage covers collecting the public's views, following a suitable period of deliberation, so mostly in the second day. The 'management/action' stage refers to the process in which options covered in the write-up are evaluated and policy decisions made. In this way, the study provided a public dialogue platform for non-specialists to critically scrutinise management options (and effects) and potentially find new ways of framing future policy.

To date, it is rare for social or substantive insights to be sought in the context of participatory methods (see Hophmayer-Tokich and Krozer, 2008). When goods to be valued are both complex and unfamiliar, typical methods used by environmental economists – such as SP techniques – can run the risk of behaviour that is not truly aligned with assumed preference and is instead driven by attempts to protest or simplify choice tasks (Shapansky et al., 2003). This is an example of the types of consideration that are important when choosing a valuation method, especially when the outputs are likely to be applied in policy decision-making (and potentially assumed to be free of such effects). Deliberation can encourage participants to share a large variety of information, perspectives and ideas, thus increasing the opportunities to more thoroughly construct informed preferences (Svedsäter, 2003, Dietz et al., 2009), and recent evidence suggests that public councils in water planning has wide ranging and significant benefits (Graversgaard et al., 2017).

Deliberative methods are certainly not free of problems, from communication decisions to consensus-building (see Spash, 2007), however the unique type of information is often useful to policymakers as it can offer insights regarding policy choice reasoning (Söderholm, 2001).

Collaborative environmental management is claimed to be able to improve environmental situations (Koontz and Thomas, 2006), and common outputs realise positions for different stakeholders, which provide both academic and policy insights. Collaborative approaches sometimes centre on generating agreements, and previous research has addressed both the quantity and contents of those outcomes (Conroy and Berke 2004; Koontz 2003; Leach and Sabatier 2005). Brody (2003) and Dryzek (2013) argue that environmental decisions benefit from the inclusion of environmental concerns in the process of participatory decision-making. The idea is that as well as creating a representation of public views, the quality of outputs from participatory processes are enhanced by bringing forth particular values and arguments from people or environmental groups and re-direct established approaches or alter actors' policy positions (Smith, 2003).

Chemicals in water (which lead to food and body contamination) is too rich a source of personal and institutional impact to remain uncharted as an item of study. To assist in understanding the constitutive role of public discourse in policy processes, this study borrows insights from Barber (1989) regarding civic education – whereby citizens can learn in a way that is promoted by policy analysts, leading to "civic discovery" (Reich, 1985). This paper also imports the use of Hajer's *argumentative* approach, a practice that can provide both theoretical insights as well as ordinary realism (Hajer, 1995). His method of discourse analysis aims to identify themes (or storylines) that "give meaning to specific physical or social phenomena," and in doing so identify the public language and opinions necessary in order to depict and – importantly – construct, the environmental discourse at hand. As he asserts, "finding the appropriate storyline becomes an important form of agency." The argumentative approach borrows from the insights of Majone (1989) who stated that "public policy is made of language. Whether in written or oral form, argument is central in all stages of the policy process… …[and] democracy has been called a system of government by discussion."

Better comprehension of the ways in which citizens approach and relate to environmental issues is a vital step in helping researchers and water managers to realise and galvanise support for policy improvements. As stated by Gelcich et al. (2014), "it is by understanding how the public frames different dimensions of complex marine impacts that scientists and policymakers can become more knowledgeable about how to trigger and support individual and collective action to improve ocean health." Further to this, and employing Hajer's storyline model in a similar fashion to Tomlinson and Potter (2010), three complementary themes are given, starting with cases and moving through to more general theoretical implications. As regularly emphasized in the literature, the relationship between public (deliberative) consultation and different outputs

and insights needs to be much better understood (Lee and Abbot, 2003; Carter and Howe, 2006; Blackstock and Richards, 2007; Carr et al., 2012; Young et al., 2013; Newig and Koontz, 2014).

Citizen participation in policymaking and enacting processes is an approach that can highlight feasible and publicly acceptable solutions to societal problems, and to date has perhaps most widely been applied in the health sector. This drive for public participation is encapsulated in the NHS's Five Year Forward View (NHS, 2014) which argues for more involved policy-development relationships with the public, highlighting the "need to engage with communities and citizens in new ways, involving them directly in decisions about the future." Public dialogue can be defined as:

> *"Deliberative (i.e. over time) participatory engagement where the outcomes are used to inform decision-making"* (RCUK, 2012).

Thaler et al. (2014) suggest that, where possible, the benefits of environmental policies should be more thoroughly investigated than normal practice and that rather than just focusing on the systems level, the benefits of specific environmental factors could be explained, addressed and valued. Through the development of shared understanding among participants regarding preferences, demands and policy capabilities, it is more probable that they will arrive at positions that increase mutual gains and benefit the environment (Ansell and Gash, 2008; Carpini et al., 2004). Intensive dialogue and participant deliberation can foster a communicative environment in which rational arguments can win through (Elster, 2000). With a 2012 European Commission survey finding that "EU citizens… …cite chemical pollution as the biggest threat to water resources," the issue is worthy of such closer study. In the UK specifically, 81% of respondents cited chemical pollution as the main threat to the water environment (EC, 2012). Furthermore, the research approach taken in this paper is in line with the Aarhus Convention of the UNECE[24], which seeks to:

> *"empower people with the rights to access easily information [and] participate effectively in decision-making in environmental matters,"* (UNECE, 2017).

As touched on earlier, whilst participatory deliberative methods can assist with understanding policy choice reasoning (Söderholm, 2001), they are not without their flaws (Spash, 2007). As described by Kenter (2014), "epistemological paradigms" (ideas about how people know things) and perceptions of what constitutes a legitimate and valid approach to valuation research are quite diverse. He provides an overview of which methods are most suited to different stages of the policy cycle and states that the complexity of the issue under consideration (in this case,

[24] United Nations Economic Commission for Europe.

chemical water pollution) should form one of five key considerations on the choice of valuation method chosen. Given the complexity of the issue in question, a deliberative approach was considered appropriate, however this does introduce some potential downsides.

A key limitation of deliberative methods is that the selection process for participants can often entail a degree of subjectivity, which can sway outcomes considerably, despite developments in processes for such selection (Varvasovszky and Brugha, 2000; Reed et al., 2009). This issue of representation can be exacerbated by the typically smaller samples used in deliberative approaches. Additionally, Kenter (2014) describes some concerns to do with the legitimacy of the deliberative process, such as whether participants are competent enough to assess the issues at stake (although this is an issue which also covers more traditional stated preference methods). Further, we must also recognise the imbalanced impact of social relations and institutions that sit outside (but nonetheless hold the potential to influence) a deliberative valuation setting (O'Neill, 2013). Finally, social and power dynamics can lead participants to adjusting their views in ways that may not occur with individual survey approaches.

The three themes explored in this paper have never been addressed in the context of chemical water pollution. The findings affirming previous theories as well as the more novel insights are likely to be of use to environmental economist and social scientists focused on public perceptions of environmental issues and how that feeds into their willingness to support projects aimed at improving environmental pollution problems. Additionally, it is the first time that a true deliberative dialogue approach has been used to address this environmental issue, rather than the typical approach of using one-off or more restricted focus groups.

On this paper as a whole, the research questions that are tested are as follows:

1) How do perceptions of cost fairness influence the expression of value judgements?

2) Does increased awareness always lead to greater perceived importance, and how do people differ in this?

3) How does the medium of information affect the level of trust ascribed to it?

Methods

Workshops Overview and Design

This study applied a deliberative public dialogue approach to explore and document constructs of public opinion regarding two types of chemical water pollution. Pollution at the local level (using metal contaminants as an example) and the distant scale (predominantly using flame retardants as an example) were discussed independently, and sometimes jointly, throughout the workshops. The two workshop days were held over two consecutive weekends, on Saturday 12th and 19th March 2016, at the EA office[25] at Sapphire East, 550 Streetsbrook Rd, Solihull B91 1QU.

The scoping and design stage of this study began in November 2015, with the content for the public dialogue workshops and its participatory exercises drafted between then and February, drawing largely from information in the public realm. This material and the workshop plan was then consulted on by a range of subject matter specialists from the EA, Defra, Sciencewise[26] and the HSE[27], and their inputs were used to refine the workshop design and focus. Following this, the workshop material was sent to the study's Advisory Board[28] to ensure the material was fairly presented and so encourage the collection of unbiased public views. Informal tests of the workshop material were held in focus groups throughout February and early March 2016.

Management, Material and Recruitment

Three independent and expert workshop facilitators assisted in running the workshops, and prior to this they provided expertise regarding the workshop material and the design of the participatory exercises used. Professional and independent facilitation, coupled with clear rules and procedures, can help to avoid environmental discussions becoming co-opted by groups or individuals (Gerjuoy and Amy, 1988; Cooke, 2001). In addition to the facilitators and lead researcher (who delivered the education sessions), three subject specialists (including from EA and Defra) were present at each workshop, primarily to provide clarification for arising questions from the participants.

[25] This location was chosen for various reasons including its ease of access, suitable facilities, budget constraints and that it is located in a broadly central area of post-industrial England with a diverse population.
[26] Sciencewise is a government funded programme aimed at increasing the effectiveness with which public dialogue is used in public policymaking covering science and technology.
[27] The Health and Safety Executive.
[28] The Advisory Board were consulted remotely, via email, and consisting of a water company, the Centre for Ecology & Hydrology, the Chemical Industries Association, two expert academics, CHEM Trust and the Royal Society for the Protection of Birds (RSPB). All were invited to provide comments on the workshop material.

The workshop material provided factual information and a broad background to chemical water pollution, using metals and flame retardants as the primary case studies. Verbal presentations were used to introduce the topics and case studies to the participants, which were then discussed in a range of groups exercises in more detail, using different media including: paper-based text information, video, infographics and photographs.

The two workshops had clear objectives and were organised in a series of distinct sessions, typically building upon previous sessions in terms of topic complexity and breadth. For the carousel sessions, the 29 participants were divided[29] into three groups (of nine or ten people each) and the members of these groups remained the same for each of the two days. Each group moved around the carousel tables and worked with different facilitators, discussing the same themes and topics within each session as the other carousel groups.

The sessions and topics of the carousel exercises were: Session 1 Day one – Introduction and first thoughts; Session 2a Local level pollution – Concerns; Session 2b Local level pollution – Awareness; Session 2c Local level pollution – Burden of cost; Session 3a Distant scale pollution – Concerns; Session 3b Distant scale pollution – Responsibility and communication; Session 3c Distant scale pollution – Uncertainty; Session 4 Day two – Deliberative homework feedback; Session 5a Local level pollution – Fixing the Problem; Session 5b Local level pollution – Action on Local or Distant Scale Pollution; Session 5c Local level pollution – Your Water Bills; Session 6a Distant scale pollution – Addressing Distant Scale Pollution; Session 6b Distant scale pollution – A Global Problem; and Session 6d Distant scale pollution – Sharing the Costs.

Data Collection and Reporting

29 people were recruited[30] for the public dialogue, consisting of a representative spread of the population in England and Wales (by age, gender and class). These same 29 people participated in both the workshops, covering the two consecutive weekends.

Audio recordings, flipcharts and written notes were used to record participants' views and comments in the carousel group tasks and plenary session discussions. Regular individual questionnaires were also used to record individual opinions regarding the discussion topics throughout the two workshop days. These were short (taking 5-10 minutes to complete) and enabled participants to portray their own personal and confidential thoughts. Homework tasks were also used to enhance participants' comprehension of the topics. In anonymous feedback

[29] The groups were divided in such a way that each had a similar mixture of ages and genders.
[30] Recruitment was organised by a professional recruitment firm, CRD Research.

from the 29 participants, almost all of them (97%) said that they thought the information used in the workshops was fair and balanced. Prior to beginning the workshops, permission to record all information was obtained from the participants. First, the findings from the flip charts, written notes and questionnaires were compiled. Then the audio recordings were listened through in full, adding in additional relevant findings to the database where they were missed in the other recording methods. All findings presented are from the group sessions and individual questionnaires. Where there was a strong majority consensus on a viewpoint, this is made clear. Where there was distinct disagreement amongst participants over an issue, the alternative views are reported together. All views are those of the participants only, and do not reflect the views or positions of the study organisers.

Theme Selection

As outlined earlier, the process of theme identification in this study is based on Hajer's *argumentative* approach to discourse analysis, as more recently applied by Tomlinson and Potter (2010). The specific sessions and topics[31] detailed above were identified in conjunction with the EA, Defra and deliberative dialogue specialists and used as a starting point for participant discussions. This was due to their relevance in modern policymaking and the bearing they have on how people approach environmental problems, which was developed in the pre-workshop focus groups.

The data from these discussions was used to identify the three selected themes – cost fairness; awareness and concern; and communication and trust – each investigating a specific and distinct way in which people frame their thinking and policy responses for the complex and unfamiliar environmental problem of chemical water pollution. Other themes emerged from the participant data, but were not deemed to be as applicable to modern policymaking or respondent decision-making in valuation tasks. Hajer (1995, p.56) describes such a theme (or storyline) as:

> *"a generative sort of narrative that allows actors to draw upon various discursive categories to give meaning to specific physical or social phenomena. They key function of story lines is that they suggest unity in the bewildering variety of separate discursive component parts of a problem."*

[31] See previous section on 'Management, Material and Recruitment'.

Tomlinson and Potter (2010) state that “the way in which policy problems are spoken about and constructed by different interests and knowledge providers… …may have profound consequences (and even furnish the justification) for subsequent policy (in)action.”

The intention was to land upon final themes, through a version of civic discovery (see Reich, 1985), that had direct relevance in terms of how people frame unfamiliar and complex problems when a) directly informing future policy decision-making; and b) providing public opinions or preferences in academic research.

Results

Theme 1 – Cost Fairness

Participants discussed and expressed their opinions regarding water pollution treatment policies that would likely be funded, at least in part, by an increase in people's water bills. Around four out of five participants were prepared to pay something additional to their existing bills if it resulted in a further reduction in chemical water pollution. The following points were raised and discussed by the participants as reasons why the public might be more willing to accept higher water bills: if companies (water providers and product manufacturers) paid a significant share of the costs; if increases in water bills were linked to what people earn; if cost changes were clearly and fully explained, including how costs are shared; and if the economic benefit of improved water quality was clearly communicated. These findings regarding cost fairness provide the empirical evidence to justify incorporating such cost fairness aspects into project appraisal and SP research – particularly when dealing with complex and unfamiliar problems such as environmental pollution.

In terms of their WTP for water treatment improvements that tackle distant scale pollutants, most participants were willing to pay something between £1 and £5 extra per month (on their existing water bills), although in this particular case it was assumed that bill increases would be matched by direct government funding. Whilst there is no institutional basis for participants assuming that their proposed bill increases would be government match-funded, the majority felt that this would be fairer. In order to ensure consistency, all groups were guided through this discussion session with this assumption in place. Almost all participants made it clear that increases to water bills would be considerably more acceptable if water companies and product manufacturers also contributed to the increased costs. This finding is linked to the concept of dual entitlement, in that the participants were willing to support the improvement (despite the increase in costs), but felt that all beneficiaries should contribute meaningfully towards it.

When the participants were asked in the questionnaires if they thought money should be spent on reducing the amount of pollution that enters our waterways and the environment, for local level pollutants 73% said 'yes', 12% said 'no' and the remainder said 'not sure'. For distant scale pollutants 86% said 'yes', 3% said 'no' and the remainder said 'not sure'. When asked if they would be happy to pay slightly more on their water bills (an example of £1-2 extra per month was given), for pollution to be significantly reduced, 77% and 68% of the participants said 'yes' for local level and distant scale pollutants, respectively. Those who said 'no' cited reasons including "water companies should pay" and "I already pay taxes and bills to water companies who make profits." Opinion was mixed regarding how willing the wider public would be to pay

to reduce the impacts of local level pollution on water quality. Many participants shared the sentiment that water companies make enough profit already and that they should put that profit back into the issue of managing water pollution. Some participants also felt that water companies should incentivise the public on the disposal of products, where this will make a difference to water pollution.

Despite most participants stating a WTP more for their existing bills to reduce chemical water pollution, one of the three workshop groups had a significant collective objection to paying higher water bills. For example, one participant in that group said that they already paid enough for their water bills and couldn't afford more. This group's reluctance to accept increased bills was in part driven by early comments within the that group regarding objections to increased bills, which then framed the group's discussions going forward, as well as real financial feasibility concerns in this group. The poorest or most financially disadvantaged in society are less able to afford to pay for improved products or activities – or in the case of opinion surveying, it is typically less straightforward to capture their underlying value judgements if the function of fairness and affordability perceptions are not incorporated by researchers (despite the significant impact they have on expressed opinions). Feedback from all groups indicated that financial and social class restraints can have a big impact on what people buy as well as their attitudes and behaviour where the environment is concerned.

Theme 2 - Awareness and Importance

The second key theme from the deliberative workshop discussions was how respondents' awareness and understanding of water pollution issues related to the level of importance that they assigned to it, and in turn the impact that this might have on future behaviour or support for environmental improvements. Many of the participants in this study stated that, before attending the workshops, they had never actively thought about water pollution or associated issues. In their questionnaire responses, 61% and 68% participants said that they had never heard of local level (e.g. metals) or distant scale (e.g. flame retardants) pollution, respectively, before attending the workshops.

There was a widely shared view that the public takes water resources for granted and that generally they have a poor understanding of what chemicals can either exist in tap water or build up in the food chain. Most participants agreed with the sentiment that if people knew more about the impacts of the chemicals they use, then they would be more likely to change their habits. This implies that without the facts being available to people, they will not care enough (or know how) to act, either in a survey scenario or real life. Interestingly, participants stated

that if people were more educated about environmental issues, then they would be more willing to accept the associated costs. A few participants cited the example of recycling, of which people nowadays have a better understanding of why we need to do it, so are more willing to change habits and help.

