Ofwat

The Use of Revealed Customer Behaviour in Future Price Limits

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of this study is "*To understand the opportunities and practical constraints in using revealed customer behaviour to assess customer priorities in setting future price controls*"[1]. The specific aims are to:

1. Review empirical literature, primarily in relation to the application of RP methods to the water and wastewater service attributes and environmental amenities relevant to the water industry.

2. Advise on the water, wastewater and environmental service areas where different types of revealed customer behaviour information could be applied by companies. This is to include an assessment of the strengths, weaknesses and opportunities of the potential approaches that are identified.

3. Provide recommendations as to further research that may be needed and the key requirements for the water industry to successfully implement the potential approaches identified.

In all of the above, the focus is on how information on revealed customer behaviour can be applied within cost-benefit analysis (CBA) to support investment planning by water companies.

The term 'revealed customer behaviour' is defined to encompass both conventional revealed preference methods and more general customer behaviours that can be observed in relation to water, wastewater and environmental services. This permits the identification of a range of sources of information that have the potential to help companies and regulators better understand customer preferences.

REVEALED PREFERENCE VALUATION

Revealed preference methods focus on certain relationships that exist between the demand for some market-priced goods and preferences for related non-market goods and services. By observing particular household and business customer behaviours it is possible to infer their preferences for levels of provision related to water, wastewater and environmental services. There are three basic relationships of interest, which centre on the 'benefit' that customers receive from these services:

[1] Ofwat Terms of Reference: The use of revealed customer behaviour in future price limits; Project Ref: PROC.01.0217 (February 2011).

- ***A 'substitute' relationship***: in this case a customer can derive the same benefit from consumption of either a market good or the services provided by a water company. For example bottled water is a substitute for tap water, and in response to a service failure related to drinking water quality customers can switch to consuming bottled water. The substitute relationship provides the basis for 'avertive behaviour approaches'.

- ***A 'complement' relationship***: in this case a customer requires the joint consumption of both the market good and the services provided by a water company to derive the benefit. A classic example is recreation benefits associated with the water-environment (e.g. swimming, fishing, walking, etc.). Here the market good comprises of the costs incurred in undertaking water-related recreation activities (e.g. travel, accommodation, food and other expenses). This is the underlying principle for the 'travel cost method', which examines demand for visits to recreation sites where time and money spent on travel to a site is complementary to recreational services of the water environment.

- ***An 'attribute' relationship***: in this case the service provided by a water company is a characteristic or an 'attribute' of a marketed good. The common example is demand for housing, where along with the characteristics of properties, the attributes of the local neighbourhood and environment (e.g. water quality, disamenity from treatment works, etc.) are key determinants of demand. This relationship provides the basis for 'hedonic pricing approaches' and 'discrete choice models'.

Section 2 of the main report reviews the methods identified above, including recent examples of application.

OPPORTUNITIES FOR USE OF REVEALED CUSTOMER BEHAVIOUR

The main findings from the study are summarised in Table ES.1; this is based on the discussion of opportunities and constraints for applying different methods and data in Section 3 of the main report. In most instances companies can make use of surveys of households and businesses to generate revealed customer behaviour data. It is recognised that this has the potential drawback in some cases of being based on customer reporting rather than objective data sets (e.g. market sales data). However, this essentially is the compromise that is required for easier implementation (both in data collection effort and cost).

There are also wider opportunities to use revealed customer behaviour data to improve the evidence base for investment planning. This includes scrutiny of customer complaints data, more general visitor survey data (with respect to open access sites that are managed by water companies) and potential refinements to wider customer surveys (e.g. tracking surveys).

Table ES.1: Summary of scope for use of revealed preference methods

Service attribute	Method	Data
Water services		
Drinking water aesthetics (taste, odour, appearance)	Avertive behaviour model	Household survey Business survey
Drinking water health risks	Avertive behaviour model	Household survey Business survey
Water hardness	Avertive behaviour model	Household survey Business survey
Interruptions to supply	Avertive behaviour model	Business survey
Security of supply	Avertive behaviour model	Business survey
Low pressure	Avertive behaviour model	Household survey Business survey
Wastewater services		
Odour, disamenity from wastewater treatment	Hedonic property pricing	Residential property sales, characteristics etc., GIS
Sewer flooding	Avertive behaviour model / defensive expenditure	Household survey Business survey
Private sewer maintenance /adoption	Avertive behaviour model	Household survey Business survey
Environmental services		
River water quality / flow levels (recreation benefits)	Discrete choice model	Household survey, env. quality data, GIS data
Bathing water quality	Discrete choice model	Household survey, env. quality data, GIS data

RECOMMENDATIONS

The following recommendations are presented for the use of revealed customer behaviour to assess customer priorities in investment planning and development of business plans:

1. **Business cases should be supported by *a range of* quantitative and economic value evidence.** Companies should review what data are collected (e.g. through customer contacts) and opportunities that exist for collating more data (e.g. by reviewing the content of tracking surveys). The objective should be to ensure that business cases can be supported by an appropriate and sufficient qualitative, quantitative and valuation evidence base. These assessments should be undertaken by companies as part of their work to establish a coherent framework for benefits valuation and applying CBA.

2. **Companies should consider the use of avertive behaviour surveys to understand better the substitution and mitigation actions customers take in response to service failures.** There is a strong case for exploring further the potential for an avertive behaviour approach. Companies may wish to develop this work individually or in collaboration. Household and business surveys could be cost-

effectively implemented and this represents a potential 'quick win' – particularly if undertaken collaboratively – to advance understanding of avertive behaviours of customers in relation to service failures.

3. **All stakeholders should review the approach to valuing environmental quality improvements associated with implementation of the Water Framework Directive.** There is considerable merit in taking stock of recent methodological developments in the use of revealed preference methods and valuing environmental water quality, particularly in terms of the application of discrete choice models. This has significant implications for continued WFD implementation. A practical starting point would be a scoping study including all stakeholders that establishes the precise requirements for estimating the benefits of continued WFD implementation.

4. **Further scoping is required to establish the role for hedonic property pricing in relation to valuing disamenity impacts associated with service failures.** There is considerable conceptual appeal in using hedonic pricing approaches to value disamenity impacts arising from odour and nuisance from wastewater treatment works. However empirical applications to date show that successful studies require considerable time, resources, data and expertise. Judgement is needed to establish if the effort required to deliver a robust study is warranted.

5. **Opportunities to combine revealed preference and stated preference approaches should be considered.** The basis for valuing changes in service levels associated with water, wastewater and environmental services should not be viewed as a choice of either revealed preference or stated preference methods[2]. Companies need to develop a coherent framework for valuing benefits of service improvements. Opportunities to apply both revealed and stated preference approaches can provide a strong grounding in actual and experienced service levels for resulting stated preference valuations.

[2] Stated preference approaches use surveys to assess customer priorities that rely on stated behaviour rather than actual observed behaviour. See UKWIR (2010) for further discussion of the use of stated preference methods in water company investment planning.

1 INTRODUCTION

1.1 BACKROUND

Ofwat (The Water Services Regulation Authority) – under the Future Price Limits (FPL) project - is currently reviewing the framework within which future price controls will be set. The review is focusing on the fundamental components of the regulatory framework: the form of control used to regulate water companies; the treatment of regulated and unregulated business in setting prices; the allocation of risk between stakeholders; incentives; and customer engagement.

The purpose of the customer engagement element of the FPL is to establish how customers' views should be taken into account when setting price limits and establishing investment priorities. Three areas are being explored: (i) different modes of engagement for different customers at different stages of service delivery; (ii) the role of customer choice in revealing preferences; and (iii) the role of Ofwat, customer representatives, and other stakeholders in the engagement process.

The review also follows from the recent experience of the 2009 Price Review (PR09) where a strong emphasis was placed on the role of customer engagement in the development of business plans. Water companies were required to use cost-benefit analysis (CBA) to support investment proposals, with the expectation that they would assess customer priorities and base benefit valuations on these priorities (Ofwat, 2007). In response companies undertook a considerable amount of work to establish customer priorities and applied a range of economic valuation methods to estimate the monetary value of costs and benefits associated with changes in service levels.

The PR09 CBA experience and lessons learnt by regulators and companies are documented in the recent UKWIR (2010) review. This highlighted that even though industry guidance was provided, which detailed the 'valuation hierarchy' (market prices – revealed preference – stated preference) (UKWIR 2007), benefits valuation was dominated by the use of stated preference (SP) methods. These are survey based valuation methods that rely on the construction of simulated markets in which customers can trade-off changes in services levels with changes in household bill amount. In contrast revealed preference (RP) methods, which infer values for changes in service levels from actual observed customer behaviour and choices, were not utilised by companies. Primarily this was due to limited scope for application of RP methods across all investment areas of interest.

While the UKWIR (2010) review found the reliance on SP methods legitimate and recommended their continued application to support companies' use of CBA, there is also the need to reconsider the potential role of RP methods, particularly in the

context of the FPL work. Here Ofwat has stressed the importance of observing customer behaviour and choices as a powerful form of engagement that can reveal information about preferences to guide companies' investment plans (Ofwat, 2010).

1.2 OBJECTIVE AND SCOPE

1.2.1 Aims and objective

The objective of this study is "*To understand the opportunities and practical constraints in using revealed customer behaviour to assess customer priorities in setting future price controls*"[3]. The specific aims of the work are to:

1. Review empirical literature, primarily in relation to the application of RP methods to the water and wastewater service attributes and environmental amenities relevant to the water industry.

2. Advise on the water, wastewater and environmental service areas where different types of revealed customer behaviour information could be applied by companies. This is to include an assessment of the strengths, weaknesses and opportunities of the potential approaches that are identified.

3. Provide recommendations as to further research that may be needed and the key requirements for the water industry to successfully implement the potential approaches identified.

1.2.2 Scope of review

In the context of this study, 'revealed customer behaviour' is defined in relatively broad terms to encompass both conventional RP methods and more general customer behaviours that can be observed in relation to water, wastewater and environmental services provided by water companies. This permits the identification of a range of sources of information that have the potential to help companies and regulators better understand customer preferences.

In addition, while the main remit for the review is to establish how revealed customer behaviour can be applied within CBA to support investment planning, there is also scope to consider how information that is readily available to companies can be used in an auxiliary manner to improve the investment planning process in general.

[3] Ofwat Terms of Reference: The use of revealed customer behaviour in future price limits; Project Ref: PROC.01.0217 (February 2011).

1.3 REPORT STRUCTURE

The remainder of this report is structured as follows:

- Section 2: reviews the conceptual basis for revealed preference methods and highlights recent examples of their empirical application, drawing on the literature review undertaken for this study.
- Section 3: establishes the potential range of revealed customer behaviour relevant to water, wastewater and environmental services areas and then provides a critical assessment of the opportunities and practical constraints for their application.
- Section 4: presents recommendations for the use of revealed customer behaviour, focussing on requirements for future research and future application across the water industry.

In addition, Appendix 1 presents a tabular summary of empirical studies identified in the literature review.

2 REVEALED PREFERENCE VALUATION

2.1 CONCEPTUAL OVERVIEW

2.1.1 Valuing investment impacts in CBA

Application of CBA for company investment planning requires that all impacts of proposals are measured in monetary terms to estimate and directly compare costs and benefits. Following Young (2005) investment impacts can be classified as:

1. Impacts for which markets exist and market prices reflect economic values;
2. Impacts for which market prices can be observed, but where prices need to be adjusted to more accurately reflect economic values;
3. Impacts for which market prices do not exist but where 'surrogate' markets and prices can be identified; and
4. Impact for which market prices and surrogate markets do not exist.

Resource costs associated with investment proposals – i.e. capital, operating and maintenance expenditure – ordinarily fall into classes (1) and (2); the latter being instances where distortions such as taxes and subsidies need to be removed from observed prices such that values reflect opportunity costs. Other relevant market-based impacts such as disruption from streetworks (e.g. value of losses to businesses) and physical damage costs from pollution (e.g. fish re-stocking) and sewer flooding incidents (e.g. damage to building fabrics and material) should also be valued via market prices[4].

Water industry regulation and price controls mean that prices paid by household and business customers do not reflect the value of water and wastewater services in terms of a formal competitive market clearing price. Moreover the water, wastewater and environmental services provided by companies are characteristic of public and non-market goods, hence the benefits and costs of changes in service levels typically fall into classes (3) and (4) above.

The distinction between RP and SP methods can also be viewed in terms of the classification of impact types. Revealed preference methods enable class (3) impacts to be valued in monetary terms, using observed behaviour in 'surrogate markets' to infer the value of non-market goods. The basis of these methods is reviewed in Section 2.2.

[4] Note though that there are additional disamenity impacts from flooding (e.g. stress, trauma, etc.) which are not captured by valuing physical damages in opportunity cost terms, but can be valued using other approaches to economic valuation.

In the absence of market prices and surrogate markets, SP methods represent the only way in which class (4) impacts can be valued. Moreover, while RP methods are limited to class (3) impacts, application of SP methods can be wider. This is demonstrated by the widespread use of SP methods in PR09 due to a variety of methodological and practical reasons (as reviewed in UKWIR, 2010). The general point though is that the most appropriate method should be used in a given situation; in some cases this will be RP methods, in others SP methods, and potentially in some instances both types of method.

2.1.2 Basis for applying revealed preference methods

Revealed preference methods analyse surrogate markets and, in particular, certain relationships that exist between: (a) the demand for some market-priced goods; and (b) preferences for related non-market goods and services - i.e. the water, wastewater and environmental services that are of interest in this study. A classic example is valuing non-market recreation benefits associated with the water-environment, such as visits to rivers, lakes, beaches, etc., through the market costs incurred in undertaking water-related recreation activities (e.g. swimming, fishing, walking, etc.). These market costs include travel (fuel, fares, etc.) and time (value of leisure time) expenditures.

