

Investigating Willingness to Pay – Willingness to Accept Asymmetry in Choice Experiments*

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Abstract

We investigate discrepancies between willingness to pay (WTP) and willingness to accept (WTA) in the context of a stated choice experiment. Using data on customer preferences for water services where respondents were able to both ‘sell’ and ‘buy’ the choice experiment attributes, we find evidence of non-linearity in the underlying utility function even though the range of attribute levels is relatively small. Our results reveal the presence of significant loss-aversion in all the attributes, including price. We find the WTP-WTA schedule to be asymmetric around the current provision level and that the WTP-WTA ratio varies according to the particular provision change under consideration. Such reference point findings are of direct importance for practitioners and decision-makers using choice experiments for economic appraisal such as cost-benefit analysis, where failure to account for non-linearity in welfare estimates may significantly over- or under-state individual’s preferences for gains and avoiding losses respectively.

Keywords: Cost-benefit analysis; Economic valuation; Discrete choice; Stated choice; WTP/WTA disparity; Reference-dependent preferences.

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1 Introduction

Asymmetry in willingness to pay (WTP) and willingness to accept (WTA) is one of the most documented economic phenomena in empirical literature. The basic finding is that while standard (Hicksian) economic theory allows for a small difference between WTP for a unit gain and WTA for a unit loss (Hicks, 1943; Randall and Stoll, 1980), numerous empirical investigations have observed discrepancies which appear significantly larger than predicted by theory, with losses being valued substantially more than gains.¹ Indeed as documented by Horowitz and McConnell (2002), the empirical evidence is pervasive and gain-loss effects have been observed for a wide variety of economic goods. This includes goods traded in formal markets as well as commodities that are non-market and/or public good in nature, in real, hypothetical and experimental settings. In particular, the disparity in terms of the ratio of WTP to WTA is found to increase the further the good is from ‘an ordinary private good’ (Horowitz and McConnell, 2002).

A variety of explanations for WTP-WTA asymmetry have been proffered. Explanations from standard economic theory emphasize the role of substitution and income effects in exacerbating the WTP-WTA disparity (Hanemann, 1991, 1999). Indeed, disposable income constrains demand for a good in terms of WTP, but not demand for compensation as relevant for WTA. In addition, low substitutability of a good might imply that it is not possible to compensate an individual for its loss, possibly giving rise to extreme WTA values. Hence observations of WTP-WTA disparity in instances of public goods, where private consumption goods are imperfect substitutes, may not be ‘anomalous’ even within the standard model.

Sugden (1999), however, contends that the degree of asymmetry observed in empirical studies would have to be generated by implausible levels of income and substitution effects. In fact the most commonly cited explanation for WTP-WTA asymmetry is that of ‘loss aversion’, an insight from psychological literature. This is formalized in the theory of reference dependent utility (Kahneman and Tversky, 1979; Tversky and Kahneman, 1991), which has been shown to

¹Relevant references are numerous. Some classics include Knetsch and Sinden (1984), Knetsch (1989) and Kahneman et al. (1990). The literature uses a variety of terminology including ‘loss aversion’, the ‘endowment effect’ and ‘status quo bias’ which essentially all accord to the same observation in behavior (Hanemann, 1999).

be capable of being a superior predictor of behavior than the standard economic model (Bateman et al., 1997). The central premise is that preferences are defined in relation to 'reference states' and will vary according to whether a gain or loss is assessed. In this setting loss-averse decision-makers will perceive losses as larger than gains of the same magnitude, with the WTP-WTA disparity arising because these valuations are formed relative to different reference states.

With regards to public and non-market goods, the bulk of WTP-WTA asymmetry evidence derives from contingent valuation (CV) studies (see for example: Brookshire and Coursey (1987); van Kooten and Schmitz (1992); Bowker and MacDonald (1993)). In this survey-based economic valuation method, respondents are invited to participate in a hypothetical market for a given good, thereby revealing their valuation for the good. To some extent however, the CV approach is limited. In particular the analyst is only able to observe WTP-WTA asymmetry for the proposed good, i.e. asking respondents WTP for a discrete change from 'A to B' and WTA for the change from 'B to A' and then comparing the elicited values.

A potentially richer setting in which to assess WTP-WTA disparity for public and non-market goods is provided by discrete choice experiments. Here, it is assumed that the utility an individual derives from a good is a function of the characteristics of the good. A discrete choice experiment mirrors this process and survey respondents are presented with sets of alternative combinations of attributes (or characteristics) and are asked to choose their most preferred bundle. Repeated choices by respondents from sets of alternatives reveal the trade-offs individuals are willing to make between attributes and hence the relative value of independent changes in each attributes. If one of these characteristics is the price of the bundle, a monetary value can be inferred for unit changes in each attribute. Hence a discrete choice experiment approach allows eliciting monetary values for a range of changes in each attribute, from which a complete WTP-WTA schedule may be inferred.

In this paper we empirically investigate WTP-WTA asymmetry within a discrete choice experiments, thereby contributing to the growing literature in this area (see for example Hess and Rose, 2009; Grutters et al., 2008; Bateman et al., 2009). The data for our investigation is taken from a survey of water company customer in North West England, eliciting preferences for

changes to water, waste water and environmental service levels. The survey instrument allowed respondents to trade both improvements and deterioration in the levels of attributes against the status quo, entitling them to both 'buy' or 'sell' the attributes. By estimating structural choice models where marginal utility is allowed to vary with the change in each attribute, we account for the possibility that deteriorations may be seen differently as compared to improvements, but also that marginal changes near the reference point are given a higher value than subsequent increments (see Tversky and Kahneman, 1991). This is potentially important for decision-making purposes, as failure to account for potential non-linearities could result in significant under- or over-estimates of WTP and WTA values.