Whilst most of the participants in this study were concerned with the issue of chemical water pollution, some felt that the chemicals that society uses are advantageous, and whilst perhaps we should be using them less, it is important that we do not deny ourselves of their benefits. When discussing their concerns regarding local level pollution and the impacts it can have on the environment, the few participants who were not particularly concerned mentioned two key factors leading to this position. First was the notion that whilst metal pollution *can* cause negative impacts, metals are naturally occurring and therefore assumed to pose less of a threat. Second was the belief that the UK has high levels of standards for water quality and that therefore the government probably has the situation under control. More obviously, some participants said that rivers and lakes are not visible in their day-to-day lives and that they were unaware of issues that are not in the news, so they were assumed to be unimportant. Summing up this sentiment, one participant used the phrase, “what I don’t see doesn’t hurt me.”

Exogenous assumptions around the impacts of chemicals (which were not covered in the workshop material) were not limited to those who assigned lower levels of importance to the issues. For example, of those who expressed higher levels of concern for local level pollution (the majority of participants), some said that if the chemicals are damaging wildlife, then they are probably harming humans too – even though it was repeatedly explained throughout the workshops that there was only evidence for human health impacts from distant scale pollutants, excluding that of metals. This tendency to rely on and apply sometimes ill-informed ideas is likely an outcome of encouraging respondents to explain positions that sometimes went beyond the scope of their knowledge.

However, it is also symptomatic of how the public can bias their opinions based on past experience or assumed knowledge, rather than new information, and as such has critical implications for public opinion and SP research going forward, as will be considered in the Discussion section below. For example, even though respondents were taught about the varying effects of metal water pollution on plants and wildlife, concerns regarding “rubbish in waterways”, “chemical smells” and “whether tap water is safe to drink” were still cited, even though these had not been mentioned in the workshop material. That said, other unqualified concerns (beyond the scope of the taught material) remain valid, such as those of one

participant who said that they were worried about the "chain reaction that damage to local animals and wildlife might have on the wider environment."

The level of importance assigned to distant scale pollution issues was also mixed amongst participants, although the majority conveyed high levels of concern, and cited the potential impacts on children and future effects as primary causes for worry. Other areas of concern covered: damage to animals at higher trophic levels; global impacts on the food chain; lack of research on the issue and scientific uncertainty over impacts; no public consultation before using the chemicals; lack of clear alternatives; and feeling helpless to make a difference.

Notably, the future impact of persistent chemicals was mentioned by some of the few participants who expressed lower levels of concern to inform their position. For example, some were generally less worried as the impacts were likely to remain for decades in the future, regardless of action. Other reasons in support of lower levels of importance included unfamiliarity with the issue and scientific uncertainty over impacts, with the latter also being mentioned as a supporting reason for those with higher levels of concern. This shows that increasing people's awareness of an unfamiliar and complex phenomena doesn't necessarily lead to people viewing a situation in the same way.

The level of concern expressed by participants in the questionnaires, in relation to the two types of chemical water pollution, dropped slightly between the first and second days. This was measured on a 7-point scale, where 1 signified 'not at all concerned/worried' and 7 signified 'extremely concerned/worried'. The average score for local level pollution dropped from 5.0 on day one, to 4.4 on day two. The average score for distant scale pollution dropped from 5.4 on day one, to 5.0 on day two.

Theme 3 - Effective Information and Trust

The participants were asked[32] to think about whose responsibility it is to inform the public about issues associated with chemical pollution in waterbodies, and how it can be done most effectively. In discussions, participants consistently rated the following groups amongst those with the highest responsibility: government (local, national and agencies), water companies and

[32] In the questionnaires, participants were asked to select, from a list, three groups that they felt are 'most responsible' for communicating the issues of local level and distant scale pollution to the public. For local level pollutants, the following four groups scored the highest (percentage of the possible vote is given in brackets, to reflect relative weights): Central Government (24%); Environment Agency (18%); Local Government (15%); and Media and Water Companies (jointly, both 11%). For distant scale pollutants, the following four groups scored the highest (also with the percentage of the possible vote shown in brackets): Central Government (27%); Environment Agency (26%); Product Manufacturers (13%); and Scientists (8%).

scientists. It was recognised that product manufacturers and metal industries also have a role to play. The most trusted sources of information come from scientists (especially peer-reviewed publications), but clarity over the source of funding for such research is important. For example, sources were less trusted where research is funded by businesses with vested interests in the research outcomes. Comparatively, government funded research was considered more trustworthy, and non-governmental but independent funding bodies even better.

Many participants felt that individuals have a responsibility to inform themselves and other people in their lives about matters like environmental pollution. As individuals seeking facts, most people said that they used Google as their primary source of information. Feedback from the participants in this study showed that word-of-mouth information from family and friends was recognised as a fundamentally unique source of information and one that is rated most highly in terms of acceptability, even though it may not be the most factual or accurate. This is because whilst participants accepted that their friends and family may not be the most informed in society, their intentions when passing on information were clear and not meant to deceive.

Whilst scientific bodies have a responsibility to make factual information available, participants felt that the media should also play a central role in getting that information across to the public. Participants varied in their views on the trustworthiness of the media, with some agreeing that well cited information is reliable. However, others felt that the media often has its own agenda, so may select information to fit specific objectives. Most agreed that making sources of information clear is a good way to help the public make up their own minds.

Participants felt that schools and teachers are generally well trusted, particularly because they are perceived to have no monetary incentives regarding the information they teach. However, participants largely thought that schools do not have a responsibility *per se*, but can strongly support the message of improving water quality through the scientific education of children. Regulatory bodies have a responsibility to communicate the validity of the relevant scientific information used to make water management decisions. Communications from local councillors, or articles in local newspapers, are generally well trusted. Some people said that they trusted environmental groups, who were perceived to produce good research and not have unclear vested interests.

Participants were specifically asked to discuss how best to communicate water pollution issues to the public in the most effective and trusted way. It was stated by all groups of participants that a range of communication methods are required, with the following being suggested: leafleting households from government agencies; putting posters and leaflets in community

centres and libraries; establishing discussion groups[33] at local city centres; promoting groups and adverts via social media; a named contact person for local pollution issues; both government-supported and independent public awareness campaigns; creating an app that combines information on local weather, pollution and traffic; using local TV and radio news[34]; TV programmes such as Countryfile; and using existing local voluntary groups to discuss and raise awareness of issues.

In terms of the role of water companies, it was felt that they should initiate better dialogue with customers in general, explaining what is happening and why decisions are being made. Many participants said that it was not easy to access information about local level and distant scale pollution online. Participants largely agreed that the information provided by water companies and government agencies should be concise and of a high quality, providing easy directions for finding further information if people wished. Importantly, these should not lead to technical reports only, but also towards more in-depth information given in layperson's terms. According the feedback from the groups, information should explain the implications of taking action (or not) as well as clarity on what proportion of their bills (and any increases) are spent on addressing the various types of pollution and associated timescales[35].

It was recommended that information should be in the form of visuals, graphs, simple facts and other forms of straightforward communication to reach out to all generations and backgrounds. It should be made clear on the envelope (if sent in postal form) what information is contained and that it is important. For people on social welfare benefits, they could be notified either via their benefits slip or as part of their receipt for rent. Everyone agreed that such a process should use simple language and avoid jargon.

[33] Participants felt that these local meetings can be effective, but that there should be an incentive (otherwise they do not attract people who do not have a direct or obvious vested interest for themselves or their families) along with clear outcomes (e.g. learning about safer products, human health improvements or other factors that are deemed serious).

[34] Where the issues are deemed serious enough, some participants thought that it would be effective to add local level pollution issues in TV news broadcast, in the same way as the pollen count or air pollution is covered. Others thought that a monthly news report on water pollution (both local and national) would be engaging for some people.

[35] For example, for replacing water pipes, finding alternative chemicals or the possible impact on the environment and humans into the future.

Discussion

'Science' and 'public views' mirror each other in how they function in society. The first recognises the importance of the unknown and argues for, and delivers, its removal. The second is formed of the knowns, from which tangible recommendations for research improvements (and public policy) can be obtained. For example, assessing the value that people place on improving water quality in England and Wales – and how those purported values are shaped – can help in guiding ongoing policy mechanisms such as the WFD. The overarching findings that arose from the two-day deliberative public dialogue workshops are summarised and discussed below. As well as providing some commentary to the outcomes from the workshops, this discussion aims to provide interpretations of the thoughts and opinions shared by the participants in addition to what these mean for future research.

Cost Fairness

The findings from this study plainly show that there is a significant public appetite for a robust policy response to the problem of chemical water pollution in England and Wales. In tandem with this runs a strong preference for the costs of such actions to be fairly distributed amongst stakeholders. Most participants were willing to pay something extra on their water bills to tackle chemical water pollution, however most of them felt strongly that any extra payments should be matched in some way by either government or the private sector (e.g. water companies or product manufacturers). This provides the empirical evidence which warrants future public opinion research to look at how preferences change according to the contribution of others, particularly when dealing with complex and unfamiliar problems such as environmental pollution.

Models for shared investment are not uncommon in modern society and one of the most relevant is that of charitable giving. For example, charitable donations are sometimes incentivised with matched giving, where an affluent donor, employer or government matches an individual's contribution by some fixed proportion. Whilst research exists on how matched giving schemes affect donations to charities (Karlan and List, 2007; Huck and Rasul, 2011), research is lacking on how matched giving in other types of transaction (such as increased bills being shared by government or companies) can affect people's willingness to support a new scheme and how such an arrangement affects how they perceive such action (and outcomes).

Research of this nature is strongly encouraged, not least as it has the potential to unlock otherwise dormant values associated with environmental improvements, that would otherwise

remain invisible to economists employing the more traditional approach of assuming that all extra costs should be directly shouldered by individuals or households. Furthermore, such an approach is fully justified given that the public (as represented by the participants in this study) see such cost distribution as fair and entirely relevant. The implication from the findings described above are that the public will to financially support such environmental improvement measures is a direct function of their perceptions around cost fairness. Without explicitly incorporating a cost fairness approach into opinion gathering methods, the final results may not necessarily accurately reflect the latent (or dormant) will that exists in a sample, thus leading to inaccurate research and suboptimal policy applications/outcomes.

Aside from government contributions, many of the participants raised and supported the concept of water companies (and other businesses considered responsible for chemical pollution) contributing more to financing water improvement projects. This should be interpreted as the equity shareholders of these businesses, as they are the parties perceived as profiting from these businesses.

Mirroring the implications outlined above, unearthing this cost fairness phenomena has implications for how costs are represented in public dialogues and SP research, as well as how value estimates are applied in CBAs used to appraise the merits of public policy projects. The indication here is that more people may be willing to pay for environmental improvement measures (and they may be willing to pay more) if cost fairness issues are addressed. This concerns both what other parties should pay as well as the reasons why participants consider those other parties as being responsible for paying.

The desire for other stakeholders to contribute to the costs, before the fuller benefits could be realised by the participants, relates to the dual entitlement theory. In this case, it seems that the participants felt it fair to pay more to improve the service (through reduced chemical water pollution), as it improves the fairness of the service itself. However, the perception of unfairness results from these participants viewing other stakeholders (e.g. water companies) as unfairly benefiting from the proposed change in policy (or simply the status quo).

In some discussions, participants were aware that an increase in costs paid for by companies directly may be passed to consumers, however what they effectively discussed and were interested in was actual fairness of costs, i.e. a genuine contribution from the private sector. Consequently, to address this cost fairness phenomena, the increased private expenditure would likely have to be financed directly out of company dividends. It is worth highlighting that this was all discussed in the context of “an increase in water bills”, not that which is already being paid for. We know from Iyer et al. (2016) that green product purchases can become

conventional choices if the increased costs (compared to non-green alternatives) are properly accounted for in terms of benefits. In terms of how such bill increases should be communicated, there are clearly lessons to be learnt here regarding the *way* in which an increase in bills is communicated to capture the most latent interest (and realise the most value).

Useful comparisons can be drawn between the findings in this paper and existing knowledge on the importance of cost fairness issues in stated preference studies. For example, we know from Jorgensen et al. (2006) that where there is insufficient information about a choice scenario there is an increased likelihood that respondents might allow fairness judgments to influence the formation of their WTP. However, these impacts don't always run in the direction of sympathetic behaviour. For example, through looking at respondent assessments of cost equity issues Lee and Cameron (2008) found that these assessments had a statistically significant effect on climate change policy support. However, this meant that where poorer people were more likely to shoulder a larger share of the costs, typically people were more likely to support these program options. Conversely, as part of their study of the distributional preferences for climate change policy costs, Cai et al. (2010) measured the extent that people professed to be worried about the fairness of probable climate change impacts. For example, they directly addressed whether respondents thought the Kyoto Protocol was fair, finding that respondents who perceived greater fairness expressed higher WTP values. The key parallel message with this paper is that ignoring cost fairness issues can have unwanted impacts on WTP statements (and ultimate policy decisions). Importantly, if these are not addressed then these impacts can occur without the drivers being observed.

Overall, these findings provide the empirical evidence that Dixit et al. (2015) says is needed to better understand how perceptions of fairness impact public opinion or WTP for policy changes. Similarly, these research contributions also provide an empirical investigation of cost fairness and policy contexts as called for by Meyerhoff et al. (2014). The results from this first theme also take forward the findings by Adaman et al. (2011) (that the financial contribution of other stakeholders is a significant driver of WTP), by affirming that people's willingness to support environmental improvements is driven in part by beliefs regarding contributions from other key stakeholders such as private companies. Crucially, however, this paper applies this concept to the role of the service providers themselves (e.g. the water companies and government).

Awareness and Importance

In terms of awareness of environmental issues (especially when they are typically unfamiliar), and how this relates to the level of importance that people assign, we must first be frank about

the overarching problem here. We need to inform respondents enough so that they can give accurate answers, whilst accepting that we are – by increasing their awareness – rigging the vote, so to speak. Furthermore, there does not appear to be any obvious method for dealing with this data collection problem. This awareness-importance dilemma is a background problem for most public opinion research looking at unfamiliar (and complex) problems, and this is the first time that it has been specifically explored in the context of chemical water pollution in England and Wales.

The level of participants' previous awareness of chemical water pollution was broadly reflective of the level of awareness that might be expected from environmental goods in the aquatic sector. Gelcich et al. (2014) looked at improving marine sustainability and found that average values for respondent awareness of marine environmental impacts ranged between *somewhat informed* and *slightly informed*. In terms of how people characterise value, we know from Gelcich et al. that people can hold higher values for the environmental issues that they are more familiar with – at least conceptually – such as habitat destruction.

The results from this paper mirror this in that participants felt that the wider public would care more about chemical water pollution issues if they knew more about them. Such behaviour-focused empirical evidence is helpful in validating the results in this paper, however it is important that qualitative findings – borne out of informed deliberative discussions – are also available to researchers and policymakers seeking to understand how the public relates to the natural environment. Work of this nature, such as the 10,000+ survey responses (from 10 European countries) reported by Gelcich et al., show how qualitative research on public awareness and concerns about marine anthropogenic impacts can inform both science and policy initiatives aimed at achieving improved marine sustainability. As with their study, the results from this deliberative dialogue research make clear that expressed levels of concern, or importance, are closely associated with the level of informedness for the different impacts covered.

That said, it is important that researchers do not assume that increases in concern are not, to some degree, caused by the effects of the terminology used per se. For example, Buijs et al. (2008) proposed that whilst lay people may not have the facility to accurately define terms like biodiversity, nevertheless they can possess an instinctual appreciation for it. So whilst social scientists and economists should aim to value specific environmental changes for proposals, care must be taken to ensure that the estimated values are not clouded by people's innate emotions associated with specific terminology.

Some participants discussed the changing awareness around recycling and the impact this has on people's willingness to act. This finding is supported by research by Seo et al. (2015) regarding environmental problem awareness and eco-friendly attitudes in hospitals, which found that the "biggest determining factor of eco-friendly nursing practice was found to be the awareness of environmental issues." The implication here for future research is that when conducting opinion surveys or SP research on unfamiliar goods, the information provision in the survey is critical to enabling accurate value estimates to be obtained. Put another way, until there is public awareness of a particular environmental issue, people's opinions will remain ignorant of the true situation. This renders many value estimates unhelpful, beyond merely capturing the strength of uninformed attitudes, which is typically not of use in policy decisions.

Similarly, the findings in this paper show that people of all levels of concern do not necessarily base their decisions and value judgements on facts. For example, exogenous assumptions regarding chemical impacts (not covered in the workshop material) were expressed by participants who assigned levels of importance at both ends of the range. Obviously, this raises issues regarding the accuracy of value estimates in surveys and SP studies. Based on this, a reasonable recommendation for future SP studies would be that, as part of *cheap talk*, researchers should highlight the fact that even when faced with specific information people often make unsupported assumptions regarding environmental impacts and their causes and implications. Researchers could remind respondents of the importance that they base payment decisions on the information provided in the given survey.

Alternatively, follow-up questions could be used to better understand the assumed (or known) information used by individuals to guide their SP payment decisions. However, it is important to keep in mind that some unqualified concerns (beyond the scope of presented material) are not necessarily invalid and that it is natural in day-to-day decision-making for people to use heuristics of this kind to arrive at value judgements.

A notable issue was raised in the findings relating to how information should be framed in public opinion research and SP surveys to properly capture people's views. For example, we know that for distant scale pollutants the potential impacts on children – as well as future generations – were viewed as primary concerns amongst the participants. Given that these are the topics which this study suggests are the most important in terms of driving public opinion, then perhaps it justifies stressing such effects as primary outcomes when framing an SP study looking at persistent pollutants. There is a risk of criticism that results from such a study are simply emotionally charged. However, if emotions are what drives opinion, and if those emotions are

well founded, then the approach could be justified. Certainly, this is a justified area for future research, now that the empirical underpinning has been established.

Additionally, given that the impacts of future persistent chemicals was used as a reason by some participants to justify lower levels of concern, it could be argued that a researcher would simply be providing more information, in a more palatable format, for participants to react to whichever way they deem appropriate. These findings further develop and add a critical nuance to those of Gelcich et al. (2014), who made clear that the level of concern felt by people is associated with the level of awareness, by showing that simply increasing informedness doesn't necessarily lead to greater levels of concern (at least for complex and previously unfamiliar goods).