The basic requirements for using revealed preference methods are that (Young, 2005):

A. Changes in the provision of the non-market good (water, wastewater or environmental service levels) actually influence some observable customer behaviour (i.e. demand for the market good);

B. Changes in customer behaviour that are at least partly (and to an observable extent) responses to changes in the provision of the non-market good; and

C. The market good is 'non-essential' such that there is a price for the good at which demand becomes zero (this is termed the 'choke price')[5].

These requirements significantly limit the scope for applying RP methods. In practice there is only a distinct set of circumstances where they are satisfied such that expenditure on some market good of interest can be observed to vary with the provision of the non-market good. Without this variation it is not possible to infer the value of the non-market good. That said information about related customer behaviour may still be useful in supporting companies' investment planning – see

[5] The choke price is the minimum price at which there would be no demand for a good. In the recreation example cited above, this implies that once the travel and time costs incurred in visiting a particular site reach a certain level, no individuals would visit it.

Section 3 for further discussion.

2.1.3 Revealed preference methods – exploiting substitute, complement and attribute relationships

The two most commonly recognised RP approaches are hedonic pricing and travel cost models. These should however be considered as 'umbrella terms' since specific empirical applications may entail different methodological approaches. In addition, further RP approaches such as 'avertive behaviour' methods are also available. Instead, a more conceptually appealing approach to classifying RP methods is on the basis of the relationship between demand for the surrogate market good and preferences for non-market good.

There are three basic relationships of interest, which centre on the benefit[6] that an individual ordinarily derives from the provision of the non-market good:

- ***The market and non-market goods are substitutes***: in this case an individual can derive the same benefit from consumption of either the market good or the non-market good. For example bottled water is a substitute for tap water, and in response to a service failure related to drinking water quality customers can switch to consuming bottled water.

  The substitute relationship provides the basis for avertive behaviour approaches, which may also be referred to as 'defensive expenditures'. In some cases the 'damage cost approach' may also be included within the definition of RP methods that exploit a substitute relationship[7].

- ***The market and non-market goods are complements***: in this case an individual requires the joint consumption of both the market good and the non-market good to derive the benefit. This is the underlying principle for the 'traditional' travel cost method, which examines demand for visits to recreation sites where time and money spent on travel to a site is complementary to recreation.

[6] Note that in economic jargon interchangeable terms such as 'utility', 'welfare' or 'wellbeing' would be used instead of 'benefit'.

[7] This section of the report does not consider the damage cost approach further. Where damage costs are based on market values and are applied to measure the value of market impacts – i.e. class (1) impacts above – this does not represent a RP approach. Where damage costs based on market prices are used to value a non-market impact (e.g. using the cost of illness and health service resource costs to value health impacts), the general understanding is that this represents a lower bound estimate of the value of the impact, such that households would be willing to pay up to the expected amount of damages to avoid them (Dickie, 2003). More formally, damage costs do not inform on an individual's preference towards the changes in the non-market good; rather just the loss of welfare from its degradation or loss.

- ***The non-market good is an attribute of the market good***: in this case the non-market good is a characteristic or an attribute of a marketed good. The classic example is demand for housing, where along with the characteristics of properties, the attributes of the local neighbourhood and environment are key determinants of demand.

  This attribute relationship provides the basis for hedonic pricing approaches and discrete choice models[8].

The following describes in further detail the application of the methods identified above, covering both the methodological basis and recent examples of application.

2.2 AVERTIVE BEHAVIOUR

The avertive behaviour approach examines expenditures on substitute market goods that customers incur in response to service failures. The underlying rationale is that a household will continue with the averting behaviour so long as the cost of the defensive expenditure is less than the value of the disamenity that is avoided and would otherwise by experienced (Courant and Porter, 1981; Dickie, 2003). This implies that averting behaviour choices in relation to the disamenity can reveal an individual's willingness to pay (WTP) to avoid it. Technically, however, this estimate will only represent a lower bound WTP (Bartik, 1988)[9]. In practice estimates of WTP can be recovered from discrete choice models that examine customer responses to service failures (see also Section 2.4).

In relation to water services, the most common empirical applications of avertive behaviour have been in relation to human health impacts. Almost exclusively these studies have focused on issues concerning household drinking water quality; no assessments have been made of defensive expenditures that may be incurred by businesses in response to service failures such as interruptions to supply. While there are no UK examples, a number of Canadian studies in recent years have applied the method to estimate the benefits of improved tap water quality. These studies have been conducted in the context of a series of isolated but high profile *E.coli* and cryptosporidium contamination incidents in Canada in the past decade.

Dupont (2005) reports on a pilot household survey that sought to establish use of tap water and tap water substitutes (bottled water, container/jug filter, in-tap filter)

[8] A point to highlight is that application of discrete choice models is analogous to the analysis of choice experiments undertaken for water companies from PR09 WTP surveys, the only difference being the use of revealed preference data, rather than stated preference data.

[9] As Young (2005) details, defensive expenditures play a complex role in measuring welfare changes related to environmental or water-pollution damages. In particular the marginal value of pollution damages (or other service failures) cannot be measured by (marginal) changes in defensive expenditures since environmental or water quality does not remain constant in relation to averting behaviours.

along with knowledge of possible contaminants in the water supply, and health concerns associated with tap water consumption. Based on reporting by respondents, annual average costs to households of substitutes were estimated to be CAN $35 (approx. £20) for a container/jug filter, CAN $189 (£100) for an in-tap filter and CAN $180 (£95) for bottled water. These cost were calculated on the basis of an equivalent annual value for one-off purchases (in-tap filtration device, container/jug)[10], and annual costs incurred in terms of replacement filters or bottled water purchases.

Similarly Schram et al. (2010) employed a survey format to examine the relationship between drinking water choices and expenditures and health risks in Canada. Data collected included the composition of drinking water, with households stating the proportion of each type of water that they consumed in an average month (bottled, in-home treated, or regular tap water). Other data included the costs for filtration and bottled water, quality perceptions, attitudes and experience with water quality issues, and demographics. For a typical month, households indicated their expenditure on bottled water. For filtration devices, households were asked to state the initial cost of the device, the amount of money spent on replacement filters, and the frequency of replacement. The average monthly cost for 100% consumption of bottled water and filtration was calculated to be approximately CAN $101 (£55) per month and CAN $11 (£6) per month, respectively.

Schram et al. used the household survey data to estimate (discrete choice) averting behaviour models to explain households' choice among the three water alternatives, based on perceived quality characteristics (taste, smell and odour) and health risks, and socio-economic characteristics. Households' perceptions of health risks – specifically mortality risk from consumption of water - were captured via an interactive 'risk ladder' on which respondents were asked to plot their perceived level of risk in relation to a range of other mortality risks (illness, accidents, etc.)[11]. Latent class models[12] were employed, such that the analysis distinguished between risk sensitive households who were more likely to choose tap water substitutes and those who were not risk sensitive. The results confirmed that health risk, in terms of perceived mortality, was a significant determinant of households' water consumption choice. Taste of water was also found to be a significant determinant of choice, along with odour and convenience (particularly for risk sensitive households). This result supported other findings from the study that the greatest dissatisfaction with tap

[10] Note though that the calculation of an annual equivalent value is dependent upon the assumed asset life and discount rate.
[11] This element of the study is more indicative of a stated preference approach. However this demonstrates the potential of combining RP and SP approaches in any application that is reliant on a survey of individuals.
[12] Latent class models are an advanced econometric specification for discrete choice models that include the familiar multinomial and mixed logit specifications from the PR09 experience of econometric analysis of choice experiment data.

water arose in relation to the taste of chlorine. The appearance of water was not found to be a significant determinant of choice.

The averting behaviour models estimated by Schram et al. also permitted the estimation of a value of statistical life (VSL) of approximately CAN $1.4 million (approx. £755,000), and monthly marginal willingness to pay (WTP) estimates for improvements in tap water to the perceived quality of filtered and bottled water (approximately CAN $3 (£2) and CAN $14 (£8), respectively). The authors note that these represent lower bound VSL and WTP estimates since they are based on averting expenditures, and do not capture any consumer surplus above this.

Further studies using the avertive behaviour method include Abrahams et al. (2000) who found that in Georgia (USA) appearance of tap water and respondent age are among the most important determinants of bottled water selection; and information regarding current or prior problems with tap water, perceived risk from tap water and income are the most important determinants of water filter selection. Outside of North America, Wu and Huang (2001) compared results from the avertive behaviour approach and a contingent valuation survey carried out in Taiwan, finding that the former did indeed provide a lower bound estimate of WTP derived from the latter. A similar analysis is reported in Rosado et al. (2006) in relation to drinking water treatment in Brazil.

Studies by McConnell and Rosado (2000) and Larson and Gnedenko (1998) also include boiling water as an alternative response to drinking water safety concerns. This action is also examined by Lee and Kwak (2007) who find that households in Seoul, South Korea, have a preference for the impaired taste of water resulting from boiling, since it lowers the health risk from potential contaminants of tap water.

2.3 TRAVEL COST MODEL

The term 'travel cost method' refers to analyses that measure demand for visits to outdoor recreation sites, such as forests, National Parks, beaches, rivers, lakes, etc. Their application enables the estimation of the non-market benefit derived by visitors to sites that have no or only a nominal entry fee. The method is reliant on 'weak complementarity' so that when consumption of the market good (travel) is zero, the benefit obtained from the non-market good is zero (Maler, 1974; Bockstael and McConnell, 1999).

Since the cost of travelling to a site will vary among visitors a demand schedule for recreation at the site can be estimated (Ward and Beal, 2000; Freeman, 2003). The 'price' of a recreational visit is calculated from travel costs (e.g. petrol, fares, etc.), along with the dis-benefit (or benefit) of actual travel time too, typically valued in terms of the opportunity cost of leisure time.

The travel cost approach is survey based, ordinarily requiring data to be collected from visitors to a recreation site in terms of the purpose of the visit, incurred travel costs, frequency of visits to the site and similar (substitute) sites over a given period, and other determining factors such as socio-economic, demographic and attitudinal information[13]. This permits estimation of a 'trip-generating function' which explains the number of visits as a function of travel costs and other relevant explanatory variables. This can then be used to estimate the demand curve for recreation at the site and calculation of the non-market value of recreation benefits at the site. Values are estimated in terms of 'consumer surplus', which in this context is the difference between an individual's WTP and their travel cost expenditure[14].

Zonal travel cost model

Early applications of the travel cost approach applied the 'zonal travel cost model' (ZTCM). This was based on visit rates (i.e. the number of visitors from an area divided by the population of that area) from different geographical 'zones' around a site, which enabled *number of visits per capita* for each zone to be calculated. Results from the ZTCM are in terms of the average behaviour of groups of visitors, which does not correspond well to the underlying principles of economic analysis which focus on the choices of individuals. Accordingly the ZTCM is seldom applied in relation to valuing benefits of non-market recreation. It does however retain useful properties for estimating trip-generating functions that are transferable between different recreation sites (Jones et al., 2010). In the context of water company investment planning, this can be useful where on-site visitor surveys are available for open-access recreation resources (e.g. reservoirs) [15] and an investment driver such as the Countryside Rights of Way (CROW) Act.

Individual travel cost model

More widely applied is the individual travel cost model (ITCM), although its use in recent years has diminished with the increasing application of discrete choice models (Section 2.4). The ITCM is derived from the number of visits an individual or household makes to a specific recreation site over some period of time (e.g. a year). Numerous examples of empirical applications are available in the early environmental economic literature, including a number of UK studies related to the water-environment. For example: Willis (1990); Willis and Garrod (1991); and Klein

[13] Note also that surveys could instead be conducted 'off-site' and still collect data on visits to recreation sites. An example of this approach is provided by the ChREAM study cited in Section 2.4.
[14] Note that for non-market goods, where no entry fees, travel costs, etc. are incurred then consumer surplus is wholly equal to WTP.
[15] For further discussion see eftec (2010) which reviews how recreation survey data currently collected in England – including the Monitor of Engagement with the Natural Environment (MENE) – could be used for generating economic valuation evidence for project and policy appraisal purposes.

and Bateman (1998). Later applications have focused mostly on forest recreation (e.g. Christie et al. 2006).

Outside of the UK, Corrigan et al. (2007) report results from an ITCM estimated in relation to visits to Clear Lake, Iowa (USA). Surveying approximately 400 resident households in Iowa, the average number of trips to Clear Lake was 3 per year. Average annual consumer surplus – i.e. the benefit derived by households each year from visits to Clear Lake - was estimated to be approximately US $200 (approx. £140) per household per year.

Combining ITCM with other revealed and stated preference approaches

Increasingly the ITCM and trip-generating function have been utilised in studies that combine these with discrete choice models (see Section 2.4) or stated preference approaches such as contingent behaviour models (following Englin and Cameron, 1996). In particular Corrigan et al. also included a contingent behaviour question to estimate the value of improved water quality at Clear Lake. In addition to reporting how many visits they took in the past year, households were also asked how many trips they would have taken had water quality at the lake been improved, in accordance with a scenario described in the survey. The inclusion of a contingent behaviour question permits WTP estimate to be calculated for improvements in recreation site quality. Since travel cost remains constant between changes in site quality, WTP is derived from the change in consumer surplus that follows from increased or decreased visits to the site. In Corrigan et al. average WTP for water quality improvements at Clear Lake was estimated to be approximately $140 (approx. £90) per household per year for a small improvement and $350 (£225) per household per year for a large improvement.

A similar combined ITCM and contingent behaviour application is reported by Hanley et al. (2003) in relation to improvements in bathing water quality at seven beaches in Scotland. Using an on-site survey, improvements to the EU Directive standard were valued at approximately £6 per visitor per year, or £0.50 per trip. Rolfe and Dyack (2010) present results from an ITCM and contingent behaviour survey that sought to estimate the value of access to the Coorong, the estuary of the Murray River, South Australia. Consumer surplus associated with visits to the Coorong was estimated to be AUS $111 (approx. £50) per visitor per day. The value of a 1 per cent change in access was estimated to be approximately AUS $17 (£7) per visitor per day.