Importantly, we also consider the utility of the monetary attribute as potentially non-linear, which permits investigation of some related issues. First, Munro and Sugden (2003) conjecture that money is valued as any other good, so that money outlays are perceived as losses rather than foregone gains (see also Bateman et al., 1997, 2005). If this effect is empirically significant, it follows that WTP-WTA disparity will also hinge upon non-linearity in the utility for the price attribute. Second, while the changes in wealth are typically small relative to the disposable income, some evidence suggests that respondents might not make choices with the entirety of their income in mind. In particular 'mental accounting' theories contend that individuals compartmentalize their budgets into a series of headings or 'mental accounts' and tend not to transfer money across these compartments (see for example Thaler, 1999). In effect individuals budget for different categories of discretionary purchases, so that income constraint effects are much more likely to occur.

The remainder of this paper is structured as follows. Section 2 provides brief details of the study from which our data is derived. Section 3 establishes the basis for non-linear specifications of the utility function and econometric estimation. Welfare estimates and WTP-WTA asymmetry results are reported in Section 4. Finally, discussions and conclusions are offered in Section 5.

2 Study design

2.1 Background – water company services and customer preferences

Water supply companies in most OECD countries provide integrated services in the sense that their operations relate to the whole cycle of water use, from intercept, to storage, to residential and industrial supply, to collection of waste water, treatment and discharge back to the environment. Public regulators oversee their operations and negotiate with the companies the terms of service concession. In such a regulated market customer preferences do not have the opportunity of being expressed through competitive market signals such as varying prices in response to quantitative or qualitative product differences. Discrete choice experiments find in this context an ideal setting for the exploration and quantitative analysis of water customer preferences.

In the UK, The Water Services Regulation Authority (Ofwat) is the public regulator responsible for oversight of water companies and periodically revises water tariffs. Following the stated preference study by Yorkshire Water during the 2004 Price Review (see Willis et al., 2005), Ofwat has placed greater emphasis on justifying investment proposals through the application of cost-benefit analysis (Ofwat, 2007). The survey underlying the present analysis was undertaken a water company in North West England, and was designed to inform the investment planning.

2.2 Discrete choice experiment attributes

Following a series of qualitative focus, fourteen service attributes were identified for inclusion in the survey. Both improvements and deteriorations in services were considered (within the regulatory constraints). To generate manageable choices for the respondents the service attributes were split into four blocks, which in effect gives four separate discrete choice experiments exercises. Two blocks of attributes related mainly to water service attributes (supply and quality of water to customers) and the two other blocks included waste water services (sewer flooding on the waste water network) as well as local and natural environment quality as impacted by waste water services. Within each block a price attribute was also specified, which was defined

in terms of the increase or decrease in the annual water and waste water bill paid by customers.

In this paper we report on analysis from only one of the service blocks, which focused on the location and severity of sewer flooding incidents.² The attributes and levels are reported in Table 1. Sewer flooding can arise due to inadequate hydraulic capacity in sewers linked to heavy or prolonged rainfall, or from failure of equipment, sewer collapses or blockages. This results in untreated sewage escaping from sewers and flooding both external locations (such as footpaths and roads and also gardens and near properties) and internal areas (this can be below ground level in cellars and basements or at ground level in living areas of properties). Incidents of sewer flooding are relatively infrequent in the service area; for instance out of a customer base of 2.7 million households and 0.2 million business premises, the number of properties affected by internal sewer flooding is around 1,000 per annum. Overall, the sewer flooding service attributes have characteristic of public goods, attribute definitions are based on the service level achieved across the water and waste water network rather than the individual level.

Four levels were specified for each service attribute on the basis of company's investment planning process. This included the status quo (SQ) level, which is the level of service currently experienced by customers, an improved level of service (L1) concordant with increased investment, a further 'aspirational' improved level of service (L2) that represents the greatest improvement that could be achieved within the current constraints of investment planning, and a reduced level of service resulting from lower investment (L-1) which still meets minimum standards required by the water industry regulator. The price attribute was specified over seven levels (L-2 to L4) including both increases and decreases in the customers' annual water bill.

2.3 Experimental design

Separate experimental designs were generated for each of the four blocks of attributes. For the discrete choice experiment of interest here, it is composed of 84 choice cards. The design was informed by analysis of responses to a pilot survey with a sample size of approximately 80

²Analysis of further blocks of service attributes show that findings reported here are not dependent to the choice of a particular block.

Table 1: Discrete choice experiment attributes and levels

Attribute (Label)	Definition	Level						
		L-2	L-1	SQ	L1	L2	L3	L4
External flooding from sewers – remote from properties (EX1)	Each year the expected number of sewage flooding incidents in public places	-	1,875	1,500	750	375	-	-
External flooding from sewers – adjacent to properties (EX2)	Each year the expected number of sewage flooding incidents in gardens or close to homes	-	2,500	2,000	1,000	500	-	-
Internal flooding from sewers - below ground level (IN1)	Each year the expected number of properties flooded in basement/cellar areas only by untreated sewage	-	800	400	200	100	-	-
Internal flooding from sewers - at ground level (IN2)	Each year the expected number of properties flooded in ground floor rooms by untreated sewage	-	875	700	350	175	-	-
Water bill (BIL)	Change in annual water bill from 2008	-£15	-£5	£0	+£5	+£10	+£15	+£25

respondents, which evidenced a propensity of respondents to select the status-quo option. This information was used to generate a design focused on increasing the efficiency of utility coefficient estimates, so called ‘D-efficiency’ (Ferrini and Scarpa, 2007). To accommodate uncertainty with regards to the utility coefficient at the stage of design derivation, a Bayesian criterion was applied assuming a uniform distribution of values for the SQ and price coefficient (Scarpa and Rose, 2008).