The fact that the same factors ostensibly provided the rationale for sometimes polarised opinions gives rise to three potential explanations. First, that participants could have cherry-picked or confabulated their reasoning and interpretations of the evidence, to fit either a pre-existing position or heuristically-derived opinion. This would be a form of confirmatory bias, where at least some respondents displayed a tendency to interpret information in a fashion that merely confirmed their pre-existing beliefs. Rabin and Schrag (1999) provide a simple model of information processing for confirmatory bias, whereby when a respondent receives information that is counter to their pre-existing belief (or hypothesis) that they deem to be more likely, a positive probability exists that they misread that information as supporting the pre-existing belief. In this model, the respondent is oblivious to the misreading, and engages in Bayesian updating that – if they were not misreading the information – would be fully rational. Most likely, the degree to which this possibility occurred probably varied from one participant to the next, and more investigation and follow-up questions would be needed in order to derive more concrete interpretations.

That said, it is not unheard of for people, observing the same facts, to draw different conclusions. Looking at empirical research in education, the commentary by Hyslop-Margison and Naseem (2007: p81) on the Gestalt switch can be applied to describe this phenomenon, whereby "two [participants] may agree on all the observable facts… …but interpret those facts on the basis of distinct fundamental presuppositions that lead them to disparate inferences and conclusions."

Second, that a given fact – such as scientific uncertainty over chemical impacts – cannot inherently be classed as strictly a promoter or reducer of associated environmental concern. This is probably driven in a large part by people's previous experience of such issues and how salient they are in the participants' minds at the time.

Third, that some of the respondents expressing lower levels of concern were less engaged with the topic and therefore failed to adequately assess the risks associated with distant scale pollution. For instance, this minority group made statements including “my diet means I’m not affected by this at the moment” and “this doesn’t affect me”, both of which are unsupported assertions as persistent chemicals exist in almost all food types and can potentially impact the health of any exposed humans (as was explained to all participants at the workshop).

Simple and familiar issues like recycling lend themselves to simple explanations, like the formation of importance (or concern with an environmental issue) viewed in the context of the general hypothesis used by Chan et al. (2014). In this framework, a linear explanation from knowledge to increased awareness and concern seems plausible. However, for complex (and previously unfamiliar) issues like chemical water pollution, the true interpretation of the interaction between awareness and concern is better achieved through a non-singular framework, as recommended by Kollmuss and Agyeman (2002). In this way, it is possible to recognise that an identical information input can lead to varying outcomes in terms of concern or perceived importance.

The final discussion point regarding the second theme concerns the saliency of an issue over time. The participants’ expressed levels of concern regarding chemical water pollution dropped between the first and the second day. Perhaps this was due to more information relieving them of previously exaggerated views, or maybe it was because people became used to the idea of chemical water pollution and so it bothered them less. These are just possibilities and more research would be recommended on this topic. This finding has implications for when SP value questions should be posed, in relation to when the supporting information is given to respondents. Environmental economists have known for some time that repeated valuation sessions over time can produce final mean value estimates significantly different from initial estimates (MacMillan et al., 2006). This issue is worthy of further thought in the field as the stability of preferences over time is a primary basis in CBAs and, to some degree, the theory of value itself.

A recent paper by Czajkowski et al. (2016) shows that, over time, people can alter the relative importance that they attach to goods and services. Coupled with the findings from this deliberative dialogue paper, it is evident that environmental economists should be paying much closer attention to the tricky issue of how expressed values change over time and what implications this has for accurate CBAs.

Effective Information and Trust

In terms of information sources, the study's participants consistently rated government, water companies and scientists as those with the highest responsibility to inform the public about issues like chemical water pollution. This provides the empirical basis from which to educate the public and design SP survey treatments with minimal interference from distrust bias. Similarly, the fact that the most trusted source of information was deemed to be scientists (especially when peer reviewed) suggests that a method of reducing some protest responses may be to stress (where true) that information supplied in public opinion surveys is from such sources. As covered in the third theme, the majority of participants also stated that people's decision-making was aided when sources of information are clear. The implication here for future research is that where information is given in surveys, the source should be well defined, in a way that makes sense to a layperson. This could reduce incidents of respondents mistrusting the information or surveyor and therefore biasing (or misinterpreting) the results.

Further recommendations for future research come from the observation that most people said they used Google as their primary source of information. These findings are mirrored by Gelcich et al. (2014) who found that whilst scientific reports and publications by independent researchers are highly trusted by the public, the internet (and television) remains the primary source of information for people. Coupled with findings from earlier research on how knowledge can be communicated in order to improve public understanding (Gregory and Miller, 1998), the evidence suggests that one of the most effective methods of increasing public acceptance of scientific information is to promote direct discussions between citizens and scientists, such as the methods employed in this paper. Gelcich et al. make clear that "simply giving people scientific information is insufficient". Similarly, other authors state that the best methods for communicating environmental issues to the public, where views on policy are sought, are based on creating engagement in a deliberative fashion (Leydesdorff and Ward, 2005; Schibeci et al., 2006; Lorenzoni et al., 2007).

These findings from previous research taken with the outcomes of this study suggests that there is merit in constructing public opinion or SP surveys in two parts. The first part could include a basic level of information and then instruct respondents to go online to found out more for themselves. Then respondents could return to the second part and complete the preference tasks. It would also be helpful to couple this approach with a set of follow-up questions to assess the range or level of information that people used online and how this affected their valuation responses. In terms of public policy more widely, a related issue is that many participants noted that they found it difficult to access information on chemical water pollution online. If people's

primary source of information (the internet) is failing to adequately provide then this poses a serious hurdle in terms of educating the public about such complex and unfamiliar environmental issues.

Word-of-mouth information, from family and friends, was rated most highly in terms of acceptability, despite the known factual issues. Therefore, in terms of increasing public knowledge of environmental issues like chemical pollution, the ultimate objective of any awareness raising efforts should be to turn chemical water pollution into a household level conversation (however the various recommended informing methods outlined in Theme 3 could provide the initial means). The issues are important and interesting enough, as shown by the enthusiasm amongst the workshop participants and their feedback, providing people are informed.

The job of those delivering future information is to capture this latent interest by supplying engaging, informative and relevant material – in a variety of forms that are accessible to people in their diversity. Encouraging awareness sharing at this household level is likely to be most effective, providing further sources of information are readily available at little effort. Future research could focus on asking people why they think different topics come to be household level conversations in order to apply the findings in awareness campaigns.

In terms of improving communication with the public, in some ways Scotland is leading the UK through the recent innovation in the price setting process of forming negotiated settlements between water providers and groups representing customers (see Hendry, 2016). Comparably, Ofgem has recently made clear – in its price control framework outline – that formal *Customer Engagement Groups* will be required of all energy network companies operating in Great Britain (see Ofgem, 2018). Similar *Customer Challenge Groups* have also been required of all English and Welsh water companies in Ofwat's current price control (see Ofwat, 2018).

However, where public consultation methods are planned, it is useful if the public's views are visibly taken on board and enacted, or the government (or water/energy company) risks alienating this key stakeholder from future decisions (for a recent example in the context of marine policy, see De Santo, 2016). On this note we know from Fairbrother (2017) that "most Britons do not trust their government to do what it says," and that advocates of green charges or taxes would "need to overcome a deficit of public confidence in the trustworthiness of government promises." The findings from this paper take forward the arguments of policy certainty and institutional motives (and how they relate to trust), as outlined in the literature review. They provide the empirical support for future research into these effects, viewing them

as a primary driver of opinion, which provides the theoretical underpinning for the relationship between political trust and WTP that Fairbrother highlighted as a research gap.

This deliberative study provides yet more evidence that using clearly sourced information has implications on how people use that information. This is of importance to researchers conducting public opinion research and makes clear the need to carefully consider information medium selection per se. Theme 3 also covered the public desire for water companies to take a greater role in initiating dialogue with customers in general, as well as on emerging issues and decision-making. Such engagement with customers could improve the probability of improved trust, future cooperation, customer loyalty and value co-creation (Vivek et al., 2012; Jaakkola and Alexander, 2014; Littlechild, 2014).

Summary

Looking forward, the findings from this research suggest that more information is needed regarding the varying necessity of using different chemicals in products. Moreover, the discussion on the second day regarding management options was somewhat hindered by participants' lack of knowledge and time to discuss the matters. Therefore, any future work should aim to establish a longer time frame of deliberation, spread over a series of months, incorporating in-depth tutoring on the topic of management options, assisted by the presence of more experts (including water company representatives, product manufacturers and ecologists). The participants achieved a huge amount over the two days, but some made clear that – by the end of the second day – they desired richer information, and more time, in order to tackle the more complex issues involved in management options.

The results from the workshops are the first findings of their kind in the UK, using a public dialogue method to investigate opinion formation regarding two types of chemical water pollution addressed under the WFD. This study found that whilst the public can easily engage with the issues and strongly support more action to reduce chemical water pollution, more public awareness is needed – in various forms – for people to engage with the issue and drive future change. Furthermore, future management decisions need to incorporate methods to manage latent dissatisfaction, and harness dormant value, arising from perceptions of how the costs of water (and product) improvement measures are shared across stakeholders and wider society. Additional studies are required if these results are to be authenticated, and to better inform future decision-making regarding reducing chemical water pollution in the UK. It will be difficult to fully assess the reliability of this study's findings until other similar studies are conducted.

Conclusion

This study applied a deliberate dialogue approach to investigate public opinion regarding water pollution in England and Wales caused by local level and distant scale chemical pollutants, such as metals and flame retardants, respectively. The three themes covered in this paper provide insights on complex and unfamiliar goods relevant to future public opinion research and SP studies as well as social scientists and environmental economists wishing to understand more about: how people's value judgements are affected by perceived distributional cost fairness; the interaction between awareness of environmental issues and the level of importance expressed by individuals; and how information regarding environmental issues can be effectively communicated. In addition to the implications and suggestions for future research, the findings from this study will be of interest to resource managers, policymakers and citizen groups working in the water sector in the UK.

In answering the three primary research questions tested in this paper, three key research contributions are drawn from the deliberative workshops and themes covered in this paper. First, people's latent (or dormant) WTP for environmental improvements can remain unaccounted for if practitioners do not incorporate cost fairness (or sharing) aspects into public preference research methods. Where valuation methods are assumed to capture people's actual WTP, this has direct and substantial implications for the accuracy of project appraisal methods (and the effectiveness of associated policy outcomes) that seek to determine the value of environmental improvements for complex and unfamiliar goods such as chemical water pollution reduction.

Second, the mechanism between awareness of an issue and the level of concern (or importance) that people assign to it is not always clear, especially in the context of complex and previously unfamiliar topics (or when value judgements are emotionally driven). Some participants in this study expressed polarised opinions, despite basing them on the same facts, for example the scientific certainty over chemical impacts was found to both promote and reduce associated levels of concern. The opinion-driving mechanisms for such topics should be investigated in future public opinion research if associated findings are to be properly understood and appropriately applied.

Third, the specific source (and funding) of information used to inform participants in public opinion research has direct implications for how they react in value statements, which is driven in part by how much they trust those sources. The implication here is that the selection of information sources (and the medium through which that information is delivered) needs

meaningful pre-testing (e.g. in focus groups) before being used in public opinion research methods, otherwise biased results – unknown to the practitioner – may manifest.

Despite the limitations of deliberative methods, this study highlights the important insights that can be gained from deliberative research approaches, especially when focusing on complex and unfamiliar goods. The way in which people respond to information, and the judgements that they make to form their opinions, are the factors which lead to outcomes from public opinion and SP research. Only by better understanding how people frame policy responses, for environmental problems involving complex and unfamiliar impacts, can those responses be most appropriately applied in policy decisions.

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5 - Paper Three

The Information Treatment Effect of Social Norms in a Stated Preference Survey

Contents **Page**

Introduction

SP techniques are useful in that they allow researchers to estimate the value for non-market goods. However, a common difficulty in valuing such goods is that they can be both unfamiliar and complex, especially when addressing emerging environmental pressures. For example, whilst the effects of local water pollution (e.g. that caused by metals) in England and Wales are well understood by scientists and water managers, the general public is largely unaware of the intricacies associated with the issue (e.g. sources, impacts on wildlife or future management options). Indeed, before taking the survey in this study, less than half of the respondents had taken an interest in environmental pollution issues and less than half were sure that they had heard the phrase *trace elements* (a term that is commonly used in association with metals and their levels in the environment).

The non-market good in question for this study is that of metal water pollution remediation, specifically in surface waters (e.g. rivers and lakes) in England and Wales. Metal pollution has multiple sources, including domestic and trade effluent, but it can also exist because of past industrial activity. Depending on the form of the metals, they can lead to local environmental risks to animals and wildlife if their levels exceed environmental quality standards set under RBMPs as part of the WFD. The broad narrative here is on the value of reducing the levels of these pollutants that are released from waste water treatment works into surface waters. From a regulatory perspective, these substances could be managed using end of pipe treatment, against an environmental standard. However, up until now, we have had little evidence to illustrate public opinion regarding this type of chemical pollution, and what management options and outcomes are preferred. Assessing the value of such action is important if future management decisions are to consider the opinions of the public, which are required under the WFD.

For people to make informed decisions about the benefits of addressing complicated issues like metal water pollution, they must first be taught about the complexities of the environmental problem itself. Typically, researchers provide survey respondents with straightforward factual evidence (to support their resulting SPs) in a manner that does not reflect the way in which people sometimes acquire and comprehend information in real life situations, such as from their social networks. Of course, practitioners routinely use group deliberation to inform final surveys, in so far as focus groups are a staple of the design process in modern SP research. However, typically these are not particularly in-depth and published accounts do not provide much information on the methods used by practitioners in doing this. Furthermore, the standard

approach overlooks the importance of how more natural information acquisitions impact not only on people's preferences, but on *how* they arrive at those preferences.

Individuals may not possess pre-existing preferences for public goods (as is typical for those that are unfamiliar), so must construct them through a preference elicitation activity. An obvious objection to any SP method is that people's expressed tastes and values are not exogenous to the SP format chosen by the researcher. By acknowledging that values from SP surveys are – in part – artefacts of the survey method chosen, research can further investigate the inevitably constructive process of such surveys. In doing so, methods can be developed that promote coherent and stable responses, enabling individuals to land on informed, meaningful and well-considered value judgements

One of the core problems associated with valuing complex and unfamiliar topics in SP surveys is the existence of biases (List and Gallet, 2001; Harrison and Rutström, 2008). This is an issue that has attracted a worthy share of criticism (Murphy et al., 2005; Loomis 2014), because respondents are required to act in a hypothetical scenario and so are at risk of biases caused by behaving unrealistically or finding the scenario itself unconvincing. If researchers are to minimise bias effects, then we need to better understand what drives them. For many years, researchers have been developing variants in survey protocol design and analysis to reduce biased responses (Mitchell and Carson, 1989). These have included referendum approaches (Cameron and Huppert, 1991), bidding tasks and auctions (Cummings et al., 1986), open-ended question methods and dichotomous-choice survey designs (Loomis, 1990; Duffield and Patterson, 1991). A more advanced version of this final method is employed in this study to derive the policy-relevant value estimates. However in terms of advancing these methods, the proposition in this paper is that social norms – derived from group deliberation – can assist people's familiarisation with complex and new topics, and thus reduce bias derived from how realistic they find the scenario to be.

Group deliberation can reduce biases if the SP format encourages considered and reliable preference formation with space for reflection and social learning (Estlund, 1990; Sagoff, 1998). Crucially, deliberative methods can enable individuals to construct values in group settings, rather than simply expressing prior preferences or poorly assembled views that are more reflective of the survey method itself than the underlying issue. The purpose of this paper is to take well-considered and informed opinions, generated through a group deliberative process (from members of the public who respondents believe to be well-informed on the topic in question), and incorporate these social learnings into a survey format. This information treatment then acts as a proxy for more natural learning from social networks.

Over two consecutive weekend workshops, the participants in this deliberative stage of the research addressed a range of relevant metal water pollution issues including: scientific understanding; the cost of environmental improvement; responsibility for improvement; public concerns; awareness in society; communication of the facts; management options; and impacts on water bills. The findings from these workshops were condensed into an information treatment usable in an SP format and then presented (during the survey's learning stage) to a random sub-sample.

This SNT was defined by three largely text-based sections, intended to best illustrate the group-learnt descriptive social norms of focus (see Literature Review section), which act as a proxy for more natural learning from social networks experienced in real-life. The three sections of the SNT (see Methods section for full details) provided a background to the deliberative workshops; information on the workshop participants' socially-formed views on metal water pollution; and basic details of how participant views differed and changed. For the purpose of this paper, the term *social norm* can be interpreted as a pattern (or rule) of behaviour (or in this case, views) derived from a group setting (see Literature Review section for a fuller discussion on this topic). The key research questions of interest are: What is the impact of this SNT on WTP, and how does it affect how convincing respondents found the SP scenario and payment tasks to be.

The intuition behind the second of these research questions is that if a respondent is made aware of the views of members of the public who are well-versed on an environmental issue and have considered it carefully, then the respondent is less likely to doubt the realism of the scenario in which that environmental issue is covered in an SP survey. Consequently, they may be more likely to find the scenario convincing, which should aid estimating a reliable WTP for an end-point associated with the given environmental issue. The SNT is an improvement to SP study design, using a novel information provision that improves scenario credibility for respondents, without simply persuading credulous respondents to shift their WTP in a particular direction, but increasing relative WTP precision. Consequently, the WTP estimates from the treated sample are considered more robust for use in policy.

The two central academic contributions in this paper come from the need for policy-relevant value estimates. The policy topic, metal water pollution, is both complex and unfamiliar to people (as can be the elicitation methods themselves). The premise is that valuation estimates can be improved by the offer of reassurance that an SNT presents, which is empirically tested in this paper. This first leads to a contribution to knowledge via the SNT, and second to a contribution to policy via generating WFD-relevant value estimates. This original approach is

also a cheaper method (in both time and money) of incorporating social norms into an SP survey than has previously been demonstrated.