Johnstone and Markandya (2006) report on a study that combined a trip-generating function and discrete choice model (Section 2.4) in the context of river water quality improvements and angling in England. Approximately 400 anglers were surveyed via a variety of methods (mail, internet, distribution to angling clubs). The trip-

generating function was estimated to predict changes in the number of visits made by an individual to a specific site resulting from marginal changes in river quality attributes. Data on environmental quality of sites were collated separately from a variety of habitat, chemical, biological and fish population indicators. Results from the trip-generating function were then inputted to a discrete choice model so that both the changes in site quality and visit behaviour could be examined – further results from this study are reported in Section 2.4.

2.4 DISCRETE CHOICE MODEL

The discrete choice model (DCM) was introduced as an approach to valuation of non-market goods by Bockstael et al. (1987)[16]. As described in Section 2.1.3 its application is based on the 'attribute relationship' that exists between the level of provision of some non-market goods and demand for particular market goods. The non-market good is an attribute of the overall good that is consumed, and changes in its quantity or quality will influence demand for the overall good.

By far the most common application is in relation to recreation demand. In this context the DCM can be used to estimate the value of changes in the quality of recreation services by focussing on the decisions of individuals to visit a specific site rather than alternative substitute sites. The DCM provides a convenient way to explain the choice among mutually exclusive alternative sites and permits control of relevant substitution and site quality effects. Typically this represents a more accurate representation of individual's recreation choice behaviour than that of the ITCM (Phaneuf and Smith, 2005).

Accordingly, the DCM is now the dominant revealed preference method used in relation to valuing environmental improvements at recreation and other visitor sites, and much of the academic literature in recent years has focussed on its methodological development[17]. The key consideration is that individuals and households will visit multiple recreation sites over a given period of time. The value of a change in quality of one site (e.g. an improvement in river water quality) will depend on the site's initial quality, its proximity to where the household resides, and also on the quality and proximity of the other sites (i.e. other river sites that the household may visit). Essentially there is an interaction between sites and

[16] Unfortunately terminology can be confusing. This approach is also often termed as 'multi-site recreation demand models' or 'random utility models' (RUM) after the underlying model of behaviour it utilises. They can also be grouped with travel cost models since the most common application is the valuation of non-market recreation benefits based on travel costs incurred in site visits. Models may also be termed as 'Kuhn-Tucker models', which can be seen as an extension of the basic DCM such that choices are modelled over a period of time (i.e. a recreation season) (Phaneuf and Siderelis, 2003).

[17] For a sample see: Phaneuf et al., (2000); von Haefen (2007); Timmins and Murdock (2007); and Bockstael and McConnell (2007).

households will value the set of sites, all of which have different qualities and characteristics. In contrast the ITCM (see Section 2.3) focuses on a 'continuous' choice (annual visit to a specific site) rather than a discrete choice (the decision of which site, if any, to visit).

Application of DCM requires a survey to collect data on individuals' choice of site, their place of residence, socio-economic and demographic characteristics, attitudinal information, frequency of visits to the site and other similar sites and trip information (e.g. purposefulness, length, associated costs etc). This can be collected from either an on-site or off-site survey. Data are also required on the specific characteristics of different recreation sites and the level of the quality of these characteristics. These can either be collected from 'objective' datasets (e.g. river quality monitoring data), or based on the 'subjective' perceptions of quality by visitors, or both (Jeon et al., 2005). The latter case of 'subjective' perceptions can however limit the transferability of results; i.e. 'objective' data on site quality can be easily collated for out of sample sites, data on individuals' perceptions is not usually readily available.

From the survey data, the choice of which site to visit is modelled as a comparison between the characteristics of each site that could be visited (known as the 'choice set')[18]. The estimated model controls for factors such as income and socio-economic characteristics, travel costs and travel time, and site quality characteristics to estimate the benefit derived from a recreation visit. The monetary value of a change in environmental quality can be calculated by relating the estimated model coefficient for environmental quality to the 'price' of a visit, which, as in the ITCM, is inferred from the cost of travel to a site.

The most recent UK application of the DCM in relation to valuing improvements in water quality is the ChREAM study[19] (Bateman et al., 2010). In the context of implementation of the Water Framework Directive (WFD) this study sought to examine the relationship between improvements in water quality and increased recreational visits. A face-to-face survey was carried out in West Yorkshire (Bradford, Leeds and surrounding areas). A large study area was defined which included multiple diverse rivers, several hundred urban and rural recreation sites, and substantial variation in accessibility and river water quality at different sites. Households were selected from diverse locations across the full study area to provide variation in socio-economic and demographic characteristics, as well as the quality and location of recreation and substitute sites. Computerised software was used to

[18] In principle the choice set should include all possible recreation sites (i.e. not just all water sites) and the 'outside good' (the choice of not visiting anywhere).
[19] Catchment hydrology, Resources, Economics and Management (ChREAM).
See: www.uea.ac.uk/env/cserge/research/relu/index

identify the location of each respondent's home address and possible destination sites, such that geographic information systems (GIS) could be used to calculate travel times and travel costs between the respondent's home and the choice set of sites. Respondents were asked to identify the location of any water recreation sites they visited and to rate the water quality at the site. 531 possible sites were identified on three rivers.

Initial results from ChREAM indicate a significant relationship between improvements in water quality and increased recreational visits. However this finding does not apply to all changes: households were found to be insensitive between different grades of poor quality water, but sensitive to improvements between medium to good quality water. The implication is that there are non-linear variations in recreation value as water quality changes, both for single sites, and for groups of sites. For a specific site, use levels and values may be unresponsive to small improvements at the poor quality end of the scale, then increase quite rapidly moving towards the good quality. For groups of sites, the aggregate value of improving water quality in more populated areas outweighs the benefits of improvements in sparsely populated areas. Moreover the value of further improvements is lower the closer a water body is to another high quality substitute water body. Findings of this nature have significant implications for economic analysis of continued WFD implementation, particularly where results applied in PR09 and the first round of river basin management plans were more or less based on linear valuations.

A further UK example of the DCM is provided by Johnstone and Markandya (2006). As reported above, this applies the approach to value benefits to anglers from improvements in river water quality. They found that river flow rate, dissolved oxygen (DO), fish species diversity and fish population sizes were significant determinants of site choice across upland, lowland and chalk river types. Willingness to pay for improvements in these quality indicators (assuming linearity) ranged between £0.00 to approximately £4 per angler per trip.

Beyond the UK numerous empirical applications of the DCM have been undertaken. Notable examples water related include: Phaneuf and Siderelis (2003) in relation to canoeing and kayaking in North Carolina (USA); Hunt et al. (2007) in relation to choice of fishing site by anglers in Canada; and Hynes et al. (2008) in relation to kayaking in Ireland. Jeon at al. (2005) and Egan et al. (2004) report results from the Iowa Lakes Valuation project, which surveyed approximately 4,000 households in Iowa as to their recreation use of 129 of Iowa's principle lakes.

Information collected from respondents included their recreation choices over time (site choice and number of visits), socio-economic data, attitudes towards water quality issues and travel costs. Data was also collated on the characteristics of sites

(e.g. visitor facilities). In addition the study ran in parallel to monitoring of water quality at the same lakes, giving a time series of data on various physical measures of water quality over a period of five years[20]. The analysis of the data finds that households' recreation choices are responsive to the physical measures of water quality, particularly the clarity of water. The authors estimate consumer surplus for a number of water improvement scenarios, ranging from significant improvements across all lakes (approximately US $200 (£130) per household per year) to very focused initiatives on the most quality impaired lakes (approximately US $5 (£3) per household per year[21]).

Finally, while application of the DCM is predominantly in the context of environmental quality and recreation demand, it can also be applied in much broader settings. This is demonstrated by reporting in eftec (2008) which estimates a DCM to examine how specific attributes of new cars (e.g. fuel efficiency, CO_2 emissions, etc.) influence overall demand. Other common applications include transport (modelling transport mode choice) and marketing.

2.5 HEDONIC PRICING

The hedonic pricing method (HPM) also utilises the 'attribute relationship' that exists between the level of provision of some non-market goods and demand for particular market goods. The approach is based on the assumption that the price of a marketed good is a function of its various characteristics, each of which has an 'implicit price'[22]. Hence it is dependent on weak complementarity such that changes in the provision of the non-market good change the price of the market good (Maler, 1974).

The most familiar use of HPM is in relation to demand for property ('hedonic property pricing' – HPP), with the most common application to private house purchases. It can also be applied to the rental market, commercial property, undeveloped land and agricultural land. Wider applications include valuing occupational health and safety through wage-risk premia. Focusing on HPP, differences in the market price of a property that result from its specific attributes are termed as 'price differentials'. Many attributes of properties command a price differential, and include the physical characteristics of the property (e.g. number of rooms, size of garden), proximity to transport links and public services, environmental quality (e.g. air quality, peace and quiet, availability of green space),

[20] Data was collected on: water clarity, chlorophyll, nitrogen, total phosphorus, silicon, acidity, alkalinity, inorganic suspended solids, and volatile suspended solids.

[21] Jeon et al. note that this low value can be reasonably explained by the fact that Iowa has an abundance of lakes of a reasonable water quality and hence bringing low quality level lakes to this level does not represent much of a benefit. This finding is consistent with the initial findings from the ChREAM study in relation to river water quality.

[22] Note the distinction between the DCM and HPM; the latter is estimated in terms of the *price* of a specific marketed good. In the DCM the analysis is concerned with the *choice* between alternative goods.

and other neighbourhood characteristics (e.g. crime rate).

Application of the HPP is data intensive, requiring information on property sales and prices, along with details of the property characteristics and relevant environmental and neighbourhood attributes. Econometric analysis of the data requires two stages of estimation: (i) the hedonic price function, which models property price as a function of property attributes; and (ii) demand curve for the non-market good of interest. Few studies in the UK have applied HPP in relation to water or wastewater services. A dated example is provided by Garrod and Willis (1994) who estimate the amenity effect of a water-side location on properties, finding a premium on property values of 1.5% to 5% in locations in London and the Midlands. There are though more examples in the wider literature. This includes use of HPP in relation to disamenity from road traffic noise (Bateman et al., 2004; Day et al. 2007) and landfill sites (Defra, 2003), as well as the value of local amenities, services and green space (Gibbons, 2001; 2003; and Gibbons and Machin; Smith, 2010; Gibbons et al. 2011).

The one explicit application in the context of the water industry in England and Wales is UKWIR (2008a). This study sought to investigate the relationship between the odour from wastewater treatment works and residential property prices in surrounding areas, and included both SP and HPP analyses. The HPP element of the study attempted to model house prices against a small set of property characteristics, including odour level. This is a partial analysis as it uses only stage 1 of the HPP methodology. Some statistical associations between house prices and odour levels were found; however very limited econometric models were estimated with no control for any other factor than the basic property type. No information on property characteristics, local services and amenities and other local environmental factors were included in the analysis. This suggests that the reported results are likely to be subject to significant omitted variable biases.

Outside of the UK more successful water-related examples of application of the HPP are available. Gibbs et al. (2002) report on the use of HPP to value the costs of eutrophication in lakes in New Hampshire, USA. They found that a one-metre decrease in water clarity can lead to decreases in lake-front property prices of between 1 – 6%. In a similar context, Leggett and Bockstael (2000) value the impact of water quality in Chesapeake Bay, Maryland (USA), on residential house prices. Measuring water quality in terms of faecal coliform count, they found that a 100mL change results in a 1.5% change in property price. This equated to a change of approximately US $5,000 – 10,000 (approx. £4,000 - £8,000) per property. Poor et al. (2007) value the impact of water quality on house prices in the St. Mary's watershed (also in Maryland). They find that higher levels of suspended solids and dissolved inorganic nitrogen have a negative impact on house prices; a 1 mg/L increase in total suspended solids reduced average house price by approximately US

$1,000 (£700), a 1 mg/L increase in dissolved inorganic nitrogen reduced average house prices by approximately $17,500 (£12,100).

A wider application is presented by MacDonald et al. (2010) who use an HPP approach to estimate the impact of water restrictions on property values by examining how they affect preferences for private green spaces and public green spaces. The authors used housing market data from Adelaide, South Australia, to test whether increasingly severe water restrictions[23] lead home owners to value public green spaces (public parks, playgrounds, sporting fields and large reserves) more highly over private green spaces (lawns and gardens), where restrictions result in overly onerous maintenance efforts for the latter. The HPP model controls for various housing characteristics, local environmental amenity and neighbourhood characteristics[24].

Results indicate that increased private green space (measured as the ratio of private green space to property area) adds to the selling price up to a certain point (a ratio of green space to property area of 0.42) whereupon increasing green space starts to detract from the value. The authors posit that this may reflect a preference for smaller gardens which take less time to maintain. Water restrictions are not found to influence households' preferences for private green space. However they have a changing impact on the relationship between proximity to playgrounds and house prices. The relationship is insignificant in the absence of restrictions, but when restrictions are in force, proximity to a playground is valued in the range AUS $4 – 6 (approx. £1.50-£2.50) per metre closer. In contrast large public green spaces, such as nature reserves are considered disamenities with householders willing to pay more to live away from them – approximately about AUS $11 (£5) for each additional metre farther away[25]. This is interpreted as preference against reserves being left in their natural state – i.e. brown and dry during summers, with a heightened danger of bush fires.

[23] Restrictions range from relatively minor intended to reduce garden water losses (e.g. time restrictions on sprinkler systems) to more significant and rigid restrictions on when gardens can be watered (e.g. no watering during winter).

[24] These included: date of sale, lot size, building area, number of main rooms, number of bathrooms, building age, building condition and the presence of a swimming pool, carport/garage and sheds; proximity to the central business district, coastline, schools, cemeteries, golf courses, main roads, water bodies, watercourses and whether houses were in commercial zones, historic residential zones, recreational zones, industrial zones and hills facing zones.