2.4 Sample

The full survey comprised of a random sample of 2107 residential customers, reflecting the population distribution of the customer base. The sample was largely representative of the socio-economic profile of North-West England. The questionnaire was administered face-to-face via computer-aided personal interview (CAPI) in respondents’ homes by a market research firm. Each respondent was presented with two of the four choice experiment blocks, which were randomly allocated and ordered. For each block, respondents were shown eight choice cards. For the discrete choice experiment concerned with the sewer flooding service attributes, this resulted in approximately 1,000 respondents and over 8,000 choice task observations.

3 Model specification

3.1 Representation of preferences

We employ the standard approach to analyzing discrete choice experiment data, based on random utility modeling (RUM), where individuals are assumed to select the choice alternative that yields the greatest expected utility to them. As customary (but not indispensable), it is assumed that the utility function is additive and separable in its arguments, and that its random component (or error term) is also additive.³

In this framework, the traditional approach to model the preferences of the decision-makers

³Although not investigated in this work, an alternative approach would be to directly assess non-linearities in willingness to pay space (see for example Train and Weeks, 2005; Scarpa et al., 2008).

is through a linear utility function. In particular, given a set of K attributes, and denoting the level of the k^{th} attribute by X_k , the utility of a given bundle of attributes can be written as:

$$U(X_1, \dots, X_K) = \beta_1 X_1 + \dots + \beta_K X_K$$

where the β 's measure the (constant) marginal utility of each attribute.

Following the classic contributions by Kahneman and Tversky (1979) and Tversky and Kahneman (1991), we extend this simple representation of preferences by considering the properties of a reference-dependent utility function: (i) it is non-decreasing in its arguments; (ii) changes are evaluated relative to a reference point; (iii) it displays diminishing sensitivity, so that it is concave for gains and convex for losses - i.e. 's-shaped'; and (iv) a change of the same magnitude has larger impact on the respondent's welfare if it is a deterioration than if it is an improvement.

Formally, we define utility derived from attribute X_k as a continuous, non-decreasing function:

$$v(X_k) = \begin{cases} v^+(X_k) & \text{for } X_k > 0 \\ v^-(X_k) & \text{for } X_k < 0 \end{cases}$$

with $v(0) = 0$, and where X_k is defined as the difference between the final endowment and the status quo level of the good. Assuming the first and second derivatives $v'(X_k)$ and $v''(X_k)$ exist, this function has the following properties:

- Loss aversion:

$$v(X_k) < -v(-X_k), \quad X_k > 0 \quad \text{and}$$

$$v'(X_k) < v'(-X_k), \quad X_k > 0$$

- Diminishing sensitivity:

$$v''(X_k) \leq 0, \quad X_k > 0 \quad \text{and}$$

$$v''(X_k) \geq 0, \quad X_k < 0$$

For the purposes of our empirical investigation, we use two alternative functional forms from the empirical literature: (i) a piecewise-linear function; and (ii) an exponential function.⁴

The piecewise-linear function is a direct extension of the linear utility function commonly used in discrete choice models, and represents a ‘basic’ non-linear formulation:

$$v(X_k) = \begin{cases} \beta^+ X_k, & X_k > 0 \\ \beta^- X_k, & X_k < 0 \end{cases}$$

with $\beta^- \geq \beta^+$. In the context of discrete choice modeling, Hess et al. (2008) apply this functional form to investigate gains-loss asymmetry in attributes of travel trip-time.

The piecewise-linear functional form can capture gains-loss asymmetry, but it rules out potential non-linearities within gain and loss domains. This limitation is relaxed by the exponential function, while still nesting the linear model as a special case. Formally the exponential specification can be written as:

$$v(X_k) = \begin{cases} \beta^+ \cdot \frac{1 - \exp(-\mu X_k)}{\mu}, & X_k > 0 \\ \beta^- \cdot \frac{\exp(\gamma X_k) - 1}{\gamma}, & X_k < 0 \end{cases}$$

where $0 < \mu \leq \gamma$ and $\beta^- \geq \beta^+$. For, $\mu = \gamma \rightarrow 0$ this expression reduces to the piecewise-linear function, and if in addition $\beta^- = \beta^+$, we have the standard linear model. The case for applying an exponential function formulation in gain-loss asymmetry setting is supported by

⁴Other non-linear specifications were tested, including the logarithm utility function and the power (Cobb-Douglas) utility function. However, the logarithm function does not allow specifying the curvature of the utility and is ill-behaved between zero and one, whereas the power function entails the possibility that $v(X_k) < -v(-X_k)$ (see Köbberling and Wakker, 2005) and yielded implausible welfare estimates. For a comprehensive review of candidate functional forms, see Stott (2006).

both normative (Köbberling and Wakker, 2005) and empirical considerations (Stott, 2006).

In this setting, our objective is to compare the standard linear function to the two non-linear functional forms presented above, which permit the assessment of WTP-WTA discrepancies. The non-linear specification is also applied to the price attribute, which can provide further insight as to the source of WTP-WTA asymmetry. Note that an important consequence of such preferences is that, unless the valuation function is symmetrical around the status quo, the possibility arises that the ratio of WTP to WTA will in part be dictated by the size of the change under consideration.