The remainder of this paper is organised as follows: first, the paper will review the concept of social norms and how they have been incorporated into valuation methods; next, the methods used to develop the survey and SNT are explained, as well as describing how the survey data was analysed; following this, the results are presented and analysed; and finally a discussion of the findings is given followed with some concluding remarks on the research and policy implications of the approach taken.

Literature Review

As will be investigated in this literature review, preference formation is a natural part of decision-making, even in real life settings. For SP methods, this puts a great deal of responsibility on the information provided to nudge people towards more meaningful preferences within the context of a survey time window. This study uses group deliberation to harness SP realism and precision, whilst avoiding the problems associated with group settings (e.g. group-think and social desirability bias). In doing so, this approach aims to remove some of the imperfections typically associated with both deliberative and SP survey methods, whilst combining these techniques with the intent to create something which strengthens the economic evidence base of environmental policy.

First, this review will assess the role of bias in SP surveys. The review will then formally introduce the concept of social norms. It will identify those that are of most importance to this study and describe the relevant ways in which social norms can influence the interpretation of topics that are complex or unfamiliar. Next, the importance of social learning and deliberative approaches to improving valuation methods will be considered. Following this, existing methods of incorporating social norms and learning into SP research will be addressed, providing the established methodological basis for this study. Finally, this review will use existing research to construct the framework of the novel approach applied in this paper.

Scenario Bias

In SP surveys, a common bias can occur when people's behaviour differs in hypothetical scenarios than in the same scenarios in real life. This can cause a problem for SP research, which aims to mimic behaviour and preference reporting that would otherwise occur in real life settings. This paper focuses on the effect of an information treatment on how convincing or real people find scenarios to be, as a means of reducing bias behaviour that might otherwise be caused by a relative lack of realism.

Bias in SP surveys can be directly related to unfamiliarity with, and the complexity of, the scenario and payment tasks. For example, many practitioners choose to use familiar taxes (i.e. those that already exist) as payment vehicles to reduce the bias associated with valuation scenarios (Bateman et al., 2002). Furthermore, unfamiliarity and complexity linked to the environmental good itself can strengthen biases, as people are forced to consider imaginary situations which are both new to them and difficult to comprehend. If people are more comfortable valuing goods or services they commonly make use of, they may be less prone to

errors in their value judgements (List and Gallet, 2001). Harrison and Rutström (2008) suggest, using experimental evidence, that scenario bias may be reduced in elicitation applications where subjects are more familiar with the good being valued. Ultimately, when people are more familiar with a good or service, "the hypothetical nature of the contingent valuation exercise is greatly reduced," (Naylor and Drew, 1998). Some evidence indicates that scenario bias can exist when respondents are uncertain, but as noted by Murphy and Stevens (2004), "the causes of this uncertainty and its implications for valuation are not well understood."

Social Norms

There are various ways in which researchers have chosen to categorise how people learn, one of which is social norms. These affect how people comprehend a situation or problem, and how they react. The term *social norms* is used to describe patterns (or rules) of behaviour that are derived from group settings. As described by Ostrom (2014), advances in evolutionary theory and empirical research strongly support the assumption that people have inherited a "propensity to learn social norms". Predominantly, research in this area has focused on the effects of ignoring social norms, such as social ostracism or suffering some other kind of consequence. For example, common human feelings such a shame are reflective of an individual's knowledge that others have observed their failure to abide by social norms (Posner and Rasmusen, 1999). Complying with social norms can also be the most appropriate action when group wisdom positively serves both the individual and the group. Authors like Cialdini (2008) have developed research on social decision-making, which has its roots in animal behaviour literature of the mid 1990s, finding that people can rely on group decisions to inform their own actions, especially when faced with unfamiliar or complex tasks. In such situations, an awareness of social norms can,

> *"provide a convenient decision-making heuristic and thus obviate the need to think critically about the consequences of each decision before acting on it"* (Lapinski and Rimal, 2005).

There are many types of social norm (Reno et al., 1993; Harland et al., 2007), one of which is known as *collective* social norms, which refers to the idea outlined above, whereby social groups or communities exhibit behaviours that are cultural accepted. Having displayed their own behaviour in the past and been exposed to the consequences, people have a repertoire of appropriate choices available to them, based on personal judgement or precedence (Arrow and Burns, 2004). It has been accepted for a long time that when there is uncertainty over appropriate behaviour then people make decisions based on their past experiences

(Bettenhausen & Murnighan, 1985). It follows that where people are lacking in personal experience associated with a scenario (hypothetical or real) then they may borrow from that of others who they deem to be well-versed in the issue, and that this may directly improve the level to which they accept the realism of a (hypothetical) scenario. If other people are believed to have adequately addressed the issue before the respondent, they can defer certain judgements and are more convinced by the scenario.

By anonymising the normative preference collection method (through individual surveys), this study moves beyond the basic concept that social norms are only important to the extent that people associate their violation with social sanctions (Bendor and Swistak, 2001), the focus of *injunctive* social norms. Contrastingly, this study will look more closely at what are referred to as *descriptive* social norms: beliefs regarding actual actions or views shown by most others in one's social group. Introducing anonymity is assumed to avoid problems associated with groupthink and social desirability bias (Loomins, 2014; Sunstein and Hastie, 2015) and in doing so enable the effects of social norms to be addressed, rather than just their drivers. This approach is particularly pertinent in the context of preference formation regarding unfamiliar and complex goods. Lapinski and Rimal (2005) state that "when situations are characterized by ambiguity [people] seek information from those around them for assistance in interpretation." As such, social norms have the potential to assist personal interpretation of complex or unfamiliar tasks, providing they trust the views of the social group in focus and believe them to be considered and realistic (over 90% of those presented with the social norms in this study trusted those public views). Taking this a step further, beyond acknowledging that social norms provide guidance on how to behave in a situation (Festinger, 1954), Fazio (1990) states that,

> *"[social norms] serve to help persons define a particular situation, and this definition allows them to understand specific events within that situation."*

So whilst communication of social norms can result in conscious behaviour change, often influenced by the presence of an external observer, there is a subtler effect that social norms can have, associated with reasoning. This distinction can be seen in the work of Bandura (1986) who shifted the focus from behaviour to cognitions, through social cognitive theory. It has been suggested that in addition to the more obvious effects associate with behaviour, social attitudes might affect an individual's behaviour more spontaneously, without them actively considering the social norms and without the individual necessarily being aware of the influence of social attitudes. Fazio (1990) posits that, "the [social] attitude may influence how the person interprets the event that is occurring and, in that way, affect the person's behaviour". If true, then one could reasonably expect group-learnt *descriptive* social norms (such as that used in this study as

a proxy for natural social network learning) to improve the perceived credibility of a situation, such as in an SP scenario, through helping people to define and accept it more easily. That in turn would increase the credibility of any estimated WTP values. In addition to observing the impact on WTP estimation precision, this is the key focus of this paper. It aims to demonstrate that social norms are characterised by more than just social pressure and that group-learnt descriptive social norms can impact on behaviour by assisting problem solving competences through increasing scenario acceptance.

Social Learning and Deliberation

As mentioned in the Introduction, deliberation – of a sort – is employed in most SP surveys because the format itself often necessitates some pre-testing with people via focus groups. Beyond this, the idea that group discussion and deliberation can improve the reliability of environmental valuation methods has its roots in public participation theory (Fiorino, 1995; Laird, 1993), as well as that of group decision-making practices (Burns and Überhorst, 1988; Clarke, 1991) and social psychology and learning (Bandura, 1971; Delbecq et al., 1975; Habermas, 1981). For SP surveys on unfamiliar goods, respondents must construct preferences, rather than them being predetermined. The preference construction procedures may legitimately include social learning, as this is exactly what happens in real life situations (Sagoff, 1998). For example, even in existing markets for goods or services, preference construction is often informed by the advice, views or experience of other people in our social networks. Consequently, there is no reason to exclude such social views from decision-making processes in SP surveys.

Some have considered that social approaches to environmental valuation can provide more convincing and legitimate evidence than basic aggregation of individual values (Farber et al., 2002; Parks and Gowdy, 2013), or at least provide complementary assessments, thus enabling a more comprehensive portrayal of such values (Bebbington et al., 2007; Fujiwara and Campbell, 2011). As described by Kenter et al. (2015),

> *"shared and social values are not just about generating more accurate, more complete or more legitimate evidence, but also about recognising the importance of inclusiveness in decision-making."*

A traditional view (see Schwartz, 1999) would be that collective (or shared) values *are* the aggregated values of individuals (who share underlying common values and are rooted in a shared culture). Others however discuss how shared and social values can only be articulated

through group deliberation, and that the concept of total economic value can incorporate these benefits through non-use altruistic, bequest and existence values (see Kenter et al., 2015). What matters is that these individually stated (but shared) values are assumed to relate only to personal satisfaction, thus avoiding double counting. It follows that where CBAs incorporate values derived from individuals who are aware of the social impact of their stated preference decisions (e.g. climate change or pollution), they are already aggregating shared values, and Kenter et al. (2015) take the view that "neither stated nor revealed preferences can avoid being influenced by them." More generally, if shared values are derived from group identities (e.g. those relating to politics) then they could fit less well with the Total Economic Value framework compared with more conventionally assessed (individual) values. With a shared values approach, there is a notion that the total value is more than the basic sum of the parts, which suggests these values are in some ways fundamentally different to individual ones.

Even beyond the environmental context, the inclusion of shared and social values beyond conventional welfare economics is increasingly being recognised in health services valuations (Mooney et al., 2002; Cleary et al., 2011). Changes in values or behaviour are more likely to endure when they reflect individual's social environments via social learning processes (Bardi and Goodwin, 2011), and research should aim to integrate perspectives on social environmental values and behaviour (Kenter et al., 2016). Irvine et al. (2016) make the case that shared values per se do not necessarily exist a priori, but that they are normative constructs achieved through a social process of value formation.

Social Norms and Learning in Stated Preference Studies

The effect of social norms in SP surveys has been studied before, but typically this is in the context of the influence of social norms on behaviour (Czajkowski et al., 2017). Further, culture and social norms have been shown to be associated with promoting the acceptability of environmental policies in the context of climate change (Alló and Loureiro, 2014). An established method of combining social components associated with environmental goods into the valuation process is that of the *market stall* approach (or valuation workshop). This method has been used in recent years to address the lack of social learning, deliberation and consensus-building in conventional SP analyses but that otherwise exist in more natural social networks. It uses a participatory technique similar to the *citizens' jury* method and combines it with an SP exercise, incorporating time to reflect on preferences and allowing for greater information provision in the context of unfamiliar goods. For example, Alvarez-Farizo et al. (2007) looked at how changes in the decision-making setting (e.g. individual and anonymous choices verses those

made in a group context) affect estimated welfare measures. In the context of water quality improvements under the WFD, they demonstrate that the SP format can be implemented in a market stall approach, resulting in more agreement on management options and more considered preferences that recognise the necessity of costs to the public. The authors make clear that the study does not determine whether the participatory analysis used and combined with a CE is any better than equivalent CV methods, stating that "no formal test of such improvements exists".

Another established development is that of *deliberative monetary valuation* (DMV), which seeks to combine economic and social factors, to reveal social values beyond the typically individualistic approach to estimating environmental change benefits. Standard SP approaches have been criticised for assuming learned and well-formed preferences whilst ignoring real-life sustainability concerns such as rights, fairness and equity. DMV addresses these criticisms whilst enabling individuals to "research their underlying preferences, form and then state a willingness to pay value," (Macmillan et al., 2002). The key idea is that a group setting of deliberation incorporates concepts of social norms and WTP which are distinct from simply aggregating individual values. Spash (2007) states that "social values can be speculative, expressive or arbitrated," and he shows how social and deliberative decision-making can incorporate societal interests as well as those of a self-interested focus.

Providing that a factor driven by a social norm (such as pro environmental behaviour) forms part of the utility function for an individual, then there is a mechanism by which a social norm can affect WTP. That is the general model that is assumed in this paper. Nyborg (2011) provides a theoretical discourse on how utility can be driven by a sense of duty (much like a social norm), and states that "moral responsibility may induce the duty-oriented to contribute more." Similarly, but in the context of household recycling, Czajkowski et al. (2017) found that norms associated with morality can be linked with WTP.

Incentive Compatibility

Carson and Groves (2007) state that for stated preferences to be incentive compatible, survey respondents must consider their responses as having the potential to influence subsequent actions. Additionally, they explain that the respondent must care about the outcome of those actions. It follows that if the respondent considers their preferences to have influence, and they care about the outcomes, then they should treat the survey questions as a chance to affect those potential consequences. Whilst there should be some prospect that a respondent's choice can influence an outcome, Vossler et al. (2012) describe how this doesn't mean that every choice in

a survey needs to have a direct marginal effect. For example, the outcome could rely on a form of majority rule, however the possibility must exist that a respondent's choice could be pivotal in that outcome.

Johnston et al. (2017) provide a helpful review of the conditions necessary for incentive compatibility. They summarise the issues outlined above by stating that the questions posed to respondents should involve "a plausibly consequential decision," thus minimising the likelihood of strategic or anomalous response behaviours. More specifically, part of their *Recommendation 8* states that one of the easiest ways of achieving incentive compatibility is to use a single (binary choice) question for each respondent. The survey in this paper, however, required respondents to answer two binary choice questions, due to the distinct advantages that the DBDC approach offers in terms of statistical efficiency through reduced WTP estimate variance (Hanemann et al., 1991). Indeed, Johnston et al. (2017) state that "incentive properties should be only one of the considerations that influence the selection of a response format."

The respondents in this survey were not told that their payment decisions would definitely lead to the described outcome (should they be willing to pay for it), though payment consequentiality existed to the extent that respondents were told that their water bills would permanently increase should the government improve waste water treatment systems. So, whilst the proposed payment was not "mandatory (or binding)" (Johnston et al., 2017), respondents believed that their offered payments were contingent on the proposed environmental outcome taking place. It is acknowledged, however, that this leads to a potential difference between the empirical application and the theoretical model.

A New Approach

The discussed methods of bringing social norms and social learning into the preference formation process tend to focus on how social norms or learning can impact WTP and are helpful examples of combining individual preference formation with social norms and "preference moralisation" (Lo and Spash, 2013). However, these approaches usually tell us little about the role of social norms in preference formation, despite the fact that social isolation has been found to be directly linked to stated preferences (List et al., 2004). In contrast, this paper primarily looks at the role of social norms on scenario acceptance, which if improved is assumed to reduce the cognitive burden of SP surveys and thus improve their credibility. In addition, it will also test the treatment effect of this social norms information on WTP estimation precision.

Previous research addressing bias is SP techniques has either investigated impacts on WTP (Harrison and Rutström, 2008) or how methods such as cheap talk, consequentiality and certainty follow-up question can reduce it (Penn and Hu, 2018). Other studies have shown that encouraging respondents to swear an oath of truth, before valuation tasks, can reduce bias (Carlsson et al., 2013; Jacquemet et al., 2013).

Including information on social norms via the method used in this paper is beneficial as the approach allows individuals to learn from others and saves significant costs associated with knowledge accumulation (Boyd and Richerson 1988), especially when dealing with complex or unfamiliar goods. Additionally, this alternative approach is well rooted in the emerging research around deliberation and value elicitation (Lienhoop et al., 2015). It is also in accordance with existing views that group deliberation offers improvements to traditional non-market valuation techniques, assisting people to make informed judgements on environmental issues (Christie et al., 2012; Geleta et al., 2018).

The type of group-learnt descriptive social norms that are constructed and applied in this study's SNT assist in understanding more about how people interpret situations and make decisions. Wielgus et al. (2009) make clear that,

> *"In order for the results of stated-preference valuations to be considered valid, valuation scenarios must comply with the assumption that they are realistic and credible to the respondents."*

If the perceived credibility of the SP can be significantly increased then respondents will be less likely to rely on unhelpful heuristics to inform their decisions. "If… …respondents rely on a set of heuristics, in effect they will be answering a different question from that being asked; thus, the resulting values that are elicited will not reliably measure willingness to pay," Arrow et al. (1993). The justification for using *scenario acceptance* as a measure of SP technique improvement is further supported by Krupnick and Adamowicz (2007) who suggest that respondents with low expressed levels of scenario certainty should not be included in analyses. In addition to improving scenario acceptance, the SNT provides a useful direction for future research and practice in line with the recommendations of Schläpfer (2008) who suggests that "respondents should be given the option to answer based on information about the positions of large parties and interest groups with known [agendas] rather than based on the raw policy information." Finally, Glenk and Colombo (2011) support the idea that providing richer information in SP surveys can improve scenario acceptance (or credibility) and therefore the reliability of benefit estimates derived from them.

The approach used in this study incorporates group-learnt descriptive social norms into the learning stage of a CV survey, by expressly providing details about the opinions and views of members of the public who participated in real-life DPWs on the topic of metal water pollution. This information was given to a randomly assigned sub-group of the sample, with the other respondents not receiving the SNT. To best reflect the way in which individuals normally acquire information from well-versed people in their social networks, the SNT used in this paper is centred on one type of information, supplemented by two others. First, and primarily, are group-learnt opinions (i.e. those formed through informed group deliberation) regarding remediating metal water pollution complemented by summary quotes to illustrate opposing views or opinions that were widely shared, whilst avoid references to specific monetary amounts. Second, an explanation of the extent to which the DPW participants felt that the information used in the workshops was fair and balanced. Third, some explanation was provided of how the DPW participants' views developed over the two workshops. Further details on the SNT are given in the Methods section below.

By randomly giving this SNT to a sub-group of the respondents, the treatment effect on how people responded in the WTP scenario was measurable, including reported scenario realism. Incorporating descriptive social norms in this way allows for socially constructed public opinion to form an explicit part of the learning process about the good, whilst avoiding the time and monetary costs associated with the in-depth teaching that would otherwise be needed to significantly improve the education level of respondents contemplating otherwise unfamiliar goods. This novel social norms approach sits amongst the numerous developments in behavioural economics research over the last 15 years and adds to those that are not satisfactorily explained by traditional economic analysis (see Carlsson, 2010). Additionally, it recognises the rising importance of information attainment (and preference formation) through social networks. As Carter and Misztal (2016) state, "the role of social and digital media on the public, politics, and journalism is reshaping ''civil society'' in profound ways," whereby people form their views using social norms rather than just relying directly on experts. The group-learnt descriptive social norms applied in this study specifically highlight how people use preference information taken from well-versed groups of members of the public to inform their decision-making.