[25] These values are in terms of change in house price (i.e. capital value). Much greater impacts are reported for aspects such as property characteristics; for example a swimming pool adds AUS $31,400 (£13,500) to house price.

2.6 LIMITATIONS

Where there is a genuine choice between RP and SP methods, the general view appears to be that the former are favoured since they estimate economic values based on actual observed behaviour. In particular RP methods are not prone to the potential hypothetical biases that can influence results from SP methods and hence are usually deemed to be more 'valid'. This is based on the assumption that what individuals do is a more accurate reflection of their preferences than what individuals say they will do.

In addition some empirical analyses have demonstrated that valuations from SP methods exceed those from RP methods. **Box 2.1** provides a brief summary. Often such findings are generically interpreted ignoring the context-specific nature of results and consequently – and often without good reason (for further discussion see UKWIR, 2010) - commentaries can be prejudiced against the use SP methods.

Crucially these types of characterisations of RP and SP methods miss the important point that the choice of valuation method is always context-specific and should be based on both methodological and practical considerations.

Box 2.1 Comparing RP and SP valuations

Differences between actual and stated behaviour were investigated initially by Needleman (1974) in the context of estimating values of statistical life. However, the widely cited 'classic' reference is Carson et al. (1996) who provided a detailed analysis of 83 studies, with 616 comparisons between contingent valuation (CV) and RP values. They found a mean CV/RP ratio of 0.89 for the complete data set, with a confidence interval of 0.81-0.96, and a median of 0.75. Therefore a RP approach might actually produce higher values than using CV.

Wider research however has tended to show that SP choice experiments (CEs) produce higher WTP estimates than CV, so accordingly there may not be any difference between RP and CE in many cases. More recently a meta-analysis of the value of marine water quality in the Baltic Sea by Ahtiainen (2010) found that CE results were higher than CV results, which were higher than RP results.

The overall conclusion to draw from the empirical value evidence is that an *a priori* expectation that RP values will be lower than SP values may not necessarily be borne out in practice.

Here then it is important to recognise the limitations that can be associated with RP methods:

- Economic values can only be estimated for readily perceived non-market impacts: RP methods are limited to changes in service levels that are manifest to individuals. In relation to the HPP this can include many long standing effects (e.g. noise and visual intrusion from transport links, local amenities such as parks) but less 'visible' elements (e.g. risk of sewer flooding) may not be well perceived. There may also be a poor match between the subjective perception of a potential impact and objective measures of the impact (e.g. health risks related to drinking water quality); although this can be true for market goods too.

- Economic value estimates are based on historic behaviour: a trade-off in utilising observed behaviour is that it can only inform on the value of changes in provision of non-market goods that are currently or have previously been experienced. Often investment planning is concerned with future levels of service that are 'out-of-sample', and it may not be possible to infer economic values for such outcomes using RP methods alone. Combining RP and SP methods can potentially overcome such obstacles; in particular adding contingent behaviour or contingent valuation questions to surveys collecting data on avertive behaviour or recreation demand (e.g. DCM) can be an effective way to 'ground' SP results in observed behaviour.

- RP methods can only estimate use values: by definition RP methods cannot provide estimates of non-use values, which arise for altruistic, bequest and existence motives. In some circumstances non-use value may represent a substantial component of the total economic value derived from a particular non-market good, and hence reliance on RP approaches could lead to a significant under-estimation of aggregate costs or benefits.

- Application of RP methods can be data intensive: practical implementation of averting behaviour models, ITCM and trip-generating functions, DCM and HPP models ordinarily requires detailed and good quality datasets. This can entail considerable time and effort to collate, which should not be underestimated and can also have potentially substantial cost implications where data have to be purchased from third party sources. Robust application also requires advanced technical skills in econometric estimation. This could be one of the reasons why there are relatively few recent empirical applications of RP methods in the UK as the review of studies summarised in Appendix 1 reveals.

- Accuracy of estimation and results: the robustness of economic values estimated by RP methods is dependent on the representativeness and validity of the

observed data from which they are inferred, and crucially the methodological techniques used in estimating models (e.g. functional form and fit to data) (Young, 2005). While there can be a lack of theoretical guidance in this regard, such issues can largely be addressed empirically by appropriate scrutiny of econometric results and validity testing.

3 SCOPE OF REVEALED CUSTOMER BEHAVIOUR

3.1 IDENTIFY THE RANGE OF CUSTOMER BEHAVIOURS

This section sets out the scope of customer behaviour that could potentially be observed by companies, regulators and other stakeholders, as part of investment planning and the development of business cases. This scoping exercise has been informed by:

- The methodological and empirical literature reviewed in Section 2 and summarised also in Appendix 1;
- Review of other relevant documents, including selected aspects of companies' PR09 final business plans;
- Consultation with the representatives of a number of water companies, and
- Consideration of practices in other sectors.

Findings are presented in **Table 3.1**, which identifies various observable behaviours by household and business customers. For each behaviour the table establishes the substitute, complement or attribute relationship that could be utilised for the purposes of valuing water, wastewater and environmental services provided by companies. Where relevant other likely determinants of demand for the market and non-market good are also identified; these are the factors that would need to be controlled for by any analyses in order to isolate the effect of interest.

Table 3.1 also identifies a set of behaviours that do not accord with the conditions for using revealed preference methods (as reviewed in Section 2.1). Nevertheless such quantitative information can be valuable in supporting business cases and this role is considered further in Section 3.2.4.

Table 3.1: Identification of customer behaviours [H = Households; B = Businesses]

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Purchase of bottled water [H & B]	Bottled water - differentiated product (many brands)	Substitute / defensive expenditure for drinking water	Taste, smell, appearance concerns of tap water Perceived health concerns related to tap water	General preferences - brand, image, etc. Convenience (bottled water is portable)	Aggregate level – data provided by sources such as InfoScan Reviews, Nielsen, Dunnhumby, Kantar World Panel, Tesco Club Card Household / business level – survey of consumption and expenditure
Purchase of water filters (for jugs, kettles, etc.) and replacement cartridges [H & B]	Jugs, kettles, etc. that have a water filter cartridge	Substitute / defensive expenditure for drinking water, or in relation to water hardness	Taste, smell, appearance concerns of tap water Perceived health concerns related to tap water Water hardness	General preferences - brand, image, etc.	Aggregate level – data provided by sources such as InfoScan Reviews, Nielsen, Dunnhumby, Kantar World Panel, Tesco Club Card Household / business level – survey of consumption and expenditure

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Purchase of water filters (plumbed in) and replacement cartridges [H & B]	Water filtration devices that are plumbed into kitchen/drinking water taps	Substitute / defensive expenditure for household drinking water and/or in relation to water hardness	Taste, smell, appearance concerns of tap water Perceived health concerns related to tap water Water hardness	General preferences - image, etc.	Aggregate level – market sales data Household / business level – survey of consumption and expenditure
Purchase of water softeners [H & B]	Devices that are plumbed into mains supply (ion exchangers) or are attached to it (electronic or magnetic descalers)	Substitute / defensive expenditure in relation to water hardness	Water hardness	General preferences Avoided damage to water using appliances Reduced requirement for detergents in cleaning processes	Aggregate level – market sales data Household / business level – survey of consumption and expenditure
Purchase of limescale cleaners [H & B]	Variety of chemical cleaners for water using appliances (kettles, washing machines, dishwashers), taps, showerheads, pipes, and stained baths/sinks etc.	Substitute / defensive expenditure in relation to water hardness	Water hardness	General preferences Avoided damage to water using appliances	Aggregate level – data provided by sources such as InfoScan Reviews, Nielsen, Dunnhumby, Kantar World Panel, Tesco Club Card Household / business level – survey of consumption and expenditure

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Replacement of water using appliances [H & B]	Washing machine, dishwasher - differentiated products (many brands, specifications, etc.)	Substitute / defensive expenditure / damage cost in relation to water hardness	Water hardness	General preferences - brand, image, etc.	Aggregate level – data provided by sources such as InfoScan Reviews, Nielsen, Dunnhumby, Kantar World Panel, Tesco Club Card Household / business level – survey of expenditure
Storage of water [B]	Water as an input to production processes (manufacturing, agriculture, sports facilities, etc.).	Substitute / defensive expenditure in relation to interruptions to supply	Planned/unplanned interruptions to supply Security of supply	Health and safety regulations	Business level – survey of mitigation measures for service failures and expenditure Water companies key accounts
Purchase of water pump [H & B]	Booster pumps (including power shower fittings) that increase mains water pressure where existing supply is insufficient.	Substitute / defensive expenditure for mains water pressure	Low pressure	General preferences Avoided damage to water using appliances	Aggregate level – market sales data Household / business level – survey of expenditure

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Purchase of more efficient water appliances [H & B]	Washing machine, dishwasher - differentiated products (many brands, specifications, etc.)	Water *efficiency* is an attribute of water using appliances	Water conservation - environmental/sustainability motives	General preferences - brand, image, etc. Meter customers – household/business budget Energy efficiency (likely to be complementary to water efficiency)	Aggregate level – data provided by sources such as InfoScan Reviews, Nielsen, Dunnhumby, Kantar World Panel, Tesco Club Card Household / business level – survey of expenditure
Replacement of lead supply pipe to properties [H & B]	Resource costs associated with replacement of pipe (material, labour, etc.)	Substitute / defensive expenditure for removal of lead pipes	Health concerns	n/a	Household / business level – survey of expenditure
Actual expenditure on water supply connection repairs [H & B]	Resource costs associated with repair (material, labour, etc.)	Substitute / mitigation cost for unplanned interruptions to supply (for connection that is responsibility of household/business)	Unplanned interruptions to supply	n/a	Household / business level – survey of expenditure
Actual expenditure on drainage repairs [H & B]	Resource costs associated with repair (material, labour, etc.)	Substitute / mitigation cost for private sewer maintenance	Private sewer adoption	n/a	Household / business level – survey of expenditure

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Purchase of insurance for water supply connection repairs [H & B]	Insurance product that covers underground supply pipe to properties; typically includes repair, reinstatement, and temporary accommodation	Substitute / defensive expenditure for unplanned interruptions to supply (for connection that is responsibility of household/business)	Unplanned interruptions to supply	Other risks that are covered by insurance policy (e.g. internal plumbing, central heating system)	Insurance provider (e.g. HomeServe) Water companies*
Purchase of insurance for drainage repairs [H & B]	Insurance product that covers external underground drains/drainage from properties; typically includes repair, reinstatement, and temporary accommodation	Substitute / defensive expenditure for private sewer maintenance	Private sewer adoption	Other risks that are covered by insurance policy (e.g. internal plumbing, central heating system)	Insurance provider (e.g. HomeServe) Water companies*
Purchase and installation of flood resistance and resilience measures [H & B]	Fittings, materials and modifications in a property to mitigate against flood damages, such a door barriers, tiling, raising electrical wiring, etc.	Defensive expenditure for impacts of flooding (potentially all types: river, coastal, surface water and sewer flooding)	Sewer flooding	Risk of other flood type events (level of risk and severity of damages can vary by flood type)	Household / business level – survey of expenditure

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Purchase of property/land [H & B]	House, flats, commercial property, land	Various WS, WWS and ES are potential attributes of property/land	Water availability (agriculture/ commercial uses) Security of supply Environmental quality/amenity including river/bathing water quality Odour, nuisance, etc. from treatment works and/or other installations	Various factors, e.g. type of property and physical characteristics, neighbourhood features (schools, transport links, crime) and other environmental factors (e.g. green space)	Land Registry data for house prices and characteristics plus various other sources for environmental and neighbourhood data
Visits to a water-related recreation site (e.g. river, lake, reservoir, canal, beach) [H]	Travel costs: fares, petrol, vehicle depreciation, insurance. Recreation equipment costs (e.g. hire/purchase) Opportunity cost of time (proportion of wage rate)	Complement relationship between visits to a specific water-related recreation site and travel and time costs	Environmental quality/amenity including river/bathing water quality	General preferences Availability of substitutes Proximity to site	Visitor/household survey data plus other sources for costs

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Choice of site for water-related recreation [H]	Travel costs: fares, petrol, vehicle depreciation, insurance Recreation equipment costs (e.g. hire/purchase) Opportunity cost of time (proportion of wage rate)	Environmental quality/amenity including river/bathing water quality is an attribute recreation site quality	Environmental quality/amenity including river/bathing water quality	General preferences Other site quality and environmental characteristics (e.g. facilities) Availability and quality of substitute sites Proximity to sites	Visitor/household survey data plus other sources for costs (e.g. fuel costs)
Water conservation actions [H & B]	Potentially a range of actions related to dev ices such as water butts, cistern devices, more efficient appliances/taps/show er heads, water recycling, etc.	Substitute / defensive expenditures for security of supply risks	Security of supply Water conservation - environmental/sustain ability motives	General preferences	Aggregate level – potentially data provided by sources such as InfoScan Reviews, Nielsen, Dunnhumby, Kantar World Panel, Tesco Club Card Household / business level – survey of consumption and expenditure Water companies – water audits; provision of devices to customers

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Treatment of effluent [B]	On-site (partial) treatment of effluent discharges by non-household wastewater customers	Substitute / defensive expenditure for pollution incidents and/or environmental quality	Pollution incidents Environmental quality/amenity including river/bathing water quality	Regulatory compliance Business costs	Business level – survey of mitigation measures and expenditure Potentially key account information held by water companies
Complaints to water companies [H & B]	Potentially opportunity cost of time associated with written or telephone complaints (proportion of wage rate)	Potentially captures impact of service failures where customers behaviour does not involve any or little avertive behaviour	Taste, smell, appearance concerns of tap water Planned / unplanned interruptions to supply Low pressure Water hardness Odour, nuisance and other disamenity from treatment works and/or other installations Customer service/contact		Water companies complaints data

Customer behaviour	Market good	RP relationship	WS, WWS and/or ES	Other demand factors	Data sources
Membership of environmental organisations [H]	Subscriptions paid to organisations Value of volunteer time – opportunity cost of time (proportion of wage rate)	Potentially a proxy for pollution incidents and/or environmental quality *but* it is not clear that weak complementarity exists	Pollution incidents Environmental quality/amenity including river/bathing water quality Water conservation - environmental/sustainability motives	General preferences – image Altruism	Membership lists of national, regional and local organisations
Charitable donations/legacies to environmental charities [H & B]		Potentially a proxy for pollution incidents and/or environmental quality *but* it is not clear that weak complementarity exists	Environmental quality/amenity including river/bathing water quality Water conservation - environmental/sustainability motives	General preferences Altruism	Financial accounts of national, regional and local charitable organisations

Notes: H = household customers; B = business customers; WS = water services; WWS = wastewater services; ES = environmental services. n/a = unlikely to be any other factors that determine demand.