3.2 Econometric estimation

In estimating the non-linear functions, we first note that gains-loss asymmetry is characterized as a discontinuity in the function at the status quo attribute level (the ‘reference point’). In this model, the perception of the current situation is therefore a central aspect of the respondents’ valuation, providing a potentially important source of unobserved heterogeneity (Scarpa and Acutt, 2007; Hess and Rose, 2009). Second, the parameters describing the effects of an attribute change in terms of utility gains and losses are potentially different. Such differences can manifest themselves in terms of magnitude (β 's in expressions above) and/or in terms of the curvature parameter (the γ 's and μ 's) for the exponential functional form.

From the data for the four service attributes (IN1, IN2, EX1 and EX2) we observe four points on the utility function for each respondent: the status quo, which is given a value of zero; a reduced level of the attribute (L-1); and two increased levels of the attribute (L1 and L2, where $L1 < L2$). In this setting, it is possible to identify the curvature parameter for improvements in the level of attributes, but not for reductions. Since diminishing sensitivity to losses has revealed to be an important aspect of individual’s decision-making (Tversky and Kahneman, 1991), we specify the utility in the loss space to be convex and set the value of the curvature parameter to be the same for gains and losses. As shown below, this approach permits for flexibility in the estimation and conveniently captures potential gains-loss asymmetry. It is also supported by findings in the literature (see for example Tversky and Kahneman, 1992) and is consistent with

the piecewise-linear model, which trivially has the same curvature for gains and losses. For the price attribute (BIL), which is specified over a greater range of attribute levels (L-2 to L4) it is possible to retrieve the exponent parameter for both gains and losses.

The specification of the utility function used in the modeling is obtained by defining:

$$X_k^- = \begin{cases} X_k - X_k^{SQ}, & \text{if } X_k < X_k^{SQ} \\ 0 & \text{otherwise} \end{cases}$$

and

$$X_k^+ = \begin{cases} X_k^+ X_k^{SQ}, & \text{if } X_k \geq X_k^{SQ} \\ 0 & \text{otherwise} \end{cases}$$

so that the utility of a bundle of K attributes and the price attribute P is given by:

$$U_i(X_1, \dots, X_K) = .. + \beta_{ki}^- v^+(X_k^-) + \beta_{ki}^+ v^+(X_k^+) + \beta_{Pi}^- v^-(P^-) + \beta_{Pi}^+ v^+(P^+) + \dots + \varepsilon_i$$

where $v^-(\cdot)$ and $v^+(\cdot)$ are one of the functional forms reviewed above and represent utility for improvements and deteriorations respectively, and ε_i is an idiosyncratic (random) error term, assumed to follow a Type I extreme value distribution.

Information about gain-loss asymmetry is conveniently summarized in the difference between the parameters of the econometric model. For the non-price coefficients, $\beta_{ki}^- > \beta_{ki}^+$ would provide evidence for individual i being loss-averse with respect to attribute k , since it would imply $v(X_k) < -v(-X_k)$ and $v'(X_k) < v'(-X_k)$, $\forall X_k > 0$. For the price coefficients, we need to account for differences in both the curvature and scale parameters.

To retrieve the parameters of interest, we use a mixed logit (MXL) model, which we estimate via simulated maximum likelihood (Train, 2003) assuming normally distributed coefficients⁵, using robust standard errors, and 500 Halton draws to approximate the integral of the uncon-

⁵Models estimated with a log-normal distribution instead yielded implausible welfare estimates, mainly because of imprecisely estimated standard deviations parameters.

ditional likelihood of each panel of choices. We thereby control for unobserved heterogeneity in the respondents' tastes by exploiting the panel structure of the collected data. As mentioned above, this is a potentially crucial aspect of the specification since the decision-making process is modeled as relative to the individually experienced status quo.

Direct estimation of the curvature parameters revealed to be numerically infeasible if unobserved heterogeneity is accounted for, this being due mainly to the differing amounts of information gathered for gains and losses. Hence, in order to estimate the models with exponential functional form, we use an auxiliary regression where each attribute level is entered as a dummy variable. This corresponds to a 'non-parametric' utility function, since it does not impose a specific functional form on the choices made by the respondents (Hey and Orme, 1994). Because of the relatively large number of parameters to estimate (19 in total), the auxiliary regression is based on a multinomial logit (MNL) model. The estimates from the auxiliary model are then used to compute an approximation of the curvature coefficient to be used in the main MXL estimation.⁶ This first step also provides a descriptive assessment of the shape of respondent preferences.

4 Results

4.1 Auxiliary regression – non-parametric utility function

Results from the auxiliary MNL model with dummy coding of attribute levels are presented in Table 2. Estimates of the curvature parameter for the exponential functional forms are also reported. The model's estimates should be interpreted as the utility of each attribute's level, so that for non-price attributes any improvement level should display a positive value, while deterioration levels will be perceived negatively. On the other hand, the shift to a higher bill level is expected to have a negative impact on welfare, while the shift to a lower bill level should

⁶For the exponential utility function, the curvature parameter is implicitly given by:

$$\frac{\Delta X_{L2}}{\Delta X_{L1}} = \frac{1 - \exp(-\mu \Delta X_{L2})}{1 - \exp(-\mu \Delta X_{L1})}$$

and can be retrieved numerically.