Methods

Survey Design

Discussions were held with EA and Defra economists between January and March 2016, with the objective of identifying end-points and subsequent WTP measures that would be most appropriate for informing the next round of RBMP in England and Wales under the WFD. Various focus groups were held throughout February, March and April, to test the survey and its content. Two of these consisted of eight people[36] who were professional survey takers and focused heavily on the online survey material, its presentation format and how the questions were phrased. These latter focus groups took place in London and consisted of equal female and male members[37] across ages 24-65.

Survey Structure

The full survey, covering 801 respondents, consisted of four sections and was designed to take no longer than 15 minutes to complete. The first section asked about respondents' attitudes, knowledge and behaviour regarding societal issues, the environment and chemical water pollution. Posing questions of this type can enable respondents to think carefully about their expressed preferences as well as provide internal tests for response credibility where they predict respondent behaviour (Arrow et al., 1993; Wilcock et al., 2004).

The primary purpose of the second section was to educate respondents on the subject matter, attempting to ensure that they understood the drivers of local chemical water pollution caused by metals and its potential effects. This section covered: the various sources of the type of chemical water in question; characteristics of the chemical type; effects that the chemical type can have in the natural environment (covering specifics regarding animal and plant health); and the expected consequences of remediation efforts. Due to respondents' unfamiliarity with – and the complexity of – the subject matter, short tests were interspersed throughout this section, in order to ensure that respondents understood the topics and the WTP scenarios. At this point, a randomly selected sub-sample of the respondents (n=399) received the SNT.

The third section of the survey centred on the main DBDC WTP questions and its contextual scenario. A series of typical follow-up questions was then used to gauge respondents' reasoning and confidence in their answers, as well as to highlight protest votes and opinions regarding the

[36] So 16 in total.
[37] Recruitment was organised by a professional recruitment firm, PureProfile.

SNT (for those that received the treatment). On the latter, three follow up questions[38] were used to measure the extent to which respondents learned and understood the social norm treatment information. Three quarters of the treatment group answered all three of these questions correctly (with 92% correctly answering two of these).

The final section was mostly comprised of questions relating to respondents' socio-economic characteristics and personal habits.

Survey Scenario

The scenario used, as a baseline, a state in which 10%[39] of our national[40] surface waters (e.g. rivers and lakes) have a level of metal pollution that poses a threat to local animals and wildlife (i.e. the percentage cover that does not meet environmental quality standards, under the WFD and RBMPs, for metal water pollution). Given the complexity and presumed unfamiliarity with metal water pollution, a considerable portion of the survey (prior to the SP scenario) was dedicated to informing respondents about the following topics: metals in the environment; sources and applications; pollution pathways; health impacts (on animals, plants and soil[41]); management options; and cost implications.

It was explained that to tackle this problem, the government is thinking about improving some waste water treatment systems in order to remove these metals before they enter local surface waters. This would reduce metal concentrations, so that no surface waters continue to fail environmental quality standards for metals, and associated damage to local animals and wildlife by metal water pollution would be reduced accordingly in the future. Respondents were informed that, to help pay for the improvements and necessary upkeep of these waste water treatment systems, water bills for households and businesses would permanently increase. The vast majority of the respondents already have experience with this payment vehicle, thus improving plausibility (Morrison et al., 2000). A number of other payment vehicles were explored in the focus groups and water bills were chosen by those members as the most likely to produce meaningful and reliable responses.

The respondents were asked the following dichotomous choice question:

[38] 1) "How many members of the public attended the water pollution workshop?" with five answer options and "I don't know"; 2) "Were most people happy to pay more for their water bills?" with answer options of Yes, No and "I don't know"; and 3) "Were most of the expert citizens concerned with the current level of metal water pollution?" with answer options of Yes, No and "I don't know".

[39] The figure was estimated following discussions with EA experts.

[40] England and Wales only.

[41] This study was restricted to environmental impacts of metal water pollution, excluding impacts on human health, as it is very rare for metal water pollution to impact human health in the UK.

Would your household be willing to permanently pay the following extra amount on your monthly water bill, so that all our rivers and lakes have a level of metal water pollution that does not pose a risk to wildlife and the environment?

The 801 respondents were randomly assigned to one of five sub-groups, each facing a different initial bid amount of either 50p, £2, £5, £10 or £25 (per household, per month) for the given surface water improvement. Respondents were then asked a follow-up WTP question (thus forming the double-bounded component of the dichotomous choice question), depending on their response to the first bid. For example, respondents who gave a negative response to the first bid were then given a lower bid amount in the follow-up question. Conversely, respondents who gave a positive response to the first bid were faced with a higher bid amount in the follow-up question.

The full template of first and (subsequent) second bid amounts is given in Table 1b. The initial (first) bid amounts (and subsequent second bid amounts) were determined following feedback from the pilot survey, as well as the FGs. The intent was to ensure that the proportion of acceptance of the first bid amount was close to 90% for the lowest bid, 10% for the highest bid, and that a broadly even spread occurred in between. As Table 1b shows, this outcome was achieved.

Table 1b: DBDC Bid Flow.

First bid	Second bid (if first bid response was positive)	Second bid (if first bid response was negative)	Acceptance rate of first bid amount
50p	£2	10p	90.6%
£2	£5	50p	70.0%
£5	£10	£2	49.4%
£10	£25	£5	25.5%
£25	£60	£10	9.4%

Deliberative Public Workshops

This paper forms part of a wider collaboration with the EA and Defra, in which the DPWs were used to obtain qualitative information from the public about their thoughts and opinions regarding metal water pollution and the implications for future management options in England and Wales. This section is included to provide some relevant information regarding how those DPWs were administered and what they consisted of.

The two workshop days were held over two consecutive weekends, on Saturday 12th and 19th March 2016, an EA office[42] in Solihull, England. The content for these DPWs was drawn largely from already existing information in the public realm, with some information being provided directly by the EA and Defra. This material was then consulted on by experts from the EA, Defra, Sciencewise[43] and the HSE[44], and their inputs were used to refine the workshops' design and focus.

Following this, the workshops' material was sent to the study's Advisory Board[45] to ensure the material was fairly presented and so encourage the collection of unbiased public views. Informal tests of the workshops' material were held in February and March. Three independent and expert workshop facilitators ran the workshops, and prior to this they provided expertise regarding the workshops' material and the design of the participatory exercises used. In addition to the facilitators, three subject specialists (including from the EA and Defra) were present at each workshop, primarily to provide clarification on arising questions from the participants. The workshops' material provided factual information and a broad background to local chemical water pollution, using metals as a case study. Verbal presentations were used to introduce the topics to the participants, which were then discussed in groups in more detail, using different media including: paper-based text information, infographics and photographs.

29 people were recruited[46] for the DPWs, consisting of a representative spread of the population in England and Wales (by age, gender and class). These same 29 people participated in both the workshops, covering the two consecutive weekends. The two workshops had clear objectives and were organised in a series of distinct sessions, often building upon previous sessions in terms of topic complexity and breadth. For the carousel sessions, the 29 participants were divided[47] into three groups (of nine or ten people each) and the members of these groups remained the same for each of the two days. Each group moved around the carousel tables and worked with different facilitators, eventually discussing all the same themes and topics as the other carousel groups.

The topics of the exercises (group and plenaries) included: Introduction and first thoughts to Local Pollution; Concerns; Awareness, responsibility and communication; Burden of cost;

[42] This location was chosen for various reasons including its ease of access, suitable facilities, budget constraints and that it is in a broadly central area of post-industrial England with a diverse population.
[43] Sciencewise is a government funded programme aimed at increasing the effectiveness with which public dialogue is used in public policymaking, covering science and technology.
[44] The Health and Safety Executive.
[45] The Advisory Board were consulted remotely, via email, and consisting of a water company, the Centre for Ecology & Hydrology, the Chemical Industries Association, two expert academics, CHEM Trust and the Royal Society for the Protection of Birds (RSPB). All were invited to provide comments on the workshops' material.
[46] Recruitment was organised by a professional recruitment firm, CRD Research.
[47] The groups were divided in such a way that each had a similar mixture of ages and genders.

Deliberative homework feedback; Fixing the problem; Action on Local (vs Far-Reaching) Pollution; Your water bills; Management options and sharing the costs; and What we've learnt. The homework task required participants to discuss what they'd learnt on the first day with their friends, family and colleagues over the week between the two DPW days. This element of the learning process aimed to mimic the social aspect of learning associated with typical awareness building in society and so provide a more meaningful and natural grounding from which to continue learning on the second day.

Audio recordings, flipcharts and written notes were used to record participants' views and comments in the carousel group tasks and plenary session discussions. Regular questionnaires were also used to record individual opinions regarding the discussion topics. Prior to beginning the workshops, permission to record this information was obtained from the participants. First, the findings from the flip charts, written notes and questionnaires were compiled. Then the audio recordings were listened through in full, adding in additional relevant findings to the write up where they were missed in the other recording methods.

Scenario Acceptance and the Social Norms Treatment

One of the key variables of interest in this paper is scenario_acceptance. This is treated as a dummy (or binary) variable, representing those respondents who answered either *convincing* or *very convincing* to the following question:

> *The payment task you've just completed was not a real situation, and so required you to imagine that it was a real scenario. How convincing did you find it to be?*

This question was positioned directly after the primary WTP follow-up questions (used to filter out protest responses). This variable was used as the dependent variable in all logit regressions investigating the impact of the SNT.

The SNT used in this study incorporated the views of citizens who had learnt about, comprehended and discussed many different issues associated with the complex matter of metal water pollution. The purpose of the SNT was not to give more factual information about the good in question (metal water pollution), nor to encourage preference elicitation in a social setting. Rather, the intent was to provide additional information specifically about (and limited to) the views of informed members of the public, to determine how this kind of descriptive social norm affects scenario acceptance. All the social views presented in the SNT were from the participants in the DPWs and did not reflect the views or positions of the organisers.

The three text sections shown below in italics are those that were used in the SNT, designed to best illustrate the group-learnt descriptive social norms described in the introduction, which act as a proxy for more natural learning from social networks experienced in real-life. In addition to the text, simple graphics were used to represent the participants at the public workshops, whilst avoiding depicting people of specific ages, races or genders (which might otherwise have biased people's reactions to the views from the DPWs). The wording used in the SNT and the types of topics covered were developed in the focus groups preceding the launch of the online survey.

> *Unfortunately, there is not time in this survey to provide you with a lot of detail about the impacts of metal water pollution. To help your understanding of the importance of metal water pollution to the public, we will share with you some findings from a public consultation that was held on the topic last month, in the UK. 30 members of the public were invited to the consultation, where they learnt from scientists and experts about metal water pollution. They participated in group exercises and tasks aimed at improving their understanding of the issues around metal water pollution. The idea was to train up these members of the public as experts, so they could act as expert citizens. The learning was spread over two Saturdays, with a week in between to help digest all the information. We will now give you a summary of these expert citizens' concluding views and opinions, at the end of the two days learning.*

This first section of the SNT (above) provided the rationale for providing information from the DPWs as well as giving a brief overview of the workshops themselves, how they were administered and their purpose.

> *In anonymous feedback from the 30 expert citizens, almost all of them (97%) said that the information used in the consultation was fair and balanced. Three quarters (75%) of the participants thought that money should be spent on reducing the amount of metal water pollution that enter our surface waters and the environment. The majority (80%) of the participants said that they would be happy to pay more for their water bills, in order to reduce metal water pollution in our surface waters and the environment.*
>
> *Of the 80% who were happy to pay, they said things like:*
>
> *"We all need to take more responsibility for metal pollution"*
>
> *"The environment and wildlife are suffering because of human actions"*
>
> *"We need to spend more to control metal pollution"*
>
> *Of the 20% who were not happy to pay, they said things like:*
>
> *"I already pay water bills, and companies profit from that"*
>
> *"Responsibility should be with the water companies"*

"The water companies should pay"

The objective of this second section of the SNT was threefold. First, it was deemed necessary to provide some indication of whether the DPW participants felt that the information used in the workshops was biased in any way. Second, socially constructed opinions (i.e. those formed through informed group deliberation) regarding the DPW participants' WTP for water quality improvements were represented, whilst avoiding reference to specific monetary amounts (which could otherwise bias the SNT responses). Third, the cause for primary differences in opinions was illustrated, using quotations, so as to personify the findings.

> *At the end of the two Saturdays, most of the expert citizens stated that they were concerned with metal water pollution. Although on average, people were slightly less concerned than they were at the end of the first Saturday. Before attending the first day, 60% of the participants had never heard of metal water pollution before.*
>
> *Other opinions, shared by most of the participants, included things like:*
> *"The costs of improving metal water pollution should be shared across the country"*
> *"There is a lack of awareness about metal water pollution in the public"*
> *"The views of informed members of the public should make a difference to policy"*
> *"I didn't realise that all of us contribute to metal water pollution"*

The purpose of the DPWs was to reveal the range of public views, rather than create consensus opinions, on the various aspects of metal water pollution addressed in the workshops. However, there were several themes of opinion on which the participants tended to agree, and this final section of the SNT was used to provide details on some of those positions. It was also deemed important to highlight the change in importance of the issues over the two days, as well as the DPW participants' knowledge of metal water pollution before attending the workshops.

Distribution

The internet-based pilot survey (100 respondents) was completed in April 2016, the results of which were used to determine appropriate dichotomous choice bid amounts and improve the final survey, which was administered from May 2016. The survey used logit and DBDC approaches and was designed to be completed over the internet in order to avoid interviewer bias issues, reduce financial and time costs and allow respondents more time to think (Hudson

et al., 2004). Online surveys also limit data input errors and allow implementation flexibility (Atkinson et al., 2018), like split samples and response filtering. Furthermore, internet-based SP studies have been shown to produce more conservative WTP estimates (Marta-Pedroso et al., 2007). Olsen (2009) found no significant difference in WTP estimates between internet and postal surveys and it is assumed that the internet method used in this study did not produce any significant bias in the final WTP figures.

The pilot and the final survey were distributed via a professional survey firm[48], using their probabilistic panel of the English and Welsh population. Quotas were set to encourage the respondents' ages (minimum 18) and genders to reflect the target population. Due to the use of a distributing survey firm, there is certainly some bias relating to self-selection by respondents, a common issue with internet-based surveys. Additionally, around 1 in 7 households in Great Britain do not have access to the internet (ONS, 2014), so a sizable portion of the general population has been excluded from this study. This raises an issue regarding representation as people without internet access in the UK are likely to be less educated, have lower incomes or be retired (Dutton and Blank, 2011).

Econometric Models

The logit regression analyses were undertaken using version 14 of the Stata statistical package (Stata, 2016), with the 'doubleb' command package developed by López-Feldman (2013) which uses maximum likelihood (under the assumption of normality) to estimate the DBDC model for CV proposed by Hanemann et al. (1991).

Logit

The standard practice of using coefficients from the regression models to estimate mean WTP (Hanemann and Kanninen, 1996) produced similar results for the logit and probit models, so only logit models are reported. The logit models used either *scenario_acceptance* or *wtp_firstbid* as the dependent variables (see Table 3b). An example using the latter (wtp_firstbid) is depicted below, where the probability of observing a positive response, Prob(yes), is given as:

$$\text{Prob(yes)} = \pi^{y} = \text{Prob(WTP} \geq \text{BID)} \quad (1)$$

whilst the probability of observing a negative response is simply $1 - \pi^{y}$. In the logit model π^{y} takes the form:

[48] PureProfile.

$$\pi^{y}(\text{BID}) = G(\text{BID},\Theta) = (1+e^{[\alpha-\beta(\text{BID})]})^{-1} \quad (2)$$

where $\Theta = (\alpha, \beta)$, α and β represent the estimated coefficients, and BID is the first bid amount presented to respondents. Further respondent variables were added to (or used as the dependent variable in) this basic model to account for their relative effects. The maximum likelihood estimation is the most common method of computing the logit model (Lee, 1997). Following Hanemann et al. (1991) the log-likelihood function is given as:

$$\ln L(\Theta) = \sum_{i=1}^{N}\{wtp_i^{y} \ln \pi^{y}(\text{BID}_i) + wtp_i^{n} \ln [1-\pi^{y}(\text{BID}_i)]\} \quad (3)$$

where $wtp_i^{y} = 1$ when the ith response is positive to the bid offer and 0 otherwise, whilst wtp_i^{n} is 1 if the ith response is negative to the bid offer and 0 otherwise.

DBDC

The DBDC model is an extension of the logit format (Kanninen and Khawaja, 1995) which uses the four possible outcomes of the bid flow described in Table 1b. The possible outcomes and respective probabilities are:

yes-yes = π^{yy}

no-no = π^{nn}

yes-no = π^{yn}

no-yes = π^{nn}

Denoting d_i as a binary indicator variable for responses to the two bids in the DBDC payment tasks, the log-likelihood function (parameterised by Θ) is given as:

$$\ln L(\Theta) = \sum_{i=1}^{N}\{d_i^{yy} \ln \pi^{yy}(\text{BID}_i, B_i^{u}) + d_i^{nn} \ln \pi^{nn}(\text{BID}_i, B_i^{d}) + d_i^{yn} \ln \pi^{yn}(\text{BID}_i, B_i^{u}) + d_i^{ny} \ln \pi^{ny}(\text{BID}_i, B_i^{d})\} \quad (4)$$

where BID_i is the first bid value, B_i^{u} is the higher follow-up bid value and B_i^{d} is the lower follow-up bid value.