* Data availability may vary between companies – a number have partnerships with insurance companies for services provided.

3.2 ASSESSING POTENTIAL USE OF REVEALED CUSTOMER BEHAVIOUR

Table 3.1 identifies the potential revealed customer behaviour information that could be analysed to input to investment planning across the range of water, wastewater and environmental services. In this section the opportunities and constraints associated with the use of this information and associated revealed preference methodologies are assessed.

Key considerations for the assessment include:

- ***Coverage of values***: as highlighted in Section 2.6, revealed preference methods provide estimates of use values only. For some service attributes, particularly in relation to environmental services, indirect use values and non-use values may be a significant component of the benefits of improved levels of service. Where these elements of total economic value are expected to be significant, then SP methods should be applied to estimate them.

- ***Data availability***: data availability is a fundamental issue for RP methods. While it is relatively easy to identify a market good – non-market good relationship, collection and analysis of data to examine this relationship could be prohibitive. Necessary data in a number of instances are not held by companies, could be fragmented between various sources or not exist at all. This is a substantial barrier to compiling robust datasets that are required for RP analyses.

- ***Implementation and analysis requirements***: robust application of RP methods requires sophisticated technical analysis and expertise. There may also be significant costs for the purchase of data held by third parties (i.e. market sales and volumes data). The likely timescale for the data collection and analysis also needs to be considered. The effort and cost of any valuation effort should be weighed against the scale of investment costs (and potential benefits) of the relevant service area.

- ***Transferability of results***: implementation of RP methods may not be limited to the company level. In some cases collaborative research may be effective, helping to ensure consistency of approach across companies, or to develop results that are suitable for value transfer.

A further consideration is the overall valuation framework that companies need to develop to build an evidence base for CBA. Ultimately there is a risk of double-counting of benefits for changes in service levels that are derived separately from several different methodological approaches (i.e. RP, SP and value transfer) and then

combined in CBA. In addition, the ever-present 'package issue'[26] also requires consideration in relation to the overall benefits valuation framework developed by companies. These points emphasise the need for a robust valuation framework to be developed by companies to aid the use of CBA in investment planning. This is a key recommendation in UKWIR (2010).

The following discusses opportunities and constraints for RP methods in relation to water, wastewater and environmental services. There is though some overlap between these areas for specific service attributes. The section concludes with overall remarks that are relevant to all three service areas and the more general role of revealed customer behaviour.

3.2.1 Water services

In relation to water services, the assessment of opportunities focuses on the potential role for an avertive behaviour approach.

Opportunities

Table 3.1 suggests that there are a number of opportunities in relation to avertive behaviour and substitute relationships that are a response to service failures experienced by households. In particular potential defensive expenditure actions can be identified for: aesthetic water quality; perceived health risks; water hardness; and low pressure. In general companies do not collect data from customers in this regard – most regular tracking surveys and responses to customer contacts focus on perceptions and 'customer experience' rather than changes in behaviour that result from service failures.

Recent evidence concerned with the acceptability of drinking water suggests that a significant proportion of households could be using a water filter, softener or purchase bottled water in response to aesthetic quality issues (UKWIR, 2008b)[27]. A household level survey could be employed by companies to examine in more detail the significance of these types of avertive behaviour. Such a survey could be focussed on a specific service failure, or much broader to also capture aspects such as insurance products, actual repairs and water conservation actions. An advantage of a household level survey is that motivations for behaviours can be elicited; this would help control for potential confounding factors that could also be significant

[26] This refers to the issue of 'package effects' in valuation where the value of the components of an investment programme (e.g. improvements in service to a range of attributes) is often found to be lower if they are valued in combination and simultaneously compared to the case if the components are valued separately or individually and added together later (see UKWIR, 2010).

[27] Specifically UKWIR (2008b) states that 55% of sampled respondents (n = 554) reported the use of a water filter, softener, or purchase of bottled water, with 54% (n = 297) of these doing so for reasons related to the aesthetic quality of tap water.

determinants of demand. **Box 3.1** sets out a number of considerations with respect to the application of an avertive behaviour approach in this context.

Box 3.1 Valuing reductions in water hardness via avertive behaviour

Cost-benefit analysis (CBA) of measures to address the hardness of tap water requires estimates of the costs of those measures and their benefits. As indicated in Table 3.1, avertive behaviour may be observed from customers via their purchases of 'substitute goods' such as softeners, filters, cleaning products and replacement of appliances as a result of water hardness.

On the basis that 'avoided costs' represent a benefit in CBA (see UKWIR, 2010) and following the discussion in Section 2.2 and 3.2.1, these expenditures can be analysed to provide a lower bound estimate of WTP for reducing water hardness. For example, where the impact on customers is measured in terms of 'properties affected per year' (ICS Consulting, 2011) this implies that aggregate benefit of a water company measure that reduces water hardness can be estimated as:

WTP per household per year to avoid water hardness
× reduction in properties affected per year

This result could be used as a validity check on values derived from a SP approach. In addition because of the 'lower bound' nature of the estimation, it could be applied as a conservative benefit estimate in CBA sensitivity testing.

Importantly analysis undertaken to estimate WTP needs to establish the extent to which avertive behaviours are attributed to the service failure. For example:

- Whether avertive behaviours are a combined response to wider tap water aesthetics and potential service failures in relation to taste, smell and discolouration as well as hardness; it may be difficult to estimate values for hardness impacts (or other attributes) in isolation.
- Whether avertive behaviours are a response (or partly a response) to perceived health risks, a potentially confounding factor (e.g. customers' perceptions of risk versus the 'objective' / actual risk).
- The importance of preferences concerning water temperature (e.g. bottled/filtered water that is refrigerated); this is not a reaction to a service failure.
- The importance of other factors in determining demand for expenditure on 'substitute goods'; e.g. various image, brand, status and lifestyle factors.
- The time frame for responses to service failures; i.e. short term and long term behaviours.

Consequently implementation of an avertive behaviour approach in this context requires careful design and testing. This is needed to ensure that the analysis is able to control for the various factors that influence the demand for substitute goods to enable estimation of robust values for the service attribute of interest.

As an alternative, aggregate level data[28] could also be utilised, drawing on sales data for substitute goods at the company, region or national level. This would be a more ambitious and technically involved analysis. The ideal approach would be to link geo-referenced asset planning data on service failures to postcode data for purchases of substitute products, along with standard socio-economic and demographic data that can be obtained at this spatial level. The advantage over the household survey is that aggregate data are based on recorded sales rather than customer recollection and reporting. However detail on motivations of households for purchases is unlikely to be available in aggregate, suggesting that challenges would be faced in establishing the extent to which observed behaviours can be attributed to impacts of service failures.

Business customers' responses to service failures may be more diverse than household customers, reflecting the heterogeneous nature of this aspect of companies' customer bases. For customers with supply requirements equivalent to domestic needs (i.e. tap water, heating), a survey approach would also appear to be feasible, since the options for avertive behaviours should be the same. While company accounts would to some extent record relevant expenditure, information about motivations for avertive behaviour can be sought via a survey[29].

For manufacturing customers where the quality and/or quantity of water is a significant input to production, avertive behaviours may be more varied and more substantial in scale. It may still be possible to use a survey to identify mitigation measures these operators have in place, particularly in relation to interruptions to supply. Water companies may also have knowledge of these measures for large users and key accounts or through drought planning.

Constraints

The main limitations in relation to applying avertive behaviour approaches to water services include:

- *Coverage of values*: as noted in Section 2.2, economic values estimated from avertive behaviour models provide lower bound estimates of WTP. Moreover the method does not capture non-use values that may be associated with changes in service levels (i.e. WTP to avoid other customers experiencing service failures, in relation to localised health impacts). At first glance, this may suggest that the role of such analysis may be to provide a validity test for SP valuations obtained via a

[28] An aggregate level approach would use data on market shares for substitute products. This in contrast to the household / business level approach which is discussed above that would examine individual choices concerning substitutes (which could be termed as a 'disaggregate approach').

[29] For instance surveys of businesses and households supported analysis of the impact of security of supply failures in Yorkshire in 1995 (Ofwat 1996; 1997).

'PR09 style' study. Such a comparison would also be an empirical test of the potential significance of non-use values in driving SP valuations of improvements in service[30].

In addition, Schram et al. (2010) demonstrate how avertive behaviour analysis can be undertaken such that WTP can be estimated for improvements in service levels that match perceived quality of substitutes (e.g. bottled or filtered water). This offers a way in which companies can potentially quantify 'peace of mind' around challenging issues such as the perceived health risk of tap water. Alternatively a survey-based approach to avertive behaviour could be combined with either contingent behaviour (i.e. how would your behaviour change if service levels improved) or contingent valuation questions which would provide information on the value of improved levels of service.

- *Data availability*: since there is an opportunity to use household level surveys to examine avertive behaviour in relation to service failures, data availability should not be a concern, provided the surveys are appropriately designed and implemented. Business customers may represent more of a challenge, with the ever-present issue of identifying the appropriate contact point, along with potential confidentiality issues concerning the disclosure of cost information. However, if respondents are willing to participate, it should be easier for them to report what actions they take or measures they have in place in relation to service failures (i.e. their actual avertive behaviour), rather than having to consider the potential implications of hypothetical scenarios concerning service failures.

  The alternative of taking an aggregate level approach – using regional or national sales data for substitute goods – would likely require significant data purchase and compilation costs and effort.

- *Implementation and analysis*: a fundamental requirement of any avertive behaviour analysis is to ensure that potentially confounding factors are adequately controlled for; i.e. other drivers of demand for substitute goods. For a survey-based approach an objective of the initial testing and piloting would be to ensure that all of these factors are identified. Also the survey exercise should not be to simply collect information on purchases of substitutes, but also to produce a dataset that enables (econometric) avertive behaviour models to be estimated so that importance of different aspects of service failures and other determinants of demand can be established. This analysis will provide a much more robust basis

[30] This would by no means be a 'perfect test', but comparing valuations derived from avertive behaviour models to choice experiments would be a highly useful exercise given much debate witnessed during PR09 as to the validity of SP methods. Conceivably WTP, for improvements in say the aesthetic quality of tap water, should not really be much greater than the costs of purchasing substitutes, unless there is a significant non-use component in valuations captured by SP methods.

for interpretation of results.

- *Transferability of results*: in practice the transferability of results will depend on the nature of the exercise that is undertaken. The first step for using an avertive behaviour approach could be exploratory research with the aim of establishing the likely significance of such behaviours based on a nationally representative study. This could be in relation to either a household/business level approach or aggregate level approach. The results from this analysis would inform on whether region or company specific studies are necessary. In particular companies could use household level surveys to targeted specific sub-populations within a region, such as those that experience particular service failures more often, along with those who experience it less often. Such targeting could be based on complaints data. Valuations generated by this approach would allow for a much richer assessment of aggregate benefits in CBA than simply assuming a constant unit value across all customers.

3.2.2 Wastewater services

The avertive behaviour approach also has some potential for wastewater services and this is considered briefly below. However the main focus of the assessment is the application of a hedonic property pricing approach (HPP) and disamenity impacts from wastewater services.

Opportunities

An avertive behaviour approach could also potentially identify actions that are relevant to some wastewater services (e.g. purchase of insurance, drainage repair costs). For example an estimate of the avoided cost associated with the maintenance of drains by private owners and local authorities (approximately £150 – 200 million per year) was used as a benefit estimate in the impact assessment of the transfer of private sewers to companies (Defra, 2010). This estimate was based on consultation with the insurance industry. Therefore in determining the scope for using an avertive behaviour approach, companies could also consider relevant aspects of wastewater services in addition to water services.

With respect to opportunities for applying HPP, there is a strong conceptual appeal in its use if disamenity impacts associated with wastewater services – such as odour and nuisance from treatment works – are well perceived by households. This is a key condition and previous assessments suggest that sewer flooding risks are unlikely to be apparent to prospective house buyers (eftec, 2006), particularly since this risk is

not identified in the standard environmental search that buyers undertake[31].

Odour and other nuisance impacts from treatment works can be intermittent in nature and are also dependent on factors such as prevailing wind direction and intervening screening, hence they are recorded as 'incidents' rather than a continuous disamenity. However it seems plausible that house buyers will at least be aware of the presence of treatment works, and even if they do not have a full appreciation of the odour impact, it is likely that their purchasing decisions will be influenced. Coupled with this, data should be available from companies' monitoring and modelling of odour (e.g. odour contours), along with proximity of treatment works to residential areas[32].

Overall there is a large literature that values the effect on property values of the proximity to noxious facilities (in particular landfills and incinerators) and this produces consistent results. In the water sector, there are fewer studies and the previous UKWIR (2008a) study encountered various challenges. Wider empirical exercises demonstrate the richness of results that can be derived from a rigorously implemented HPP study (e.g. Day et al., 2007; Gibbons et al., 2011). The lesson from these studies is the need for large and good quality datasets that utilise geographic information systems (GIS). Gibbons et al.'s analysis in relation to environmental amenity values is perhaps an extreme example, since it is based on approximately 1 million housing transactions in the UK over the period 1996 – 2008, but it does serve to highlight that collating as many data observations as possible is of key importance to any practical application. Use of GIS is particularly fundamental so that property location and proximity to local services and environmental amenities can be controlled for, along with proximity to treatment works.