Table 2: MNL model with dummy coded variables

No. observations	8328							
No. respondents	1041							
Log-likelihood	-7801.73							
AIC	15641.46							
Att.	L-2	L-1	SQ	L1	L2	L3	L4	Curvature parameter
EX1	-	-0.245*** (0.074)	-	0.005 (0.066)	0.184*** (0.070)	-	-	0.15
EX2	-	-0.499*** (0.076)	-	0.254*** (0.065)	0.205*** (0.077)	-	-	0.25
IN1	-	-0.473*** (0.078)	-	0.313*** (0.059)	0.374*** (0.073)	-	-	0.05
IN2	-	-0.499*** (0.071)	-	0.326*** (0.057)	0.264*** (0.065)	-	-	0.05
BIL	0.061 (0.079)	-0.037 (0.080)	-	-0.427*** (0.075)	-0.667*** (0.082)	-1.097*** (0.097)	-1.292*** (0.100)	0.200 ^a 0.060 ^b
SQ	-	-	0.520*** (0.102)	-	-	-	-	

Notes: Standard-errors in parenthesis; Stat. significance: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

^a Curvature parameter for reductions in the price attribute (BIL); ^b curvature parameter for increases in the price attribute (BIL).

have a positive welfare impact.

All estimated coefficients that are found to be statistically different from zero have the expected sign - reductions in internal and external sewer flooding incidents (L1 and L2) increase utility while more sewer flooding incidents (L-1) decrease utility. It is also found that for the service attributes EX2 and IN2 the utility of the highest improvement (L2) is lower in magnitude than the utility of the lower improvement level (L1). This finding indicates a potential inconsistency in choice patterns: since the Level 1 improvement is embedded within the Level 2 improvement, giving a larger weight to Level 1 violates the weak axiom of revealed preference. However, we note that confidence intervals for the estimates overlap; i.e. the welfare attributed to the improvements levels are not statistically different from each other. Hence for these at-

tributes, these results suggest strong non-linearities: initial marginal improvements are given a relatively high value, but the value of subsequent incremental improvements is not statistically significantly different from zero.

Three coefficient estimates are not statistically significant at the conventional significance levels in the MNL model: EX1 (L1), BIL (L-1), and BIL (L-2). As a consequence, the curvature parameter for the attribute EX1 is set somewhat arbitrarily. The finding with respect to the price attribute (BIL) implies that the proposed reductions in water bill (L-1 and L-2) were not large enough to have an impact on the respondent's welfare.⁷ In contrast the pattern of estimates for increases in the price attribute indicates the disutility of increases in water bills as well as evidence of diminishing marginal sensitivity.

Generally the results for the dummy coded MNL model agree with expectations. External flooding close to properties (EX2) generates greater disutility than flooding in locations that are remote from properties (EX1). And internal flooding in living areas (IN2) generates greater disutility than flooding below ground level. Moreover, more incidents/properties are affected by EX2 and IN2 type flooding than EX1 and IN1 type flooding. Hence we would expect the coefficient for EX2 to be greater than that for EX1, and the coefficient for IN2 > IN1. Mostly this is what is observed with the coefficients for EX2 > EX1, for L1 and L2; and IN2 > IN1 for L1 but not for L2 and similarly for losses where EX2 > EX1 and IN2 > IN1.

4.2 Main model estimation

Turning to the main estimation results, estimates from the MXL model are reported in Table 3. The coefficients refer to a unit change of each attribute. Hence the coefficient on the bill is expected to be negative on both the gain and loss domains (a marginally higher bill is a bad whether above or below the SQ), and the coefficients on other attributes will be positive (marginally better service is a good).

Reviewing the summary statistics, we first note the large improvement of the log-likelihood

⁷We note that the actual attribute levels (£5 and £15 reduction in water bill) represent roughly 1% and 4% reductions in the total bill (approximately £350 per annum for water and waste water services).

Table 3: MXL model with linear and non-linear specifications

		Linear function	Piecewise-linear function		Exponential function	
Attribute		Coef.	Reduction	Increase	Reduction	Increase
No. observations		8328	8328	8328	8328	8328
No. respondents		1041	1041	1041	1041	1041
Log-likelihood		-7101.23	-7025.93	-7025.93	-7010.95	-7010.95
AIC		14226.47	14095.86	14095.86	14065.90	14065.90
EX1	Mean	0.00046*** (0.00006)	0.00159*** (0.00028)	0.00020*** (0.00008)	0.21252*** (0.03785)	0.04056** (0.01646)
	S-D	0.00034** (0.00017)	0.00196*** (0.00057)	0.00029 (0.00018)	0.24013** (0.10605)	0.05410 (0.05209)
EX2	Mean	0.00045*** (0.000049)	0.00162*** (0.00022)	0.00031*** (0.00006)	0.28996*** (0.03941)	0.11998*** (0.02187)
	S-D	0.00053*** (0.00008)	0.00177*** (0.00037)	0.00034** (0.00016)	0.35697*** (0.06140)	0.16896*** (0.04946)
IN1	Mean	0.00156*** (0.00010)	0.00174*** (0.00028)	0.00160*** (0.00028)	0.03607*** (0.00649)	0.03438*** (0.00506)
	S-D	0.00138*** (0.00015)	0.00222*** (0.00036)	0.00177*** (0.00050)	0.04982*** (0.00936)	0.03286*** (0.00994)
IN2	Mean	0.00121*** (0.00008)	0.00385*** (0.00060)	0.00074*** (0.00015)	0.05851*** (0.00900)	0.01977*** (0.00365)
	S-D	0.00119*** (0.00013)	0.00402*** (0.00073)	0.00143*** (0.00017)	0.06354*** (0.01413)	0.03419*** (0.00448)
BIL	Mean	-0.04753*** (0.00327)	-0.00739 (0.00684)	-0.09341*** (0.00740)	-0.00084 (0.02141)	-0.16582*** (0.01201)
	S-D	0.06053*** (0.00394)	0.08415*** (0.01354)	0.09019*** (0.00686)	0.24852*** (0.03654)	0.15845*** (0.01141)
SQ	Mean	1.62298*** (0.07299)	0.61753*** (0.11992)		0.58207*** (0.13093)	
	S-D	1.64420*** (0.06629)	1.50382*** (0.07447)		1.47929*** (0.08400)	