Additional Notes and Data Handling

Respondents were told that to tackle the problem of metal water pollution, the government is thinking about improving some waste water treatment systems to remove these metals from surface waters. In terms of the perceived consequentiality of their responses, respondents were told that to help pay for these improvements, their water bills would permanently increase. They

were not told that their response would lead to a policy change with certainty, but respondents were assumed to believe that their hypothetical payments depended on the proposed environmental outcome taking place. No follow up questions were used to determine or measure perceived consequentiality directly, as this was not a primary focus of this paper, so this is not tested for in the models.

This paper implemented a relative measure of respondent efficiency to test the impact of the information treatment on WTP precision. This test is constructed by dividing the 95% confidence interval by the mean WTP estimate, and then comparing the results between the treatment and control samples. In this test, which has been used across many stated preference surveys (Loomis and Ekstrand, 1998; Jeanty and Hitzhusen, 2007; Kingsley and Brown, 2013; Kim and Kim, 2016, p222), a lower precision figure indicates a higher relative level of estimation precision.

Several methods were used in the SP scenarios and questions, to encourage realistic and reliable answers. First, a one-month period of time was chosen for the payment phase, in order to emulate the most common type of water bill payment period. Second, respondents were asked in an earlier part of the survey to state or estimate how much their household normally spends on water bills and respondents were reminded of these amounts immediately prior to answering the WTP questions. Third, the annual equivalents appeared in brackets next to the one-month bid amounts. Fourth, cheap-talk bullet points were displayed before the WTP questions, including reminders of budget constraints (Cummings and Taylor, 1999). Finally, answer-prompts and minimum time limits were applied to avoid nonresponses and survey rushing, respectively.

Protest bids and other invalid responses can occur for various reasons. They do not represent genuine economic values and therefore should not be used to calculate WTP values (Jorgensen, et al., 1999). Broadly following guidance in Bateman et al. (2002, pp. 145-147), such responses (less than 5% of the pre-analysis total) were identified using WTP follow-up questions and subsequently removed from the analysis. Answers by zero-bid respondents who “didn’t take the choice games seriously”, “didn’t understand the choice games” or refused to accept a bid due to a view that it is the responsibility of somebody else (e.g. government) to pay were treated as protests. However, the following types of answers were treated as legitimate zero-bid responses (which served the purpose of maximising the usable data): cannot afford or object to higher prices; other priorities; or a lack of interest. In line with Kountouris et al. (2015), this study selected a payment vehicle to maximize realism (and an information treatment to improve scenario credibility), which could have decreased protest response rates. Indeed Campos and

Caparrós (2009) show how the framing of a CV question can greatly influence the protest response rate. Household WTP values were sought (instead of individual values), as they are most appropriate when aggregating estimated values countrywide (Strand, 2007; Lindhjem and Navrud, 2009).

Results

Descriptive Statistics

The online surveys used in this study were administered from May 2016. Following the removal of protest responses, a total of 801 individuals living in England and Wales were surveyed. Quotas ensured the sample was largely representative of the target population by age (minimum 18) and gender. Table 2b gives the descriptive composition of the respondents who completed the survey, compared to the target population of England and Wales[49]. It shows that the survey sample is mostly representative of the English and Welsh public, with respect to the demographic attributes listed. However, people with higher levels of education have been over-sampled and ethnic minorities have been under-sampled.

Table 2b also illustrates differences between the group of respondents who received the social norms treatment (SNTG) and the CG. To test for differences between the two samples, the snt variable was regressed on all the observable variables used in the regressions. P values were greater than 0.1 for all variables (although $P<0.15$ for the hh_income, employed and trace_element variables), indicating that there are no significant differences between the two groups and the randomised split sample was unbiased. Further assurance of the data is provided by the fact that the estimated average annual household water bill (£369) was remarkably close to the UK average of £389 (Water UK, 2017).

Before taking the survey in this study, less than half of the respondents had taken an interest in environmental pollution issues and less than half had heard the phrase ‘trace elements’ (a term that is commonly used in association with metals and their levels in the environment).

[49] The UK public, which is where many of the reference statistics refer to, is assumed to be representative of the populations of England and Wales.

Table 2b: Descriptive Statistics.

Variable	Attribute	All Respondents (n=801)	Social Norms Treatment Group (SNTG) (n=399)	Control Group (CG) (n=402)	Target Population
Gender (%)	Female Male	47.9 52.1	49.1 50.9	46.8 53.2	50.8 49.2 (ONS, 2013a)
Household income[50] (£k)		37.9	36.3	39.5	38.1 (ONS, 2014b)
Living location (%)	Urban Rural	81.5 18.5	81.7 18.3	81.3 18.7	79.9 20.1 (World Bank, 2013)
Ethnicity (%)	White/Caucasian Asian Black/African Mixed Other[51]	91.6 4.5 0.6 1.7 1.5	90.2 4.5 0.8 3.3 1.3	93.0 4.5 0.5 0.2 1.7	87.2 6.9 3.0 2.0 0.9 (ONS, 2011a)
Marital status (%)	Single Married[52] Widowed Divorced[53]	27.7 60.9 2.9 8.5	25.8 61.2 3.5 9.5	29.6 60.7 2.2 7.5	35.6 48.1 7.0 9.3 (ONS, 2011b)[54]
Respondent education[55] (%)	School College Undergraduate Postgraduate	28.0 33.8 28.2 10.0	27.3 35.3 27.1 10.3	28.6 32.3 29.4 9.7	46.0 21.9 24.9 7.2 (DfE, 2007)[56]
Mean average household size (people)		2.5	2.6	2.5	2.3 (ONS, 2011c)
Respondent Employment (%)	Employed Unemployed Inactive/Other	60.7 3.1 36.2	61.9 2.5 35.6	59.5 3.7 36.8	59.6 4.2 36.2 (ONS, 2014c)
Living situation (%)	Homeowner Rent and Other	67.4 32.6	67.2 32.8	67.7 32.3	64.0 36.0 (ONS, 2013b)[57]
Average age (years)		49.1	49.3	49.0	
Environment importance[58] (%)	Yes No	61.3 38.7	63.9 36.1	58.7 41.3	
Heard 'trace elements'[59] (%)	Yes I think so No	46.1 29.8 24.1	48.6 29.3 22.1	43.5 30.3 26.1	

[50] Mean average annual household income before tax.
[51] Includes 'Prefer not to say'.
[52] Includes Civil Partnerships.
[53] Includes people who are separated.
[54] England and Wales only.
[55] Highest level of education completed by the respondent.
[56] For individuals in England only, excluding those with 'no qualifications'.
[57] England and Wales only.
[58] Respondents who answered 'important' or 'very important' to the question: "How important is the issue of 'Climate Change and the Environment' to you?".
[59] Respondents were asked: "Have you ever heard the phrase 'trace elements' before [taking this survey]?".

Annual household water bill (£)		368.5	371.3	365.6	
Answer to 'surface water' question[60] (%)	Correct Incorrect	80.0 20.0	79.9 20.1	80.1 19.0	
Interested environmental pollution[61] (%)	Yes No	45.8 54.2	48.6 51.4	43.0 57.0	
The following variables were all collected *after* the SP task					
High policy certainty[62] (%)	Yes No	31.2 68.8	31.3 68.7	31.1 68.9	
High scenario acceptance[63] (%)	Yes No	69.2 30.8	71.2 28.8	67.2 32.8	
High public support[64] (%)	Yes No	68.2 31.8	71.4 28.6	64.9 35.1	
High concern[65] (%)	Yes No	70.4 29.6	75.4 24.6	65.4 34.6	
Health above average[66] (%)	Yes No	32.3 67.7	31.6 68.4	33.1 66.9	

Regression Models

Table 3b provides a list of all the variables used in the various regression models, which are shown in Tables 4-8. Initial models (not reported in full) showed that simply receiving the SNT (i.e. those in the SNTG) did not have a statistically significant impact on scenario acceptance. On closer inspection, the results showed that of the group of respondents who received the social norms treatment (SNTG), some (<10%) appeared not to have paid full attention to the SNT information. These individuals were identifiable due to their incorrect answer to the following post-SNT follow-up question:

> *[In order to reduce metal water pollution in our surface waters and the environment] were most people [in the DPWs] happy to pay more for their water bills?*

[60] Respondents were asked: "What are surface waters?". The correct answer in the context of the survey was 'Rivers and Lakes'.

[61] Respondents who answered 'yes' to the question: "Before taking this survey, had you ever taken an interest in environmental pollution issues?".

[62] Respondents who answered 'sure' or 'very sure' to the question: "How sure are you that the proposed 'waste water treatment' systems would have the result described in the scenario (e.g. that the government and water companies would act efficiently and as instructed, resulting in [the specific environmental improvements stated])?".

[63] Respondents who answered 'convincing' or 'very convincing' to the question: "The payment task you've just completed was not a real situation, and so required you to imagine that it was a real scenario. How convincing did you find it to be?"

[64] Respondents who answered 'supported' or 'strongly supported' to the question: "If 'waste water treatment' systems across [England and Wales] were improved, to remove harmful levels of metals from our surface waters (e.g. rivers and lakes), do you think this would be supported or opposed by the public overall?".

[65] Respondents who answered 'concerned' or 'very concerned' to the question: "How concerned are you about the impacts that metal water pollution can have on animals and wildlife?".

[66] Respondents who answered 'above average' to the question: "How well do you rate your health, compared with the average UK person?".

Consequently, the binary *snt* variable shown in all tables denotes respondents in the SNTG who also correctly answered this simple comprehension question about it. This ensures that the models are testing individuals who paid attention to the SNT and so truly received it. Note that some of the results tables have, at the bottom, an indication of the insignificance of the sntg variable when replacing the snt variable. It is also relevant to note that only 6% of the SNTG stated that they did not trust the public views in the SNT.

Table 3b: List of Variables.

Variable	Type	Description
age	interval	Age of the respondent in years Coded as the midpoint of the stated range in survey, >77 coded to 80
bills_estimate	interval	£ value of respondent's estimated annual household water bill The average of £369 for those who didn't know
bills_knowledge	dummy	Respondent knew how much their household spent on water bills 0 = no, 1 = yes
bills_responsible	dummy	Respondent is fully responsible for paying the water bills in their household 0 = no, 1 = yes
charity	dummy	Respondent donates 'once a month' or more to charity 0 = no, 1 = yes
chem_concern	dummy	Respondent was 'concerned' or 'very concerned' about the impacts that metal water pollution can have on animals and wildlife 0 = no, 1 = yes
city	dummy	Respondent lives in a city 0 = no, 1 = yes
climate_env	dummy	Respondents stated that the issue of 'Climate Change and the Environment' was 'important' or 'very important' to them 0 = no, 1 = yes
dbdc_certain	dummy	Respondent was 'absolutely certain' about the stated preference payment decisions they made in the dbdc questions 0 = no, 1 = yes
dbdc_easy	dummy	Respondent found it 'quite easy' or 'very easy' to answer dbdc questions 0 = no, 1 = yes
education	dummy	The highest level of education completed by a member of the respondent's household is an undergraduate degree/Bachelor's or higher 0 = no, 1 = yes
employed	dummy	The respondent was employed in paid work (full-time, part-time or self-employed) 0 = no, 1 = yes
env_pollution	dummy	Respondent had taken an interest in environmental pollution issues before starting the survey 0 = no, 1 = yes
exercise	dummy	Respondent exercises '3 days per week' or more 0 = no, 1 = yes
female	dummy	Respondent was female 0 = no, 1 = yes
firstbid	interval	£ value of first bid (annualised), multiplied by 10[67]
gov_responsible	dummy	Respondent stated 'Government' as one of the top actors responsible for providing reliable information to the public about the impacts of metal water pollution 0 = no, 1 = yes
habit_fire	dummy	Respondent checks their household fire-alarms at least once a year 0 = no, 1 = yes
habit_insurance	dummy	Respondent always gets insurance before a holiday 0 = no, 1 = yes
habit_organic	dummy	Respondent often buys organic food

[67] Multiplying by 10 avoided decimal places, which were necessary to avoid in the statistical analysis.

		0 = no, 1 = yes
habit_pension	dummy	Respondent puts into a pension scheme every month 0 = no, 1 = yes
hh_income	interval	Respondent's household income before tax, in £1,000s Coded as the midpoint of the stated range in survey, <£10k coded as £5k, >£200k coded as £250k, 'Prefer not to say' coded as the average £38k
policy_certainty	dummy	Respondent was 'sure' or 'very sure' that the proposed waste water treatment systems would have the result described in the scenario (e.g. that the government and water companies would act efficiently and as instructed under the new policy) 0 = no, 1 = yes
policy_knowledge	dummy	Respondent correctly identified how many surface waters would fail safety levels for metal water pollution if the government improved waste water treatment systems 0 = no, 1 = yes
pollution_knowledge	dummy	Respondent correctly answered at least two (out of four) 'true or false' questions about (1) metals in the environment, (2) pollution pathways, (3) impact on animal and wildlife and (4) management options 0 = no, 1 = yes
products_knowledge	interval	The number of correct answers to questions about what consumer products contain metals (four maximum)
public_support	dummy	Respondent stated that the water quality improvement policy described in the scenario (to remove harmful levels of metals from surface waters) would be 'supported' or 'strongly supported' by the public overall 0 = no, 1 = yes
referendum	dummy	Respondent answered 'yes' to the referendum WTP question 0 = no, 1 = yes
scenario_acceptance	dummy	Respondents answered either 'convincing' or 'very convincing' to the following question: "The payment task you've just completed was not a real situation, and so required you to imagine that it was a real scenario. How convincing did you find it to be?" 0 = no, 1 = yes
single	dummy	Respondent's marital status is 'single' 0 = no, 1 = yes
snt	dummy	Respondent was (randomly) assigned to the SNTG and correctly answered the test question ("Were most people [in the DPWs] happy to pay more for their water bills?"), thus proving they paid attention to the treatment 0 = no, 1 = yes
sntg	dummy	Respondent was (randomly) assigned to the SNTG but did not necessarily answered the test question correctly (see snt variable description above) 0 = no, 1 = yes
trace_element	dummy	Respondent had heard the phrase 'trace elements' before talking the survey 0 = no, 1 = yes
two_bed	dummy	Respondent's household has no more than two bedrooms 0 = no, 1 = yes
vege	dummy	Respondent is a vegetarian 0 = no, 1 = yes
water_knowledge	dummy	Respondent correctly identified that 'surface waters' consist of 'rivers and lakes' 0 = no, 1 = yes
white	dummy	Respondent described their ethnic background as 'White or Caucasian' 0 = no, 1 = yes
wtp_firstbid	dummy	The respondent was willing to pay the first bid amount 0 = no, 1 = yes

Logit Models

In all logit models (Tables 4-7), scenario_acceptance and wtp_firstbid are used as the dependent variables (as indicated in the model titles). The first two basic models are shown in Table 4b, with extended models investigating respondent demographics, attitudes and behaviours in Tables 5-7, respectively. Whilst there are many approaches to building regression models, for the purpose of this paper the objective was to first explore the relationship between distinct types of variables and the dependent variables. Of course, these variables are mostly jointly determined, however splitting them out in the first instance simply makes the interpretation more manageable, by breaking the associations into tangible groups of variable type. A jointly determined approach is ultimately given in the final models in Table 8b (i.e. they combine the relevant variables across these categories), which are better suited for broad interpretation and policy-relevance.

Across the three extended models in Tables 5-7, the treatment effect of the SNT was a 70-78% increase in the probability that respondents found the hypothetical scenario and payment tasks more real and convincing. The snt variable was highly statistically significant (P<0.01) in all scenario_acceptance models and none of the WTP models, indicating that the SNT does not influence WTP directly via the estimated mean. As expected, the firstbid variable was consistently (negatively) significantly associated with respondent WTP.

Table 4b: Basic Models.

Model Variable	Logit scenario_acceptance basic	Logit wtp basic
snt	0.4321*** (0.1564) [1.5405]	0.3294* (0.1687) [1.3901]
firstbid		-0.0015*** (0.0001) [0.9985]
Constant	0.6225*** (0.0999)	1.1057*** (0.1389)
Observations	801	801
Log likelihood	-490.977	-421.270
Pseudo R^2	0.0078	0.2410
P value of sntg (when replacing snt)	0.219	0.365

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard Errors in parentheses. Odds Ratios in square brackets.
All figures given to three or four decimal places.

Of the demographic variables modelled in Table 5b, across both models people's income, house size, gender and location did not impact the dependent variables. Similarly, the size of respondent bills (and whether they were responsible for paying it) did not have a significant effect. Being white and in a relationship was positively associated with the dependent scenario_acceptance variable, and similarly respondents who were employed in work were

about 60% more likely to find the scenario convincing. In the WTP model, respondent age and household education level were both positively associated with WTP.

Whilst some of these variables are not obviously linked to scenario_acceptance, they were included as they're all demographic variables and may act as proxy variables for something unobserved. Given their strong association in some cases (e.g. variables white and single) it seems prudent to retain them in the reported statistics rather than ignore them on the grounds that an obvious link cannot be readily made. For example, there may be unobserved but real average differences in the way that white or single people view the world, such as is suggested by the results in this paper.

Table 5b: Demographic Models.

Model Variable	Logit scenario_acceptance demographics	Logit wtp demographics
snt	0.5761*** (0.1660) [1.7791]	0.3254* (0.1723) [1.3846]
firstbid		-0.0016*** (0.0001) [0.9984]
female	0.1798 (0.1637)	0.1566 (0.1759)
age	0.0115* (0.0070) [1.0115]	0.0164** (0.0075) [1.0166]
city	0.2010 (0.1788)	-0.2002 (0.1898)
bills_responsible	-0.0923 (0.1775)	0.0351 (0.1938)
hh_income	-0.0046 (0.0033)	0.0039 (0.0036)
two_bed	0.2213 (0.1792)	-0.0487 (0.1894)
education	0.3124* (0.1735) [1.3667]	0.4629** (0.1872) [1.5887]
employed	0.4619** (0.1975) [1.5871]	0.0239 (0.2127)
single	-0.5715*** (0.1903) [0.5647]	0.1502 (0.2052)
white	0.7762*** (0.2870) [2.1731]	0.4230 (0.3158)
bills_estimate	-0.0006 (0.0004)	0.0009* (0.0005) [1.0009]
Constant	-0.6977 (0.5585)	-0.8001 (0.6224)
Observations	801	801
Log likelihood	-471.9926	-410.1822
Pseudo R^2	0.0462	0.2610
P value of sntg (when replacing snt)	0.279	

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard Errors in parentheses. Odds Ratios in square brackets, only reported when p < 0.1.
Most figures given to four decimal places.