There are also HPP studies that have been used to examine the impact of environmental water quality on property prices, as well as the effect of water use restrictions on local environmental amenity[33]. If relevant and sufficient (time series) data can be compiled on aspects such as odour, environmental quality, water use restrictions, and other necessary data (property sales prices, property characteristics,

[31] Fluvial and coastal flooding risk is reported in the environmental search. If a property is recorded on the DG5 register (at risk of flooding due to inadequate sewer capacity) it should be reported in a residential drainage and water search; however the DG5 register does not include all properties that are at risk of sewer flooding. There is of course also an asymmetry of information between house sellers and buyers, with the former likely to be, but not always, aware of the sewer flooding risk, particularly if experienced directly. This could be reflected in their willingness to accept a lower selling price (all else equal).

[32] An important point is that the disamenity to be valued is related to the level of odour rather than the proximity to treatment works (unless the investment context was concerned with the construction of new facilities). Hence proximity may be considered as proxy for the disamenity from odour but it is invariant to abatement actions undertaken by companies and so would not provide an indication of the benefits of these investments.

[33] A further issue that could be explored via hedonic pricing, but has not been addressed in the literature, is the presence of lead connection pipes for some properties. This may be revealed in a residential and drainage search depending on information supplied by water companies.

local services, other elements of local environmental amenity) and if individuals are aware of the environmental amenity factors being valued, then HPP can be used.

Constraints

Limitations in relation to applying an HPP approach to disamenity impacts of service failure include:

- *Coverage of values*: an HPP approach will not capture non-use values associated with service failures, nor use/non-use values associated with the wider customer base; for example where odour affects a major arterial road, place of work or commercial retail area. In this regard empirical evidence is limited as to the significance of these use and non-use motivations in households' valuations. Results from PR09 SP studies could feasibly be strongly driven by these factors, particularly in situations where only a relatively small proportion of household customers are close enough to treatment works to be directly impacted. Comparative analysis with results from a well-designed HPP study could help reconcile valuations from SP studies, if this was determined to be a significant issue.

  Another point to note is that business customer valuations would not be captured by an HPP study which deals with residential sales data[34].

- *Data availability*: even when relevant data for HPP exist, the effort, time and cost required to compile such data for further analyses should not be underestimated. With the exception of monitoring data on odour, all other data would need to be purchased from third-party sources. However it may be possible to extend the dataset collated by Gibbons et al., (2011) to include location of treatment works and odour levels[35]. If feasible this would represent a significant opportunity to develop an HPP approach.

  In relation to other service attributes, water quality data would be available to companies based on the Environment Agency monitoring.

- *Implementation and analysis*: a well-designed and implemented HPP study would be an ambitious undertaking, requiring considerable input and technical expertise from leading practitioners. In practice any proposed application would benefit immensely from an initial scoping study that would explore in more detail

[34] Analysis could be undertaken on commercial property sales and lettings with respect to business customers but this would likely be an ambitious undertaking.
[35] Pers. comm. S. Mourato (London School of Economics and Political Science), April 2011. In principle the Gibbons et al. HPP dataset could be extended to include further environmental (dis)amenities, but such an undertaking would require more detailed consideration of available odour and treatment works data, plus the permissions that would be needed to extend the scope of the analysis.

the key methodological issues around data and estimation. This in particular would establish if the approach could be successfully implemented on a local housing market basis, a regional basis, or even at the national level.

- *Transferability of results*: the degree of transferability of results will depend very much on the specific details of any analyses. Potentially though, 'generalisable' results could be produced if an HPP study was appropriately designed.

3.2.3 Environmental services

Here the assessment focuses on the analysis of household demand for recreation and how water-environment quality improvements could be valued.

Opportunities

The principle context for valuing water-environment quality is the continued implementation of the Water Framework Directive. To date valuation effort has focused on the use of SP methods, via companies' PR09 studies and the 'national benefits assessment', which is reported in Nera (2007). However, discrete choice models (DCM) are increasingly used to analyse households' demand for recreation sites such as open access rivers, lakes, reservoirs – which is ably demonstrated by the ChREAM and Iowa Lakes Valuation projects – or for specific user populations such as anglers. Therefore the DCM approach needs further serious consideration in relation to its potential role in further valuation efforts.

Bateman et al. (2010) particularly emphasise the need for studies valuing improvements in water quality to control for scope of environmental improvements, the availability and quality of substitute sites, spatial variation in household socio-economic characteristics, their proximity and access to recreation sites. All of these elements can be accounted for within the DCM approach, particularly when combined with GIS. The framework for the analysis also provides the basis for estimating transferable WTP values and functions, which widen the scope for using results.

Implementation requires a household survey to collate visit data, along with attitudes towards water quality issues, travel costs to sites visited and socio-economic characteristics. In addition the GIS element can utilise spatially-referenced national datasets for household socio-economic characteristics at post-code level, and can also be used to calculate travel costs and times for all substitute sites (Bateman et al., 2003). Measures of physical water quality can be sourced from Environment Agency monitoring.

In practice the survey and analysis could be undertaken at a company level; i.e.

identifying the main recreation sites and access points for water bodies within a region or catchment. Collecting visit data over a prolonged period of time would also enhance the dataset, as water quality would be observed to vary within sites as well as between sites. Alternatively a national level study could be implemented such that enough representative sites across the country were identified and surrounding populations surveyed such that 'generalisable' results could be estimated.

A further point is that a DCM could be combined with contingent behaviour or other SP approaches to generate wider economic value evidence; i.e. estimating the benefit of the highest environmental quality possible either by asking how visit behaviour would change, or what households would be willing to pay to attain those levels.

Constraints

The proposed opportunity for the DCM approach presents a number of potential limitations:

- *Coverage of values*: DCM approach does not capture non-use values. However it is arguable that in the first instance a fuller understanding of use values associated with the water environment (e.g. recreation benefits) is essential to support continued WFD implementation. For example if the case for improvements in water bodies can be justified on the basis of robustly estimated use values alone, then non-use arguments will serve to reinforce the cases for proposed programmes of measures. If use values cannot justify improvements (i.e. costs of measures outweigh benefits), then much stronger scrutiny will be needed on the validity and application of estimates derived from SP studies that also capture non-use, because of 'burden of proof' considerations.

- *Data availability:* overall, the availability of data should not be a significant concern for the application of DCM. The ChREAM study demonstrates how the framework for the analysis can be drawn together, combining household survey data, with water quality monitoring data and GIS inputs. However, that is not to say that significant effort would not be required to ensure that the study is well designed and formulated.

- *Implementation and analysis*: application of the DCM, including the data and analysis requirements (e.g. using GIS) would be a 'step-up' for companies compared to experiences at PR09. Practical implementation will require the necessary technical skills and expertise to deliver what can be considered to be 'state-of-the-art' valuation analysis. As with the potential for applying the HPP approach, any proposed applications of DCM would benefit from a scoping study to establish the precise aims and objectives for the work, particularly given the number of stakeholders engaged in the WFD implementation process.

- *Transferability*: given that DCM can be designed explicitly to provide transferable results, this is not a limitation here but a further opportunity.

3.2.4 Further remarks

Sections 3.2.1 – 3.2.3 focus on the main opportunities for applying RP methods to value changes in the provision of water, wastewater and environmental services. The main findings are summarised in Table 3.2. Significantly, in most instances companies can make use of customer surveys to generate data. As noted above, this has the drawback in some cases of being based on customer reporting (e.g. avertive behaviour), rather than objective data sets (e.g. market sales data). However, this essentially is the compromise that is required for easier implementation (both in data collection effort and cost).

Table 3.2: Summary of scope for use of revealed preference methods

Service attribute	Method(s)	Data
Water services		
Drinking water aesthetics (taste, odour, appearance)	Avertive behaviour model	Household survey Business survey
Drinking water health risks	Avertive behaviour model	Household survey Business survey
Water hardness	Avertive behaviour model	Household survey Business survey
Interruptions to supply	Avertive behaviour model	Business survey
Security of supply	Avertive behaviour model	Business survey
Low pressure	Avertive behaviour model	Household survey Business survey
Wastewater services		
Odour, disamenity from wastewater treatment	Hedonic property pricing	Residential property sales, characteristics etc., GIS
Sewer flooding	Avertive behaviour model / defensive expenditure	Household survey Business survey
Private sewer maintenance /adoption	Avertive behaviour model	Household survey Business survey
Environmental services		
River water quality / flow levels (recreation benefits)	Discrete choice model	Household survey, env. quality data, GIS data
Bathing water quality	Discrete choice model	Household survey, env. quality data, GIS data

There are also wider opportunities to use revealed customer behaviour data to improve the evidence base for investment planning. For example:

- *Customer complaints data:* it is essential that any business case put forward for an investment is justified on all available data. Complaints data are companies' primary metric for establishing the significance – in terms of impact on customers - of many service failures, and as such provide the initial 'sense check'

for results that are estimated from both RP and SP studies; i.e. can the unit and aggregate benefit estimates be reconciled with the observed number of complaints, their frequency and distribution across the customer base. Interpretation of quantitative and monetary evidence in this context also allows richer qualitative arguments to be put forward to support investment proposal.

- '*Valuing' customer complaints:* some service failures may not be significant enough (in magnitude or frequency) for customers to undertake avertive behaviours and incur expenditures on substitute goods. However it still can be inferred that some disamenity is experienced, particularly if customers contact companies to complain. A proxy value for this disamenity could be estimated by attributing a monetary value to a complaint that a company receives from either a business or household customer. In fact Atkinson et al. (2004) consider different measures of inconvenience in terms of writing letters of complaint, signing petitions, contacting MPs, and coordinating protest; all of which can be valued in monetary terms provided assumptions are made as to the time expended on each action (e.g. 5-10 minutes for a telephone call) and the value of time (e.g. average wage rate for business contacts).

- *Visitor survey data:* a number of companies manage large open access recreation sites such as reservoirs. Here there are opportunities to collate data on visitor numbers, frequency of visits and activities to establish supporting arguments for the importance of maintaining or improving access to these sites (e.g. in relation to the CROW act) for local populations. Opportunities could also exist for using smaller scale travel cost (ITCM), trip-generating functions, and DCM surveys to examine specific issues.

- *Wider customer surveys:* companies' current customer tracking surveys and other initiatives focus on perceptions of services and customer experience. Considering the range of behaviours listed in Table 3.1, there are also opportunities to assess how these types of surveys could be used to generate wider quantitative data on aspects such as water conservation actions, recreational visits, and membership of environmental organisations. These could also seek to elicit information on responses to service failures, such as complaints or avertive behaviours. This could provide a basis for establishing the need for further analysis for specific service attributes.

4 RECOMMENDATIONS FOR FUTURE USE

The following concludes by presenting recommendations for the use of revealed customer behaviour to assess customer priorities, for the purposes of CBA, investment planning and development of business plans:

1. **Business cases should be supported by *a range of* quantitative and economic value evidence**

   Given certain practical considerations for developing a coherent basis for benefits valuation, SP methods are likely to continue to be the principal approach to valuation for companies developing CBAs for investment proposals. However there is significant scope for data on revealed customer behaviour to provide a robust validity test for benefit estimates. Moreover in some cases RP methods may represent the 'preferred' approach; e.g. recreation benefits associated with water quality improvements.

   Added to this, wider revealed customer behaviour evidence could be used as a sense-check on unit and aggregate values; e.g. comparing complaints data to the magnitude of benefit estimates. This does not imply that there needs to be a direct (or indeed any) relationship between behaviour data and valuations but comparison itself will be a learning experience for companies and stakeholders.

   Companies should review what data are collected (e.g. through customer contacts) and opportunities that exist for collating more data (e.g. by reviewing the content of tracking surveys). The objective should be to ensure that business cases can be supported by an appropriate and sufficient qualitative, quantitative and valuation evidence base. These assessments should be undertaken by companies as part of their work to establish a coherent framework for benefits valuation and applying CBA.

2. **Companies should consider the use of avertive behaviour surveys to understand better the substitution and mitigation actions customers take in response to service failures**

   There is a strong case for exploring further the potential for an avertive behaviour approach. This represents a significant opportunity to compare RP and SP valuations and provide an improved validity test of the latter.

Companies may wish to develop this work individually or in collaboration. Household and business surveys could be cost-effectively implemented via an online survey. This represents a potential 'quick win' – particularly if undertaken collaboratively – to advance understanding of avertive behaviours of customers in relation to service failures. A minimum of three months should be allowed for study design, implementation and analysis.

3. All stakeholders should review the approach to valuing environmental quality improvements associated with implementation of the Water Framework Directive

There is considerable merit in taking stock of recent methodological developments in the use of RP methods and valuing environmental water quality, particularly in terms of the application of discrete choice models. Studies such as ChREAM and the Iowa Lakes Valuation Project demonstrate how observed behaviour can provide an appealing analytical framework for establishing robust economic value estimates, both in terms of unit values and aggregate benefits. Results from both studies strongly suggest that simply assuming linear WTP from improvements is inappropriate. This has significant implications for continued WFD implementation, and a simple repeat and refinement of the 'PR09 approach' is unlikely to result in valuation evidence that can inform decisions particularly well in this regard.

A practical starting point for this recommendation would be a scoping study including all stakeholders that establishes the precise requirements for estimating the benefits of continued WFD implementation. An opportunity to establish key issues for benefits valuation is provided by the current UKWIR study 'RG08 Water Framework Directive (WFD) - Disproportionate Costs' (May – December 2011).

4. Further scoping is required to establish the role for hedonic property pricing in relation to valuing disamenity impacts associated with service failures

There is considerable conceptual appeal in using hedonic pricing approaches to value disamenity impacts arising from odour and nuisance from wastewater treatment works, and potentially also the effect of water use restrictions and water-environment quality. However empirical applications to date show that successful studies require considerable time, resources, data and expertise.