Notes: Standard-errors in parenthesis; Stat. significance: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

and AIC criterion of the MXL model as compared to the MNL dummy coded model, confirming the importance of unobserved heterogeneity.⁸ Secondly, Table 3 shows that the non-linear

⁸As noted above it was not feasible to estimate a MXL model with dummy coded variables. We have, however, compared the results of MNL models across all specifications. Interestingly, the dummy-coded model generally

specifications fit the data significantly better than the linear specification in terms of both log-likelihood and information criterion. Furthermore, the exponential specification, which imposes diminishing marginal sensitivity, fits the data better than the piecewise-linear utility function, even though the difference in goodness-of-fit measures is relatively small.

The inferiority of the linear model is also confirmed by the interpretation of the magnitude of the coefficients, as results for both external flooding ($EX2 < EX1$) and internal flooding ($IN2 < IN1$) are at odds with expectations. Findings for the piecewise-linear and exponential utility models are in line with expectations as we find that $EX2 > EX1$ for both gains and losses and $IN2 > IN1$ for losses. For internal flooding gains, the results indicate that $IN2 < IN1$, although the difference is not statistically significant. In general, it can be seen that the magnitude of the difference is greater for the model with exponential utility function, whereas coefficients are generally not statistically significantly different from each other in the piecewise-linear model.

As previously mentioned, an important aspect of our estimation is the perception of the status quo. Interestingly, we find that the magnitude of the coefficient capturing the utility of the status quo declines significantly when gains and losses are estimated separately, whereas the standard deviation of the SQ variable remains roughly constant across models. This pattern indicates that the constraint imposed by a linear utility specification artificially inflates the welfare attributed to the SQ alternative (for a similar line of argument, see Scarpa et al., 2005; Scarpa and Acutt, 2007; Hess and Rose, 2009).

Turning to gains-loss asymmetry, we find that in almost all instances the absolute value of coefficient estimates associated with losses is of greater magnitude than those for gains. There is also a tendency for the standard deviation coefficient to be more pronounced for losses rather than gains, implying greater heterogeneity in preferences in this regard. The price attribute (BIL) is also subject to gains-loss asymmetry, with increases in the bill inducing significant disutility, whereas a reduction in bill is not found to have a statistically significant effect (at the mean of the distribution). However, there is evidence of significant heterogeneity surrounding

outperforms other specification in terms of log-likelihood, but not if we penalize it for the number of variables included in the model. In fact, we find that the AIC is worst for the 'non-parametric' utility function as compared to the alternative specifications.

the effect of the price attribute, so that some respondents were sensitive to decreases in their bill, but always to a much smaller extent than for an increase of the bill of the same magnitude.

The extent of gains-loss asymmetry is illustrated graphically in Figure 1 for the attributes IN2 and BIL. Graphs for EX1, EX2 and IN1 are reported in the Appendix. Generally we observe that the linear model overestimates positive welfare effects for reductions in internal and external sewer flooding incidents and reductions in bill, and underestimates negative welfare effects of increased sewer flooding incidents and increased bills, particularly in relation to the better fitting exponential model.

4.3 Comparing WTP and WTA

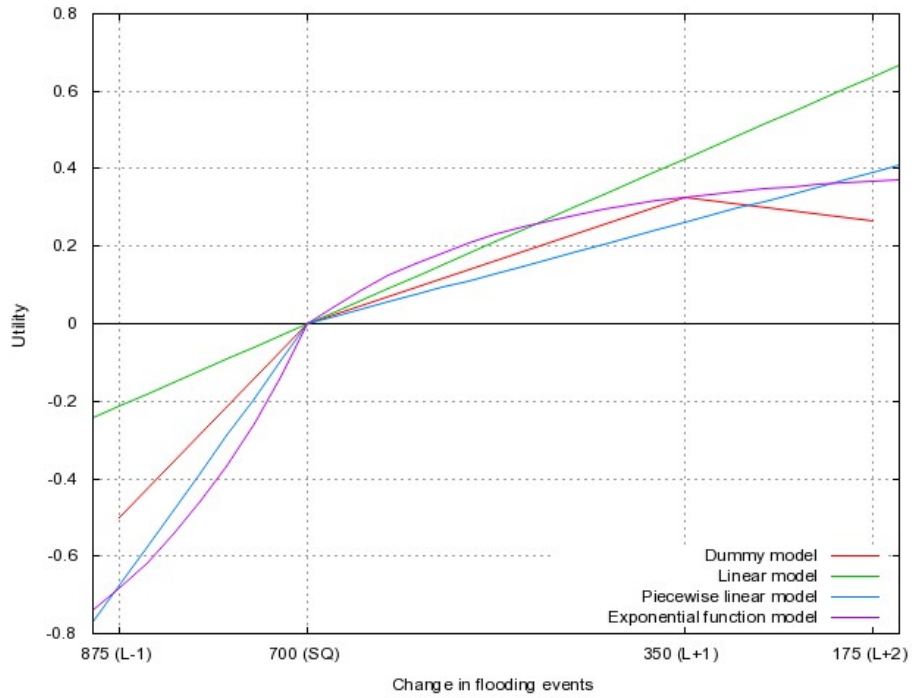
In the linear model, individual-level marginal WTP for a service attribute is given by the ratio of the marginal utility of an attribute divided by the negative of the price coefficient. By construction, it is constant for all improvements since the marginal utility estimate for each attribute (and the price) is constant. It follows that WTP will be equal to WTA.