Table 6b shows the relationship between respondent attitudes and the dependent variables scenario_acceptance and wtp_firstbid. In addition to the snt variable, several other variables were found to be significantly associated with perceptions of scenario realism. Notably, respondents who were the surest that the proposed waste water treatment systems would have the result described in the scenario (e.g. that the government and water companies would act efficiently and as instructed under the new policy) were about 10 times more likely to find the

survey's scenario and payment tasks convincing. As one would expect, respondents who were most concerned with the impacts of metal water pollution on animals and wildlife were more likely to accept the first bid amount. Interestingly, a lack of certainty regarding the SP payment decisions was associated with higher bid acceptance rates. Unsurprisingly, people who answered the referendum question positively were also more likely to accept the first bid.

Table 6b: Attitudinal Models.

Model Variable	Logit scenario_acceptance attitudes	Logit wtp attitudes
snt	0.5287*** (0.1888) [1.6967]	0.0772 (0.1891)
firstbid		-0.0017*** (0.0001) [0.9983]
climate_env	-0.0259 (0.2011)	0.3093 (0.2041)
trace_element	-0.1540 (0.1919)	-0.0418 (0.1957)
bills_knowledge	0.2421 (0.1965)	-0.1711 (0.2021)
referendum	0.3184 (0.2149)	1.1849*** (0.2136) [3.2705]
water_knowledge	0.4844** (0.2368) [1.6232]	-0.2301 (0.2574)
policy_certainty	2.3831*** (0.3026) [10.8387]	0.4114* (0.2133) [1.5089]
public_support	0.5996*** (0.1952) [1.8214]	0.2858 (0.2164)
chem_concern	0.3753* (0.2130) [1.4555]	0.8597*** (0.2271) [2.3625]
gov_responsible	0.2598 (0.1855)	-0.1020 (0.1890)
dbdc_easy	-0.2572 (0.2226)	0.2162 (0.2271)
dbdc_certain	0.2223 (0.2017)	-0.4610** (0.2043) [0.6307]
products_knowledge	0.1884** (0.0954) [1.2073]	-0.0507 (0.1029)
policy_knowledge	0.7027*** (0.2557) [2.0192]	-0.3730* (0.2054) [0.6887]
pollution_knowledge	0.9378** (0.3986) [2.5543]	0.0171 (0.1102)
Constant	-2.6696*** (0.4296)	0.4594 (0.3962)
Observations	801	801
Log likelihood	-375.6717	-367.4330
Pseudo R^2	0.2408	0.3380
P value of sntg (when replacing snt)	0.224	

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard Errors in parentheses. Odds Ratios in square brackets, only reported when p < 0.1.
Most figures given to four decimal places.

Table 7b shows the relationship between respondent behaviours and the scenario_acceptance and wtp_firstbid variables. People who had previously taken an interest in environmental pollution were more likely to have found the scenario and payment tasks convincing, as were people who always get insurance before a holiday. Similarly, higher WTP was positively associated with environmental pollution interests. Remarkably, but understandably, respondents who often buy organic food were five times as likely to accept the first bid than those who don't. Regressing scenario_acceptance on the behavioural wtp_firstbid variable

shows a positive and significant relationship between the two, however the second model clearly shows that this is not directly driven by the SNT.

Table 7b: Behavioural Models.

Model Variable	Logit scenario_acceptance behaviour	Logit wtp behaviour
snt	0.5477*** (0.1661) [1.7292]	0.2270 (0.1766)
firstbid		-0.0016*** (0.0001) [0.9984]
wtp_firstbid	0.4826*** (0.1637) [1.6203]	
env_pollution	0.5306*** (0.1683) [1.7000]	0.7689*** (0.1847) [2.1575]
habit_organic	-0.5295* (0.2966) [0.5889]	1.6173*** (0.4308) [5.0397]
habit_insurance	0.3458** (0.1614) [1.4131]	0.3297* (0.1779) [1.3905]
habit_fire	-0.0718 (0.1870)	-0.0653 (0.2045)
habit_pension	0.2016 (0.1653)	0.2453 (0.1796)
charity	0.0472 (0.17587)	0.2617 (0.1945)
exercise	0.2305 (0.1665)	-0.0714 (0.1835)
vege	0.1031 (0.2994)	-0.0552 (0.3177)
Constant	-0.1416 (0.2106)	0.4836** (0.2397)
Observations	801	801
Log likelihood	-469.2000	-395.4533
Pseudo R^2	0.0518	0.2875
P value of sntg (when replacing snt)	0.321	

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard Errors in parentheses. Odds Ratios in square brackets, only reported when p < 0.1.
Most figures given to four decimal places.

Extended Logit and DBDC WTP Models

Some of the most influential and meaningful variables were then used in the 'Logit wtp combined' and 'DBDC wtp extended' models (see Table 8b). The extended DBDC model has various highly statistically significant variables and applies the most advanced SP method in this paper. Therefore, the WTP estimate from this model – mean WTP[68] of £73.79 household^{-1} yr^{-1} (95% confidence interval = £66.87-80.72) for completely removing metal water pollution from surface waters (in England and Wales) – is the most recommended for policy use and that which is reported.

Interestingly, unlike with the logit models, the household income variable is strongly and positively associated with WTP in the DBDC models. The habit_organic, chem_concern and dbdc_certain variables all behaved in accordance with the previous WTP models. This extended

[68] For ensuring that all surface waters are free from environmentally damaging levels of metal pollution (baseline = 90%).

DBDC model is the only one to show a significant relationship (positive) between WTP and larger households[69], as well as WTP and the frequency with which respondents give to charity.

As described in the Methods section, this paper incorporated a relative test of respondent efficiency to measure the impact of the information treatment on WTP precision. Using the confidence intervals and mean WTP from model 'DBDC wtp basic' (see Table 8b), the measure of WTP precision improved in the treatment group (reducing from the control group level of 0.275 to 0.193). Similarly, the control group's measure of precision in the 'DBDC wtp extended' model (0.252) reduced (to 0.188) for the treatment group. All precision figures reported to three significant figures. As per the protocol followed in previous studies (Loomis and Ekstrand, 1998; Jeanty and Hitzhusen, 2007; Kingsley and Brown, 2013; Kim and Kim, 2016, p222), this indicates that the information treatment improved WTP precision, relative to the control group.

When 'less sure' respondents[70] (n=196) were removed from the sample, the impact on mean WTP was insignificant. However, there was an observed reduction in WTP precision relative to the models reported in Table 8b, with the measure of WTP precision increasing from 0.193 (for the 'DBDC wtp extended' model) to 0.214.

[69] Those with three or more bedrooms.

[70] This was constructed from the dbdc_certain variable, by only selecting respondents who answered 4 or 5 to the follow up question: "How certain are you about the 'yes or no' payment decisions you have just made (on a scale of 1-5)?".

Table 8b: Final Logit and DBDC Models.

Model Variable	Logit wtp combined	DBDC wtp basic	DBDC wtp extended
snt	0.0552 (0.1841)	82.6333 (73.2905)	-32.6208 (72.2507)
hh_income	0.0024 (0.0035)	4.6308*** (1.3975)	3.6318*** (1.3975)
habit_organic	1.6474*** (0.4382) [5.1934]		434.2130*** (137.3253)
chem_concern	1.1601*** (0.2045) [3.1901]		621.1619*** (81.9347)
dbdc_certain	-0.3291* (0.1846) [0.7196]		-161.9836** (72.4721)
two_bed			-165.2120** (76.1854)
charity			151.8131** (76.9285)
bills_estimate	0.0014*** (0.0005) [1.0014]		
firstbid	-0.0017*** (0.0001) [0.9983]		
env_pollution	0.55498*** (0.1902) [1.7418]		
Constant	-0.2702 (0.3043)	527.6645*** (73.1320)$^{\beta}$ 899.0278*** (36.5292)$^{\sigma}$	216.7674** (103.9824)$^{\beta}$ 853.7235*** (34.2231)$^{\sigma}$
Observations	801	801	801
Log likelihood	-377.1257	-1058.7938	-1011.9164
Pseudo R^2	0.3205		
Estimated mean WTP household^{-1} yr^{-1} (£)		74.0471*** (3.6469)	73.7939*** (3.5336)
WTP estimate 95% Confidence Interval		66.90-81.19	66.87-80.72

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard Errors in parentheses. Odds Ratios in square brackets, only reported when p < 0.1. β = beta coefficient, σ = sigma coefficient.

Most figures given to four decimal places.

WTP figures were estimated straightforwardly, by summing that model's constant and explanatory variable values (multiplied by their average value, determined directly from the full sample), as per the guidance provided by López-Feldman (2013), who also provides a full econometric estimation using the double-bounded model. So for example, for the 'DBDC wtp basic' model, WTP = (527.6645)+(82.6333*0.4494382)+(4.6308*37.93508), and then the estimate is divided by 10 in order to reverse a prior data treatment (which multiplied the bid amounts by 10 to remove decimal places before running the models).

Discussion

Treatment effect on WTP

The SNT was not found to significantly ($P<0.05$) affect WTP in any of the models where it featured (both logit and DBDC). This provides some shelter from criticism that such treatments unfairly bias WTP estimates per se. Past research has either focused on the effect of bias on WTP (Harrison and Rutström, 2008) or how certain methods can reduce bias, such as cheap talk, consequentiality and certainty follow-up questions (Penn and Hu, 2018). Instead, this paper addresses a new way to reduce the drivers of such bias, without affecting the WTP estimates.

The information treatment doesn't directly drive a change in the estimated mean of the WTP value. However, with its strong influence on scenario acceptance, and the lack of studies on this phenomenon to date, this suggests that the SNT could still matter for practical purposes. This paper incorporated a relative test of respondent WTP efficiency (described in the Methods section), which indicated that the information treatment had the effect of a relative improvement in WTP precision. Whilst the average WTP result is the same with or without the SNT, the treatment appears to have reduced the WTP spread (relatively) without necessarily shifting the mean significantly. Consequently, the SNT is judged to be successful in terms of respondent experience of scenario and payment task realism and credibility, as well as an improvement in WTP precision.

Interestingly, the SNT did impact on WTP in the demographic model (Table 5b), increasing the likelihood of accepting the first bid amount by about 38%, but we can only be 94% confident of that ($p=0.059$). Whilst outside the bounds of typically used levels of significance, this does suggest that there may be more to say about the association between SNTs and mean WTP, if future research develops the foundations provided in this paper.

Treatment Effect on Scenario Bias

The SNT applied in this study consistently reduced scenario realism bias across all models. In the three extended models (see Tables 5-7), the positive and significant treatment effect of the SNT was a 70-78% increase in the probability that people found the hypothetical scenario and payment tasks more real and convincing. This improvement indicates that incorporating such SNT methods can increase the reliability of results from SP research. The preferred method of assessing the extent of bias caused by a hypothetical scenario is to measure SP outcomes with that of real life (Harrison and Rutström, 2008). The approach taken in this paper provides a

means of assessing the extent of scenario realism bias for complex and unfamiliar goods, where no *real* market exists. To some extent, the SNT may have offered some convenient decision-making heuristics (Lapinski and Rimal, 2005), which mimic the way in which people might make such decisions in real life. Further, the results verify the views of Fazio (1990), that such social information can help people to define particular situations and better understand information within them.

It is perhaps not surprising that the SNT had such an influence on how realistic people found the scenario to be, given that a key finding from the DPWs was that the most highly trusted source of information was determined to be friends and family (the most *social* group available to choose from, compared with scientists, the government, regulators and the media). This held even when workshop participants admitted that such information may not always be accurate, as what mattered was that the source was perceived not to intentionally deceive, unlike other types of information. Similarly, over 90% of those receiving the SNT in this study trusted the public views in it. The outcome is in line with the opinions of Sagoff (1998), that preference construction procedures can justifiably include social learning which mimics that of real life conditions.

Future research could investigate, using follow-up questions with respondents who receive an SNT, the aspects of the treatment that made the biggest impressions. This might provide a means of guiding the construction of more specific SNTs, as well as helping to explain *how* SNTs can reduce any biases associated with a lack of scenario realism.

Simply receiving the SNT (i.e. those in the SNTG) was not shown to have a statistically significant impact on scenario acceptance, unlike the snt variable. This result shows that respondents need to pay attention for an SNT to work and it highlights the necessity of using follow-up questions to test whether or not people have truly received such treatments. Such authentication is highly recommended in future research, where the aim should be to develop the foundational approach applied in this study of incorporating group-learnt descriptive social norms into SP surveys.

Scenario Bias

Beyond the SNT, other variables were also found to have had an impact on the extent to which respondents may have been biased by how realistic they found the scenario and payments tasks to be. As noted in the Results section above, policy certainty was found to be powerfully associated. People who were most sure of the scenario's policy certainty (that the government

and water companies would act efficiently and as instructed under the new waste water treatment policy) were around 10 times more likely to find the survey's scenario and payment tasks convincing. Past research has investigated the effect of choice certainty on WTP (Berrens et al., 2002; Maier et al., 2015; Andor et al., 2017), however this is the first time (to the best of the author's knowledge) that the relationship between policy certainty and scenario realism has been empirically measured. Similarly, people who found the scenario convincing were also more likely to think that the proposed water quality improvement policy would be supported by the public.

The model in Table 7b shows that improved scenario realism (indicated by more convincing scenario and payment tasks) is positively and significantly associated with WTP. Whilst this indicates an association between scenario realism and WTP (Harrison and Rutström, 2008), the second model in Table 7b clearly shows that the SNT does not influence WTP directly via the estimated mean.

The models also found that respondents who had previously taken an interest in environmental pollution were significantly more likely to have found the scenario and payment tasks convincing. This appears logical, given that such interests are likely to have provided some further contextual background to the SP scenario, rendering it less unfamiliar, thus alleviating concerns regarding its validity. It was also found that people who always get insurance before a holiday were more likely to find the scenario convincing. It is perhaps not surprising that people who are used to regularly paying to avoid potential risks are more comfortable with such scenarios.

Various other variables relating to respondent knowledge[71] were found to be associated with how convincing and realistic they found the survey scenario and payment tasks to be. It is reasonable that that respondents who better understood the information given in the survey found the scenario more convincing. Subsequently, this relationship shared by these variables indicates that people are more convinced by things if they understand them.

It is not clear why single, non-white and unemployed people found the scenario and payment tasks less convincing. Consequently, these observations merit further research.

[71] Specifically water_knowledge, policy_knowledge, pollution_knowledge and products_knowledge.

Social Norm Effects

Group dynamics can sometimes weaken the quality and democratic objectives that justify them, when introducing group social norm dynamics that influence behaviour when decisions are made in a group setting. However, as noted by Vargas and Diaz (2017), such unwanted group effects can be prevented where their occurrence is conditional on the method of incorporating deliberative techniques. In line with the approach used in their study, this paper enabled participants to state their WTP individually and anonymously, whilst still being exposed to the deliberative views via the SNT. Consequently, it advances the participatory approaches covered by Vargas and Diaz, in doing so measuring the effect of social norms on people's WTP.

This approach, which is an advancement on existing market stall or DMV methods, avoids the impacts of social conformity and desirability bias that are known to be greater when a collective or public decision is required (Loomins, 2014; Vargas et al., 2017), whilst allowing for shared values to be incorporated (Irvine et al., 2016). Consequently, this paper goes some way to advancing the calls made by Tadaki et al. (2017) for environmental valuation research to address citizen empowerment and environmental democracy. Their paper makes clear that exploring how environmental valuations can facilitate different forms of participation, new frameworks and hybridizations can emerge. By focusing on the treatment effect of social norm information on scenario realism and WTP precision, this paper addresses the *way* in which choices are formed, not just what they amount to.

Drivers of WTP

The SNT itself was not found to significantly drive mean WTP either way, although a relative test did indicate that WTP precision improved in the treatment group. Further, various other variables were found to be associated with WTP. For example, an age increase of one year increased the probability that a respondent accepted the initial bid by 1.7%, and higher levels of household education level were also positively associated with WTP. Curiously, whilst the household income variable was not statistically significant in the logit models, it was strongly and positively associated with WTP in the DBDC model. This sensitivity of WTP to household income is in line with economic theory and understandably not an uncommon occurrence across SP research (Vecchio and Annunziata, 2015; Nosratnejad et al., 2016; van Houtven et al., 2017; Khong et al., 2018). However further investigation would be required to determine whether or not the income elasticity of the marginal WTP for surface water treatment is constant (see Barbier et al., 2017).

As one would expect, respondents who were most concerned with the impacts of metal water pollution on animals and wildlife were more likely to express higher WTP values (in both the logit and DBDC models). This is in accordance with the other papers in this submission that find a strong relationship between concern and WTP and relates to the positive association of environmental pollution interests with WTP. In the final DBDC model this was the strongest variable in terms of impact on WTP and (in the absence of further follow up questions) it is possible that this is a solely or largely self-regarding driver. However, some of the other more obviously outward looking drivers also merit comment. Interestingly, people who often buy organic food were five times more likely to accept the first bid (in the logit models) than those who didn't, and the direction of this significantly positive relationship also held in the DBDC model. As with the insurance variable, this is probably due to the person already being accustomed and interested in paying premiums to access goods that are isolated from pollution. Likewise, the DBDC model showed a significant relationship (positive) between WTP and the frequency with which respondents give to charity. A possible interpretation here is that if people are already used to giving money to good causes, then they could be more likely to give money in an SP scenario. If this was a driver, then this could indicate that they are inherently altruistic. However, given the stronger and more significant habit_organic variable, the greater driving force of the two appears to be an appetite for environmentally-friendly goods per se.