Ordinarily judgement is needed to establish if the ambition and effort required to deliver a robust study is warranted; i.e. does the uncertainty that may be associated with SP valuations justify this undertaking. However the potential to extend the dataset and analysis presented in Gibbons et al. (2011) represents a significant opportunity to offset much of the data collation effort.

Assessing the potential to develop the Gibbons et al. (2011) dataset is best suited to a collaborative effort among companies, particularly since this represents a national level data set with an opportunity to generate 'transferable' results. A staged approach would be most appropriate, with an initial scoping stage establishing the viability of the proposal by examining the necessary methodological, data, practical and resource requirements (approximately 1 – 3 months). The actual implementation and analysis in Stage 2 (approximately 3 – 6 months) would be carried out based on the specification produced by Stage 1.

5. Opportunities to combine revealed preference and stated preference approaches should be considered

The basis for valuing changes in service levels associated with water, wastewater and environmental services should not be viewed as a choice of either RP or SP methods. As UKWIR (2010) points out, companies need to develop a coherent framework for valuing benefits of service improvements. This should account not only for the 'hierarchy of valuation methods' (market prices – revealed preference – stated preference), but also the many practical considerations that have to be weighed up. There are opportunities to apply joint RP and SP approaches. In particular combining contingent behaviour questions with avertive behaviour approaches provides a strong grounding in actual and experienced service levels for SP values elicited from customers; likewise, applying contingent valuation questions in this format is also appealing.

Companies should develop a coherent framework for benefits valuation and CBA that utilise a range of valuation evidence, applying the most appropriate method or combinations of methods. Particular emphasis should be placed on the need for robust validity testing of valuation results.

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APPENDIX 1

SUMMARY OF EMPIRICAL STUDIES

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
An Assessment of the Impact of Charging for Provincial Water Use Permits	Renzetti, Steven and Diane Dupont. Canadian Public Policy 25(3): 361-378, 1999	Permits for direct water withdrawals	Simulations using models	Permit charging will temporarily offset growth in water withdrawals	n/a	Canada	Water supply
The role of water in Manufacturing	Dupont, Diane P. and Steven Renzetti. Environmental and Resource Economics 18: 411-432, 2001.	Water use sensitivity to input prices and level of output	Econometric KLEM model of manufacturing	Water use has negative elasticity to input prices. Water recirculation and water intake are substitutes.	n/a	Canada	Water supply
Water use in the Canadian Food Processing Industry	Dupont, Diane and Steven Renzetti. Canadian Journal of Agricultural Economics 46 (1998) 83-92	Water intake, recirculation and discharge	Econometric model	Water use in the food processing industry is responsive to price and output changes. Water circulation and water intake are substitutes.	Plant-level data from 1991 survey of water-using firms	Canada	Water supply
Arsenic mitigation in Bangladesh: A Household Labor Market Approach	Carson, Richard T., Phoebe Koundouri and Celine Nauges. Department of Economics, UCSD, UC San Diego 2009.	Costs of arsenic contamination of water supply through labour supply reduction	Econometric analysis with labour supply model	Arsenic in water costs a household labour supply reduction of over 8%	Household Income and Expenditure Survey from the Bangladesh Bureau of Statistics	Bangladesh	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Evidence of the Effects of Water Quality on Residential Land Prices	Leggett, Christopher G. and Nancy E. Bockstael. Journal of Environmental Economics and Management 39: 121-144, 2000	House prices to estimate benefits of noticeable environmental water quality	Hedonic pricing	Higher levels of fecal coliform significantly depress property values. A change of 100 fecal coliform counts per 100mL estimated to produce a 1.5% change in property prices. Price impacts range from $5114 to $9824 per property	House prices of waterfront property	USA	Environmental water quality
At Odds with Water: Perceived Health Risks and Water in Canada	Schram, Craig, W.L. Adamowicz and Diane Dupont. Presented at the World Congress of Resource and Environmental Economics, Montreal Quebec, June 2010	Expenditures on drinking water from perceived health risks	Avertive behaviour	Monthly marginal WTP estimates for improvements in tap water to the perceived quality of filtered and bottled water were $2.96 and $13.97 respectively. Perceived mortality is a significant predictor of water consumption choices for a large number of respondents in the survey.	Internet-based cross-Canada survey. Sample size 1304	Canada	Water supply
The impact of oil and natural gas facilities on rural residential	Boxall, Peter C., Wing H. Chan & Melville L. McMillan. Resource and Energy Economics	Impact on house prices of presence of oil and natural gas facilities	Hedonic pricing with spatial error model	Property values are negatively correlated with number of sour gas wells and flaring oil	Residential property sales in Calgary	Canada	n/a

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
property values: a spatial hedonic analysis	27: 248-269, 2005.			batteries within 4km of a property			
The value of public and private green spaces under water restrictions	MacDonald, Darla Hatton, Neville D. Crossman, Parvin Mahmoudi, Laura O. Taylor, David M. Summers and Peter C. Boxall. Landscape and Urban Planning 95: 192-200, 2010	Impact on house prices of public and private green spaces under water restrictions	Hedonic pricing	Water restrictions do not have a significant impact on the value of outdoor space on private properties. Indications that substitutions may be occurring with proximity to playgrounds, which are watered more regularly.	Digital aerial photography and house sale prices between January 2005 and November 2007	Australia	Water supply
Accommodating Complex Substitution Patterns in a Random Utility Model of Recreational Fishing	Hunt, Len M, Peter C. Boxall & Barry Boots. Marine Resource Economics 22:155-172. 2007	Quality of fishing sites by site choice of anglers	Random Utility Model	Declines in wall-eye catch rate and road degradation negatively impacted visits to sites. Welfare losses amounted to $0.24-$0.27 per day trip for road degradation and $0.33-$0.35 per multiple day trips and $0.17-$0.30 for decline to walleye catch rates for day trips and $1.47-$1.71 for multiple-day trips	655 anglers agreed to participate in an angling diary program.	Canada	Environmental water quality

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Recreation Demand using physical measures of water quality	Egan, Kevin J.; Joseph A. Herriges, Catherine L. Kling and John A. Downing. American Journal of Agricultural Economics 91: 106-123. 2009	Recreation demand based on water quality as measured by a limnology laboratory	Random Utility Model	Iowans value a few lakes with superior water quality more highly than all recreational lakes that have only adequate levels of water quality.	2002 Iowa Lakes Survey (sample size 3,859) and physical water quality measures collected by Iowa State University's Limnology Laboratory	USA	Environmental water quality
Valuing recreation in the Coorong, Australia, with Travel Cost and Contingent Behaviour Models; Testing for convergent validity between travel cost and contingent valuation estimates of recreation values in the Coorong, Australia	Rolfe, John and Brenda Dyack. The Economic Record, 2010 Rolfe, John and Brenda Dyack. The Australian Journal of Agricultural and Resource Economics 54:583-599	Recreational value of the Coorong through travel cost and CVM.	Travel cost method and contingent valuation	Values per adult visitor per day were estimated at $149 for TCM and $116 for CVM.	Survey of recreational users at site over January to April 2006. Sample size of 790.	Australia	Environmental water quality

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
The value of recreational fishing in the Great Barrier Reef, Australia: A pooled preference and contingent behaviour model	Prayaga, Prabha, John Rolfe and Natalie Stoeckl, Marine Policy 34: 244-251, 2010	Recreational value of fishing in the Capricorn Coast using travel cost method	Travel cost method and contingent valuation	High values associated with recreational fishing activity along the Capricorn Coast, and demand for recreational fishing is inelastic - values are relatively insensitive to changes in catch rates	Survey of anglers at Capricorn Coast over period of 28 weeks from late January to mid August 2007. Sample size of 311.	Australia	Environ mental water quality
Household demand and welfare: Implications for water pricing in Cyprus	Hadjispirou, S., Koundouri, P. and Pashardes, P., Environment and Development Economics 7(4): 659-685. 2002	Welfare implications of the price of water supply	Demand analysis	Price elasticity of demand for water ranges from between -.4 for households in the lowest and -.8 for households in the highest 10% of income distribution. However a move towards a more uniform marginal cost pricing system will be distributed in favour of the better off households, while households in the bottom 10% of the distribution of income will be net losers.	Family Expenditure Survey 1996/97, surveys 2700 households on annual water bill together with expenditure on a large number of other items.	Cyprus	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
An Ecological and Economic Approach to Valuing River Quality	Johnstone, Claire A. PhD Thesis, Dept. of Economics and International Development, University of Bath	River quality measured by choice of angling site	Random Utility Model	Consumer surplus per trip for a 10% change in river attributers (higher flow rates, biological quality and nutrient pollution levels) ranges from £0.04 to £3.93.	Survey of river anglers between November 2000 and April 2001. Sample size 421	England	Environmental water quality
Exploring the Hedonic Value of Ambient Water Quality: A Local Watershed Based Study	Poor, P.J., K. Pessagno and R.W. Paul. Ecological Economics, 60:4(797-806), 2007.	Impact of local water quality on house prices	Hedonic pricing	Environmental water quality affects house prices. The marginal implicit price for 1mg per litre change in total suspended solid was estimated to be $1,086 while similar change in dissolved inorganic nitrogen was estimated to be $17,642	Residential property sales within the St Mary's watershed between June 1999 to May 2003. Environmental data was obtained from water monitoring stations.	USA	Environmental water quality

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
The role of water quality perceptions in modelling lake recreation demand	Jeon, Y., J.A. Herriges, C.L. Kling and J. Downing	The role of water quality perceptions in modelling lake recreation demand	Random utility model	Annual benefit of $12.39 to $73.03 for an improvement in water quality for all 130 lakes to the same water quality as that of West Okoboji Lake. For an improvement of 9 lakes, benefits are $0.90 to $8.26 per household per year, and for improvement of 65 impaired lakes to the median water quality of the 66 non-impaired lakes, the benefits are $3.06 to $7.28 per household per year.	2003 Iowa Lakes Survey (sample size 5,281) and environmental data from Iowa State University Limnology laboratory	USA	Environmental water quality
An application of the Kuhn-Tucker Model to the Demand for Water Trail Trips in North Carolina	Phaneuf, D.J. and C. Siderelis. Marine Resource Economics 18: 1-14. 2003.	Water quality link to demand for water trail trips in northern Carolina (value measured by travel cost)	Kuhn-Tucker recreation demand model	Mean annual WTP per individual was US$4.64 for an increase by 100 trail miles and $24.44 for an improvement in water quality to at least 2 on the Index of Watershed Indicators (IWI) in the paddling areas.	Mail survey of canoeing and kayaking visitors to eastern North Carolina in 2000. Sample size was 491.	USA	Environmental water quality

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Valuing River Characteristics using combined site choice and participation travel cost models	Johnstone, C. and A. Markandya. Journal of Environmental Management 80: 237-247. 2006	Impact of river quality (chemical, biological, habitat and fish population) on visitor numbers. Measured via travel cost	Travel cost method	10% change in river attributes results in change in consumer surplus value per trip, ranging from a low of £0.04 to a high of £3.93.	Mail and online survey of anglers with sample size of 821.	UK	Environmental water quality
The Welfare Cost of Urban Outdoor Water Restrictions	Brennen, D. and S. Tapsuwan. Australian Journal of Agricultural and Resource Economics 51(3): 243-261. 2007	Water restrictions (lawn watering restrictions)	Household production model of consumer choice	A 2 day ban of sprinkler use has a welfare cost of $66 to $67. For a full ban, costs vary between $347 to $871 depending on the time cost used.	Interviews with turf industry representatives	Australia	Water supply
On combining stated preferences and revealed preferences approaches to evaluate environmental resources having a recreational use	Paccagnan, V. IEFE Working Paper Series, No. 4. 2007.	Water quality and recreational demand, measured by travel cost	Travel cost and contingent behaviour	Combined TCM and CB results to get value of €134 per trip per individual	Survey of visitors to Idro Lake in July 2005. Sample size of 155 responses.	Italy	Environmental water quality
Effects on welfare measures of alternative means of accounting for preference heterogeneity in recreational	Hynes, Stephen, Nick Hanley and Riccardo Scarpa. American Journal of Agricultural Economics 90(4):1011-1027. 2008	Water quality and recreational demand (whitewater kayaking)	Random Utility Model	Increasing water quality rating at the Liffey produces a loss for some and a gain for others, but gains exceed losses. The simulated mean is €1.89 per choice and is slightly	Survey e-mailed out to Irish kayaker e-mail lists, posted on Irish Canoe Union	Ireland	Environmental water quality

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
demand models				smaller for skilled (€1.70) than for unskilled (€2.20) kayakers.	website, and administered to a kayaking group meet. Sample size 279		
Aesthetic Values of Lakes and Rivers	Corrigan, Jay R., Kevin J. Egan and John A. Downing. 2007	Improved aesthetic water quality of lake by intended visits	Travel cost method	Visitors place a greater value on large water-quality improvements ($347 per visitor per year) over a small one ($139 per visitor per year).	Mail survey with sample size of 479	USA	Environmental water quality
A framework for cost-benefit analysis in odour control projects	O'Sullivan, F., J Wells and M Whitbread. UKWIR, 2008	House prices estimate the costs of odour from sewage treatment plants	Hedonic pricing	In one site terraced housing shows a significant difference in prices, but this is not repeated for semi-detached housing. For another two sites, there was no significant difference between house prices before and after sewage treatment works were built, although the study notes there are relatively few observations in some	Land Registry	UK	Sewage treatment

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
				cases. In one of these sites there is a difference in house prices which are and are not affected by odour. The study concludes that no unambiguous patterns in the findings emerged from the analysis.			
Water vending activities in developing countries	Whittington, Dale, Donald T. Lauria, Daniel A. Okun, and Xinming Mu. International Journal of Water Resources Development 5(3): 158-168	Market price for clean water delivered to homes	Market pricing	Benefits of water vending (as opposed to water collection) range from $110 for households with a higher value of time ($0.50 per hour) to $50 and $30 for households with a lower value of time ($0.25 per hour).	Fieldwork carried out in June and July 1986, including observations at kiosks, handpumps and open wells, interviews with water vendors and kiosk owners.	Kenya	Water supply
Valuing the benefits of coastal water quality	Hanley, Nick, David Bell and Begona Alvarez-Farizo.	Change in number of trips and welfare due to change in water quality	Travel cost method	Increase in consumer surplus per individual per year is valued at	On-site survey undertaken	UK	Environ mental water