In the non-linear specifications the estimation of marginal WTP and WTA is more complicated. Nevertheless, with the functional forms used here it is possible to derive closed form expressions for the monetary valuation of a change at the individual level. Intuitively, the requirement is to estimate the change in the price that would offset the utility or disutility brought about by the change in the attribute, so that we obtain the expressions for WTP/WTA by equating $v_i(\Delta X_{ki}) = v_i(\Delta Price_i)$, where i indexes respondents. For each of the functional forms, we have the following expressions:

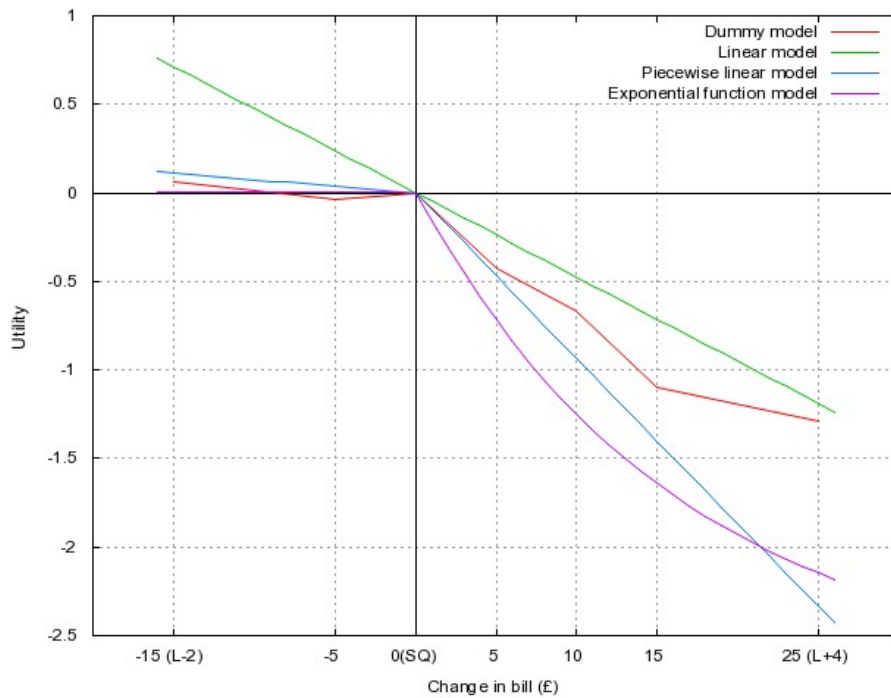
- Linear model:

$$\beta_{ki}\Delta X_{ki} = \beta_{Pi}\Delta Price_i \Leftrightarrow \Delta Price_i = \frac{\beta_{ki}}{\beta_{Pi}} \cdot \Delta X_{ki}$$

Figure 1: Gains-loss asymmetry in utility



(a) Internal sewer flooding (IN2)



(b) Price attribute (BIL)

- Piecewise-linear model:

$$\begin{aligned} \Delta X_{ki} \geq 0 : \beta_{ki}^+ \Delta X_{ki} &= \beta_{P_i}^+ \Delta Price_i & \Leftrightarrow & \Delta Price_i = \frac{\beta_{ki}^+}{\beta_{P_i}^+} \cdot \Delta X_{ki} \\ \Delta X_{ki} < 0 : \beta_{ki}^- \Delta X_{ki} &= \beta_{P_i}^- \Delta Price_i & \Leftrightarrow & \Delta Price_i = \frac{\beta_{ki}^-}{\beta_{P_i}^-} \cdot \Delta X_{ik} \end{aligned}$$

- Exponential function model:

$$\begin{aligned} \Delta X_{ki} \geq 0 : \beta_{ki}^+ [1 - \exp(-\mu \Delta X_{ki})] \frac{1}{\mu} &= \beta_{P_i}^+ [1 - \exp(-\delta \Delta Price_i)] \frac{1}{\delta} & \Leftrightarrow \\ \Delta Price_i &= \frac{1}{\delta} \ln \left\{ 1 - \frac{\beta_{ki}^+ \delta}{\beta_{P_i}^+ \mu} [1 - \exp(-\mu \Delta X_{ki})] \right\} \\ \Delta X_{ki} < 0 : \beta_{ki}^- [\exp(\mu \Delta X_{ki}) - 1] \frac{1}{\mu} &= \beta_{P_i}^- [\exp(\gamma \Delta Price_i) - 1] \frac{1}{\gamma} & \Leftrightarrow \\ \Delta Price_i &= \frac{1}{\gamma} \ln \left\{ 1 + \frac{\beta_{ki}^- \gamma}{\beta_{P_i}^- \mu} [\exp(-\mu \Delta X_{ki}) - 1] \right\} \end{aligned}$$

Where μ , γ and δ are the curvature coefficients. The value of the change is then the negative of the change in bills needed to offset the welfare change.

For improvements in service attributes, we compute marginal WTP (per household per year), whereas for decreases in service we compute marginal WTA (per household per year). Table 4 presents WTP-WTA ratios for IN2, while Figure 2 illustrates graphically the WTP-WTA asymmetry. Graphs for EX1, EX2 and IN1 are reported in the Appendix.