Certainty regarding the SP payment decisions (dbdc_certain) was found to be significantly and negatively associated with the probability that people expressed higher WTP values (in both the logit and DBDC models). Without follow-up investigation, it is impossible to know what drove this behaviour. However, it seems reasonable to suggest a couple of explanations. First, respondents who accepted higher bid amounts may have in turn felt less sure of their payment decision. Second, that people who were anyhow unsure of the payment decision task were relatively less able to make calculated decisions and therefore were more likely to express higher WTP inclinations. Notably, whilst removing 'less sure' respondents from the sample and recomputing WTP had an insignificant impact on the mean WTP, it was associated with a relative reduction in WTP precision. This might appear somewhat unintuitive, given that one might expect 'more sure' respondents to exhibit greater WTP precision. However, the relative effect on precision was weaker than that for the treatment group, and as noted above, additional follow-up questions would be needed in order to investigate this further.

The novel approach presented in this paper offers a relatively low-cost method (temporally and monetarily) of improving the reliability and relative precision of WTP estimates, by incorporating a descriptive social norm information treatment into a SP survey to improve scenario realism. A

next step could be to have DPW participants design the SP scenario themselves, in a bottom-up approach, thus ensuring that the end-points and scenario design are as relevant to a non-expert as possible, therefore potentially reducing further bias from researchers and heuristics. The final WTP figure of £73.79 is not easily compared with other studies, which have tended to only look at the level of ecological status rather than the specific substance level. Future WTP studies in this area should aim to calibrate the WTP estimates found in this paper and seek to improve on the SNT approach applied.

Conclusion

This study investigated the public preferences (in England and Wales) for reducing the level of metal water pollution occurring in surface waters (e.g. rivers and lakes). An online survey was used to value this non-market good and the parameter results were broadly in keeping with economic theory. Using a randomised split sample, respondents who received a descriptive SNT significantly increased the likelihood that they found the SP scenario and payment tasks more convincing (and their relative WTP precision improved). This novel method is considered an improvement in the quality of the preference judgements compared with standard CV approaches, as a lack of scenario realism is known to produce bias (and relative increases in WTP precision are considered an improvement). Importantly, this contribution to the existing literature offers a relative improvement in resulting WTP estimation precision and was achieved without the information treatment significantly affecting respondent mean WTP directly.

Using a follow-up question and findings from initial regression models (not reported in full), it was evident that a minority (<10%) of respondents who received the treatment (SNTG) did not pay full attention to it, and as such the treatment did not impact reported scenario realism. Such verifications are highly recommended for research aimed at developing the foundation in this paper, which incorporated group-learnt descriptive social norms into an SP survey. Importantly, such future research should investigate (perhaps using follow-up questions with a treatment group) what features of such a treatment made the biggest impressions, thus revealing *how* such treatments can improve scenario realism (and ultimately WTP estimation precision).

Beyond the treatment effect, some respondent demographics, attitudes and behaviours were also significantly associated with scenario realism. People already interest in environmental pollution issues, possibly because they were more familiar with such concepts, were more likely to find the scenario convincing. This association also held for respondents who thought that the proposed water quality improvement policy would be supported by the public. Notably, those who were sure that the proposed waste water treatment systems would have the result described in the scenario (e.g. that the government and water companies would act efficiently and as instructed under the new policy) were approximately 10 times more likely to find the survey's scenario and payment tasks convincing.

Using a DBDC model, the policy-relevant WTP figure for completely removing metal water pollution from surface waters (in England and Wales) was estimated as £73.79 household^{-1} yr^{-1}. Whilst this estimated could be used under the WFD in future RBMPs, calibrating studies are strongly encouraged. The WTP value obtained is of relevance to policymakers and water managers aiming to achieve goals set under the WFD, as they provide the first estimates of water

pollution at the substance (metals) level – rather than ecological status level – in the UK. The treatment effect was highly statistically significant ($P<0.01$) in all scenario acceptance models. Thus, the research question is answered adequately, and the results provide fruitful promise for future research aimed at improving scenario realism in SP surveys by incorporating social norm information treatments.

This paper offers two core contributions to existing knowledge and practice for valuing complex and unfamiliar goods, motivated by the need for policy-relevant value estimates. First, this paper empirically demonstrates that SP valuation methods can be improved by the incorporation of an SNT, increasing how real and convincing people find SP scenarios and payments tasks to be (and improving relative WTP precision). Second, this paper contributes to policy by calculating applicable and relatively more precise valuation estimates of the benefits of reducing metal water pollution, as required for RBMPs under the WFD.

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6 - Critical Discussion

The overall objective of the papers in this thesis was to advance existing methods of valuation applied to unfamiliar and complex environmental goods. Chemical water pollution served as a convenient means of applying a range of novel SP and deliberative techniques. Each of the three papers included its own Discussion section, so the purpose of this chapter is to reflect more widely on a couple of the methods used and in doing so, consider their state of play in policy for unfamiliar and complex goods.

Quantitative Chemical Remediation Benefits

The CE paper on persistent chemicals succeeded in demonstrating that even where scientific uncertainty permeates the understanding of environmental impacts, the construction of valuation estimates is still possible. The chosen method of capturing those estimates, a CE, was well suited to the multi-faceted nature of the environmental problem (Atkinson et al., 2018) as depicted in the survey's scenario. The key contribution from this approach was to examine, for the first time, how people react to changes in the scientific certainty over the safety of persistent chemicals. This progresses previous research, which has tended to only focus on the issue of safety in the context of topics like food (Mørkbak et al., 2011; Wu et al., 2015; Lai et al., 2018), clothing (Holmquist et al., 2018) or electrical waste (Afroz et al., 2013). This paper also progresses existing knowledge of how different types of people respond to such goods, by employing a latent class approach to tease out respondent heterogeneity.

The application of the SNT in the paper on metal pollution established an original approach to educating survey respondents whilst improving the realism of the valuation scenario. This new method improved relative WTP estimation precision and contributes to the emerging range of SP methods that incorporate social learning such as citizens' juries, deliberative money valuations and the market stall approach (Lienhoop and MacMillan, 2007; Macmillan et al., 2002; Alvarez-Farizo et al., 2007), but at a considerably lower cost per survey response.

However, despite the various accomplishments of these papers, which have been considered previously in their respective Discussion sections, there is a central matter of application that these papers – and indeed those in the existing literature – do not resolve. This relates to utilising the results in the real world and is the tricky question of how to best apply the economic estimates in a policy context. As noted by Loomis (2014), for decades environmental economists have been asked to value alternative options for policies like water quality improvements. Yet

there are two primary issues here, one of the context of the studies themselves, and another relating more generally to applying SP estimates in decision-making.

SPs associated with environmental goods tend to be remarkably context dependent (Tinch et al., 2015). So whilst the findings from the two SP papers reported in this thesis provide statistically significant valuation estimates, even applying them in the context of the chemicals in question is problematic. If we take the CE paper on persistent chemicals as an example, one of the design features of this study was to incorporate a split sample to investigate the existence of part-whole bias. This is a decades old problem with SP research (Bateman et al., 1997), and one that is not likely to be resolved in the near future, if at all. What the results showed was that, without presenting alternative hierarchical scenarios to individuals or different levels of chemical specificity (i.e. flame retardants in part, or all persistent chemicals as a whole), people do not distinguish between these two tiers or groups of chemicals.

In trying to then apply these findings in a policy context, the cautious – if guileful – remedy is naturally to assert that the estimates are best applied to persistent chemicals as a whole. This is the most reasonable and conservative solution and that which was recommended in that paper. In this case, the valuation estimates are still applicable in RBMPs under the WFD, and typically this is where the job of the valuation researcher ends, yet the underlying contextual issue remains.

Of course, van Houtven et al. (2017) are right in that without a comprehension of the nature of environmental policy option benefits, which SP methods do allow for to some degree, then policymakers are not able to determine optimal levels of support for those options. However, in the wider context of society's need to address and make decisions on environmental issues like persistent chemicals, a series of important issues relating to the application of SPs in decision-making endure.

First, not all persistent chemicals are the same. There are thousands of types of such chemicals in use today, and the vast majority of those in commercial use are not even monitored in the environment (Muir and Howard, 2006). Additionally, there is an extraordinarily large array of exposure pathways and impacts across the wide family of persistent chemicals. So whilst the fairly generic features used to describe persistent chemicals to the respondents were accurate, it is difficult to apply these to all persistent chemicals. On the other end of the scale, hundreds of different types of flame retardants exist – each with varying properties – and to perform an SP study on just one of these would produce irrelevant outputs in a policy context.

A second issue in application relates to the realism of the SP scenario itself. In order to create a hypothetical situation for use in SP research, it is often necessary to simplify it so that end-points

can be fashioned and respondents can comprehend the valuation question (Rolfe et al., 2006; Beuthe and Bouffioux, 2008; Bellemare et al., 2011; Garg and Poddar, 2015). This is necessary in order to get surveys to a form that makes sense to people, but with each manipulation by the researcher, the object of study is pushed further away from the methodological means of getting there. Whilst the survey scenario implied that removing various persistent chemicals via waste water treatment plants is straightforward, in reality that is not the case. Constructing a waste water treatment plant to remove just one type of persistent chemical is vastly expensive, to then additionally remove another type of chemical would require altogether different technology and a new plant.

This leads to a third problem – pervasive in many environmental valuation approaches – which is that ultimately respondents are not valuing these goods in the way that policy dictates they must be interpreted. Put another way, existing policy approaches to chemical remediation under the WFD assumes clear-cut, thorough and comprehensive value inputs, but that is not what SP methods deliver. This is a particular problem for the valuation of complex and unfamiliar goods.

In summary, whilst people obviously place real value of the removal of these chemicals, their complex and unfamiliar nature renders them unsuited to the identification of specific, robust and truly-reflective monetary estimates for them. For now, despite these obvious difficulties, the standard SP approach is still widely used in policy as well as private company decision-making. It succeeds in providing CBA-relevant metrics and can offer a decent interpretation of the trade-offs that people are willing to make, regardless of the sometimes-concealed troubles that they come with. However, in the long run, the monetary valuation approach is perhaps not the correct avenue for determining the benefits to society of policy options for all complex and unfamiliar goods.

Possibly, practitioners should be looking more directly at the decision-making context in policy and what is possible there, rather than seeking to produce CBA-relevant metrics, which will always be dogged by the issues described above. For example, efforts could be focused on people's willingness to accept chemicals in consumer products in the first place. This would require the policy context itself to shift away from the standard costs versus benefits approach, to one that recognises that people's preferences (e.g. the near-complete removal of persistent chemicals from the environment) is the end-goal, and not simply a possible outcome dependent on that of the CBA.

Qualitative Chemical Remediation Benefits

As one might expect, the findings from the qualitative paper in this thesis also indicated that the public has a strong preference for removing chemical pollution (both persistents and metals) from the environment. More specifically, this paper demonstrated that facilitating optimal policy decisions for chemical water remediation options necessitates the incorporation of cost fairness factors into public opinion research. Without this, people's latent preferences and WTP will likely remain unaccounted for. This was, amongst other findings, the primary contribution from this paper and one that provides the empirical evidence needed to improve practitioners' perceptions of cost fairness in public opinion research (Dixit et al., 2015). This key finding strikes at a wider issue associated with respondents' *ability to pay*, which was mentioned in the qualitative paper, and will now be developed further.

To give some context, it is common practice in SP research to remove protest votes from survey data (Tziakis et al., 2009; Alcon et al., 2010; Barrio and Loureiro, 2013; Bithas et al., 2018), and in some cases determining what constitutes an actual protest vote is not straightforward (Cooper et al., 2018). Nonetheless it is important to identify the logic behind apparent protest votes, so they can be treated appropriately, and the valuation estimates accurately aggregated. If genuine protest votes are included in survey data, then any aggregate welfare measures risk understating the true value of the good in question. Conversely, simply removing all status quo (e.g. zero bid) responses may lead to an overestimation of the good's value (Adamowicz et al., 1998).

It is not standard practice to consider an inability to pay as a protest vote, and mindful practitioners will not remove such votes from their data sets. As discussed in the qualitative paper, this type of zero bid valuation response was particularly prevalent in one of the three workshop groups which had a significant objection to paying higher water bills for environmental improvements. Feedback from this group indicated that this group's unwillingness to accept increased bills was in part driven by financial feasibility concerns. The problem here is that SP methods tend to assume that people who declare a WTP for something should also be able to do so (Russell, 1996). Put another way, if people are unable to pay for a good then in a typical SP survey they cannot express an interest in doing so. This seems to have been the case for the deliberative workshop group mentioned above.

It is from this group's responses that the issue of *ability to pay* was identified. The issue here is that non-protest zero bid votes (i.e. people who choose not to pay for any environmental improvement), whilst typically not removed from survey data, do not represent the actual value that those respondents' might otherwise place on the environmental change in question. This

illustrates one of the weaknesses of opinion surveys such as SP techniques, which typically require a respondent to possess enough budget to express value. It is not straightforward to capture underlying value judgements from such people in standard SP surveys unless some affordability function is incorporated into the survey. Without this, people's expressed opinions will be forever limited by their budget constraint, an issue touched on by (Gyrd-Hansen, 2003). In some cases, SP practitioners have examined WTP results against indicators of ability to pay, using data from income groups and social classes (Donaldson et al., 1998), however this is not always possible and is not yet common practice. As noted by Mataria et al. (2006), the relationship between WTP and people's ability to pay remains a matter of debate, and until it is remedied those who can pay more are likely to have a greater influence on WTP estimates and so have a greater influence on policy decisions (Vernazza et al., 2015).

For the group who expressed a significant collective objection to paying higher water bills, many recognised the benefits of chemical water pollution reductions, but were limited in their ability to express this financially in a hypothetical scenario. In this case, using WTP as a proxy for the target value is notably short of accurate, especially given that ability to pay is amongst the most important determinants of WTP (Brouwer et al., 2015). The conclusion here is that where researchers are basing an SP payment vehicle (or proxy) on something like a household bill then respondents' ability to pay, perceived or measured, should be considered. This, in turn, could perhaps be used as a distributional weighting (or scale) factor for their SP values, to more accurately estimate the actual utility and value of environmental improvements when social benefits and costs need to be added up.

In summary, using WTP as a proxy for target values could be inappropriate (and lead to suboptimal policy recommendations) if people's ability to pay is not adequately considered by researchers. Further research on this issue could deliver helpful insights if focused on determining an effective vehicle for representing perceived or actual ability to pay. As mentioned above, this could be applied as a scale factor, to improve the estimation of the true utility and value of environmental improvements.

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7 - Conclusion

As the initial Literature Review evidenced, the growing field of unfamiliar good valuation is fast developing new methods and knowledge. However, the nature of emerging and complex issues like chemical water pollution makes estimating the benefits of associated remediation options problematic. To tackle this, some researchers are turning to deliberative methods as a way of incorporating social values, whilst others are focusing on the performance of respondents in new branches of the standard SP approach. It is important to strengthen existing techniques and advance knowledge in new areas of environmental valuation, as the current policy context of the WFD necessitates the establishment of such values. In doing so, practitioners can learn more about how people comprehend complex and unfamiliar goods, which has ramifications for the field of environmental economics more widely.

The first paper in this thesis elicited public preferences for the removal of persistent chemicals from surface waters (e.g. lakes and rivers) in England and Wales. Required under the WFD, the valuations estimates obtained are the first of their kind in the UK and possibly the EU. The primary contribution of this paper stems from a novel approach to incorporating the lack of scientific certainty associated with persistent chemicals into a CE design. In doing so, this paper offers an advancement to the precautionary principle, allowing environmental impact uncertainty to form a part of people's value judgements and for the value of scientific certainty to be empirically measured.

An LCA of preference heterogeneity revealed four groups of people in the sample, with those who were most concerned about human health issues from flame retardants expressing the highest WTP values. This study offers an original valuation approach to estimating uncertain and complex environmental goods, producing outputs that are highly relevant to policy options for persistent chemical remediation. Further research on this issue could focus on developing the core method established in this paper, which incorporated scientific certainty into an SP survey.

The second paper in this thesis applied a deliberative method to investigate how people frame policy options for reducing chemical water pollution in England and Wales. Three themes were used to study the findings from a representative sample of participants who attended two consecutive weekend workshops. The key research finding from this study was that if practitioners do not incorporate cost fairness factors into public opinion research then latent interest and WTP will likely remain unaccounted for, allowing for suboptimal policy decisions. Along with other findings, the results from this deliberative study are of use to social scientists, civil servants and utility companies interested in reflecting natural decision-making in public opinion research or addressing the effect of cost fairness perceptions on price acceptability.

The third and final paper addressed public opinion regarding the benefits of metal water pollution remediation in England and Wales, also required for RBMPs under the WFD. Metal water pollution remediation is an unfamiliar and complex good, so a novel method was applied to improve reported scenario realism. An information treatment of group-learnt descriptive social norms was given to a subsample of the respondents, to facilitate their familiarisation with the environmental issue. The results confirm that respondents who paid attention to this treatment were significantly more likely to find the survey scenario and payment tasks convincing, and a relative measure of precision indicates that the WTP estimates from the treatment group exhibited reduced variance. This new method incorporates important social aspects of deliberation into a CV application and enhances the credibility of the results.

This new method avoids some of the pitfalls of social decision-making (e.g. groupthink and social desirability bias) and reduces per respondent costs (both temporal and monetary) associated with recent advancements in the field of environmental valuation that combine deliberative and individual approaches. This paper also generated original and policy-relevant valuation estimates for use under the WFD. Using a DBDC method, this study estimated a statistically significant ($P<0.001$) mean WTP figure of £73.79 household-1 yr-1, for ensuring that all surface waters (e.g. lakes and rivers) are free from damaging levels of metal water pollution. The SNT applied in this paper offers the foundation of a new approach to valuing complex and unfamiliar goods, and one that merits further investigation in future research.

In summary, the papers in this thesis explore and demonstrate a suite of methods available to practitioners seeking to estimate the value of complex and unfamiliar environmental goods. Some novel contributions are made to the literature, particularly in relation to the SP methods available to such practitioners. Further, the outputs from the quantitative papers provide the first policy-relevant chemical reduction valuation estimates of their kind, and these are now available for use under the WFD.