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
improvements using contingent and real behaviour	Environmental and Resource Economics 24(3):273-285. 2003			£5.81, or £0.48 per trip for improved water quality.	in 1999 on seven beaches in Scotland. Sample size 414.		quality
Joint production and averting expenditure measures of willingness to pay: Do water expenditures really measure avoidance costs?	Abrahams, Nii Adote, Bryan J. Hubbell, Jeffrey L. Jordan. American Journal of Agricultural Economics, Vol. 82, No 2 (May 2000), pp 427-437	Purchase of bottled water and/or water filters to offset possible contamination risks of tapwater	Avertive behaviour	Perceived risk from tap water, concern about water quality (taste, odour and appearance), race and age are important determinants of bottled water selection while perception of risk, income, and previous problems with tap water are important variables in the decision to use a water filter. The estimate for lower bound aggregate WTP for safe water for the state of Georgia is $346 million per year, or about $47 per person annually.	Telephone survey of Georgia residents. Sample size 400.	USA	Water supply
Valuing environmental quality changes	Abdalla, Charles W., Brian A. Roach and Donald J. Epp. Land	Respondents to a survey were asked what avertive actions they	Avertive expenditure	Total estimated costs for avertive expenditures on increased/new purchases	Postal survey of sample size 761 and	USA	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
using avertive expenditures: An application to groundwater contamination	Economics, 68(2), 163-69. 1992	took in response to a contamination event of groundwater in Perkasie, Pennsylvania. These actions included increased bottled water purchases, installing home water treatment systems, hauling water from alternate sources and boiling water.		of bottled water, home water treatment systems, hauling water and boiling water for all Perkasie households were estimated to be $61,313.29 to $131,334.06 between December 1987 to September 1989, depending on the wage rate used to reflect lost leisure time.	a telephone survey to check representativeness of sample.		
Actual averting expenditure versus stated willingness to pay	Wu, Pei-Ing and Chu-Li Huang. Applied Economics 33: 277-283. 2001.	Purchasing bottled and distilled water and water purifiers for better water quality.	Avertive behaviour and stated willingness to pay	Households had different avertive actions to water quality from combinations of water purchase and the use of water filters and purifiers. The average avertive expenditure for each household is NT $617.24 every 2 months. The stated average willingness to pay was NT$599.52 and NT$634.64 depending on the model used to	Referendum survey with a sample size of 540 households, 54 households from each district in the city of Kaohsiung, Taiwan.	Taiwan	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
				estimate it.			
Combining Averting Behaviour and Contingent Valuation Data: An Application to Drinking Water Treatment	Rosado, Marcia A., Maria A. Cunha-e-Sa, Maria M. Ducla-Soares and Luis C. Nunes. Environment and Development Economics 11(6): 729-746. 2006.	Cost of treating tap water or buying bottled water to achieve safe drinking water.	Avertive behaviour and stated willingness to pay	Households paid an average of $10 per month to treat water/buy bottled water. They were willing to pay average of $28 a month for treated tap water.	Survey of households in urban area of the state of Espirito Santo. Sample size 791.	Brazil	Water supply
An Hedonic Analysis of the Effects of Lake Water Clarity on New Hampshire Lakefront Properties	Gibbs, Julie P., John M. Halstead, Kevin J. Boyle, and Ju-Chin Huang. Agricultural and Resource Economics Review 31(1):39-46. 2002	Cost of eutrophication in lake water (measured by secchi readings) as measured by differences in value of lakefront properties	Hedonic pricing	A one-meter decrease in water clarity can lead to decreases in property value ranging from 0.9% to over 6% on average.	Market data from houses surrounding 69 lakes in 59 towns in New Hampshire.	USA	Environmental water quality

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Avoiding health risks from drinking water in Moscow: An empirical analysis	Larson, Bruce A. and Ekaterina D. Gnedenko. Presented at World Congress of Environmental and Resource Economists, Venice, Italy, June 25-27, 1998.	Costs of avertive behaviour (filtering, settling and boiling water and buying bottled water) for good drinking water quality.	Avertive behaviour	Time and use of gas for boiling and settling water were not measured, only purchase of filters and bottled water. Results were that generally expenditure on bottled water and water filters was under 20,000 Rubles per week ($3.50 at exchange rate of 5800 rubles per US Dollar).	Telephone survey of 615 households in Moscow	Russia	Water supply
Risk perceptions of arsenic in tap water and consumption of bottled water	Jakus, Paul M., W. Douglass Shaw, To N. Nguyen and Mark Walker. Presented at the Agricultural and Applied Economics Association 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29, 2009	The value of minimising perceived risk of drinking tap water through purchasing bottled water.	Avertive behaviour	People who buy bottled water for perceived health risks are willing to spend more than those people who buy bottled water for taste reasons. Of people who buy bottled water, their mean expenditure is $27.02 a month.	Mail survey, sample size 201.	USA	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Tapping into Consumers' perceptions of drinking water quality in Canada: Capturing Customer Demand to assist in better management of water resources	Dupont, Diane P. Canadian Water Resources Journal. 30(1): 11-20. 2005.	Cost of tap water substitutes to households.	Avertive behaviour	Average annual cost to households: Container water filter: $35; In-tap filter: $189; Bottled water: $180	Pilot internet survey using panel from Ipsos-Reid. Survey size of 107.	Canada	Water supply
Valuation of Cancer and Microbial Disease Risk Reductions in Municipal Drinking Water	Adamowicz, Wiktor, Diane Dupont, Alan Krupnick and Jing Zhang. Resources for the Future Discussion Paper 2007.	The value of health risk reductions of cancer and microbes from drinking water choice.	Contingent valuation and attribute-based stated choice	The value of a statistical life for microbial risk reduction is C$20 million and for cancer risk reduction is C$17 million. The value of a statistical incident for cancer is C$3.2 million, while for a microbial case is C$33,000.	Internet survey of Canadians, panel-based, sample size 1600	Canada	Water supply
Valuing drinking water quality improvement using a Bayesian analysis of the multinomial probit model	Lee, Chung-Ki and Seung-Jun Kwak. Applied Economics Letters 14:255-259. 2007.	Willingness to pay for safe drinking water is calculated through expenditure on boiled, filtered, bottled and spring water alternatives to tap water.	Avertive behaviour	The mean monthly cost is calculated at 73,498, 53,408, 101,77, and 107,109 Korean Won for boiled, filtered, bottled and spring water alternatives to tap water.	Survey with sample size 803.	Korea	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Differences in Water Consumption Choices in Canada: the Role of Socio-demographics, Experiences, and Perceptions of Health Risks	Dupont, Diane, W.L. Adamowicz and Alan Krupnick, 2009.	What variables increase likelihood of consuming bottled or filtered water	Econometric analysis	The degree of health concerns a respondent has with respect to tap water and whether the respondent believes bottled water to be safer than tap water makes the individual more likely to choose filtered or bottled water over tap water.	Internet-based survey	Canada	Water supply
Manufacturing Firms' Demand for Water Recirculation	Bruneau, Joel, Steven Renzetti and Michel Villeneuve. Canadian Journal of Agricultural Economics 58: 515-530. 2010	What variables contribute to manufacturing firms deciding to recirculate water and decide how to recirculate water	Econometric model	Long-run factors such as relative water scarcity and production technologies influence the decision to recirculate water. Imputed prices of intake water and water recirculation as well as scale of operations influences the choice of optimal quantity of water to recirculate.	Pre-existing survey results	Canada	Water recirculation

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Australians' water conservation behaviours and attitudes	Dolnicar, Sara and Anna Hurlimann. Australian Journal of Water Resources, 114(1): 43-53. 2010.	Australian attitudes towards water conservation and water conservation behaviours	Survey	Very favourable attitudes to water conservation and water efficient appliances are not always translated into action. Most common water conservation actions are those that have low effort required. Main barriers to adoption of water saving appliances are cost, perceived quality, convenience and practicality.	Survey of 1495 people	Australia	Water supply
Acceptance of water alternatives in Australia	Hurlimann, Anna and Sara Dolnicar, Water Science and Technology 61(8): 2137-2142	Likelihood of Australian residents relocating due to water supply.	Survey	Likelihood of relocating is highest when there was insufficient water to meet needs, followed by when recycled water was introduced into their supply, then the introduction of desalinated water. Scenario where residents had to rely on self-purified rain water from a tank had the lowest level of relocation	Survey of 1495 people	Australia	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
				intention.			
Desalinated versus recycled water - public perceptions and profiles of the accepters Desalinated versus recycled water - What does the public think?	Dolnicar, Sara and A.I. Schafer, Journal of Environmental Management, 90: 888-900, 2009. Dolnicar, Sara and A. Hurlimann. In I. Escobar & A. Schafer (eds.), Sustainable Water for the Future: Water Recycling Versus Desalination (pp. 375-388). Amsterdam: Elsevier. 2010	Public perceptions of desalinated and recycled water and profiles of people willing to accept desalinated and recycled water.	Survey	Following five years of serious drought accompanied by severe water restrictions across most of the country, Australians show more acceptance of desalinated water for close-to-body uses and less resistance to recycled water for garden watering and cleaning uses. Stated likelihood of using desalinated water was higher than that for recycled water for all purposes. Australians perceive recycled water as a higher health risk and desalinated water as more expensive. Perceived health risk appears to dominate people's perceptions.	Survey of 1495 people	Australia	Water supply
Drinking water from alternative	Dolnicar, S. & Anna Hurlimann. Water	Community attitudes to alternative water	Qualitative interviews	Australians hold both positive and negative	66 qualitative	Australia	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
water sources: differences in beliefs, social norms and factors of perceived behavioural control across eight Australian locations	Science & Technology, 60 (6): 1433-1444. 2009.	sources.		beliefs (mostly cost, health and environmental concerns) about water from alternative sources, however nearly all of them are willing to drink it if the Australian water crisis were to deteriorate further. People also feel they lack knowledge and information from scientists would influence their decision to drink recycle and desalinated water most. Friends and relatives are most influential in preventing people from drinking recycled water.	interviews at 8 locations		
Understanding behaviour to inform water supply management in developed nations - A review of literature,	Hurlimann, Anna, Sara Dolnicar and Petra Meyer. Journal of Environmental Management, 91(1): 47-56. 2009	Review literature to identify research on willingness of consumers to change behaviour to inform water supply management	Development of conceptual model of research required in the area of water related public acceptance studies and literature	The majority of work which has been conducted focused on personal characteristics and behavioural intentions. Significant gaps exist in relation to researching the adoption	n/a	n/a	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
conceptual model and research agenda			review.	of a wide range of demand-side water behaviours.			
When public opposition defeats alternative water projects - the case of Toowoomba Australia	Hurlimann, Anna & Sara Dolnicar. Water Research, 44(1): 287-297. 2010.	Description of how public opposition defeated proposal for a water recycling plant as a solution to water supply shortage at a time when dams (main supply of water) were at approximately 20% of their capacity.	Archival research, qualitative interviews, focus groups, observations and survey.	The referendum failed partly due to a poorly managed and late government information campaign (commencing many months after public interest groups started their campaigning). Participants did not trust information and sources of bias.	Topical internet blogs, information brochures developed by various organisation s and which were publicly available, qualitative empirical research and quantitative empirical research	Australia	Water supply
Household's willingness to pay for safe drinking water: A case study of Abbottabad district	Haq, Mirajul, Usman Mustafa, and Iftikhar Ahmad. Pakistan Institute of Development Economics, Pakistan. 2008.	Avertive behaviour for drinkable water	Averting Behaviour and Contingent valuation	58% of overall respondents had adopted safe drinking water practices (filtering, boiling or adding chemicals to water): 65% in rural areas and 54% in urban. These behaviours	Survey from district Abbottabad in 2007/08 with sample size of 455 households, or 2779	Pakistan	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
				were correlated to using tapwater (but not to well) and to satisfaction of quality of water, awareness of waterborne diseases and level of education.	household members.		
Bottled water versus tap water: understanding consumers' preferences	Doria, M. F. 2006. Journal of Water and Health: 4(2): 271-276	Why do people choose bottled water	Literature review	Taste and risk/health concerns are the most significant factors influencing bottled water consumption. Racial differences have emerged in the USA, with African American, Asians and Hispanic groups drinking a higher proportion of bottled water, despite having lower incomes than whites, but this could reflect the difference in water supply quality between living areas or memories of past problems caused by deficient tap-water systems.	n/a	n/a	Water supply

Title	Reference details	Relationship between market good and observed data	Method	Results	Source of data	Country of study	Water Service
Households and the environment 2007	Statistics Canada, 2009.	What affects drinking water decisions	Survey	Of the 54% of households with a municipal supply who treated their water prior to drinking, 58% did so to improve appearance, taste or odour, 51% treated to remove water treatment chemicals such as chlorine, 40% of households treated their water to remove metals and minerals, and 43% felt that there was bacterial contamination to their water.	Survey of with initial sample size of 29,980 households who had previously responded to the Canadian Community Health Survey.	Canada	Water supply
Drinking water consumption patterns of residents in a Canadian community	Jones, A.Q., C.E. Dewey, K. Dore, S.E. Majowicz, S.A. McEwen and D. Waltner-Toews. Journal of Water and Health 04.01, 2006	Associations between drinking water consumption patterns in Canada and various demographic characteristics	Survey	Age and race were indicators of bottled water consumption. Bottled water consumption increased with age to a peak at approximately 31 years, which was followed by a steady decline with increasing age.	Telephone survey with sample size of 1,757	Canada	Water supply