From our data and as illustrated in the figures, we observe pronounced asymmetry in WTP and WTA for the four service attributes. In virtually all cases the linear model provides larger WTP estimates for an improvement in service. Moreover, the exponential utility function gives rise to a ‘plateau’ effect, where the valuation reaches a maximum relatively rapidly. For large increases in the attribute, therefore, the piecewise-linear function also tends to provide larger value estimates for improvements.

Turning to WTA for service deterioration, the linear versus non-linear observation is reversed, with the linear model now providing a conservative estimate of WTA in comparison to the better fitting non-linear models. However, with respect to comparisons between non-linear models,

Table 4: Comparison of WTP to WTA for internal sewer flooding (IN2)

Change from SQ ^{a,b,c}	Linear function	Piecewise-linear function	Exponential function
175 fewer (WTP)	4.46	1.40	1.34
175 more (WTA)	-4.46	-91.18	-25.49
Ratio (WTA: WTP)	1.00	65.36	19.09
350 fewer (WTP)	8.91	2.79	1.86
350 more (WTA)	-8.91	-182.35	-27.22
Ratio (WTA: WTP)	1.00	65.36	14.62
525 fewer (WTP)	13.37	4.19	2.08
525 more (WTA)	-13.37	-273.53	-27.80
Ratio (WTA: WTP)	1.00	65.36	13.39

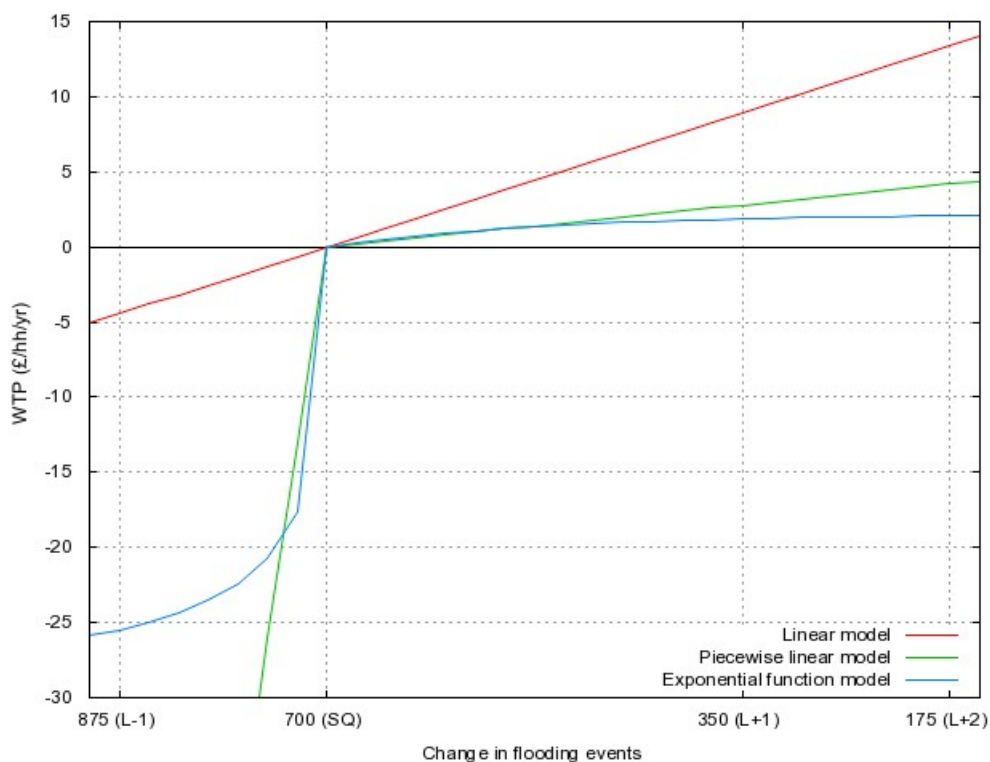
Notes: ^a £ per household per year; ^b Units: expected number of properties flooded per year; ^c Change from status quo and corresponding attribute levels from Table 1: SQ to L-1 = +175; SQ to L1 = -350; and SQ to L2 = -525.

we observe substantial differences in WTA estimates; a result that has to be contrasted with the relatively small differences across models in terms of measures of fit (as reported in Table 3). In particular the results for the piecewise-linear model show extremely high WTA, which may be attributed to the very small marginal utility associated with decreases in the price attribute. The exponential functional form yields more ‘plausible’ values and also shows the effect of diminishing sensitivity, as the value function flattens out relatively quickly. We note, however, that the latter effect is mainly a construct of our estimation procedure since we only observe one point of the utility function in the loss space. As the study design was primarily driven by the appraisal which the discrete choice experiment was to inform, future research directed at assessing non-linearities in the loss-space should aim at gathering more information in order to identify separately the scale and curvature parameters for the gain and loss domains.

5 Conclusions

The aim of this paper has been to assess WTP-WTA discrepancies in the context of a discrete choice experiment, modeling the utility of respondents as a non-linear function of attributes.

Figure 2: WTP-WTA asymmetry for internal sewer flooding (IN2)



Our empirical investigation shows that preferences for changes in levels of service related to internal and external sewer flooding are subject to relatively strong gains-loss asymmetries. We also find evidence of diminishing marginal sensitivity for improvements. Given our approach to the econometric estimation this also implies diminishing marginal sensitivity in the loss domain, although this finding is to be interpreted with caution given the data limitation of our study.

Less commonly investigated in the literature to date is non-linearity in the price attribute, an issue that is also found to be important in our data. We suggest that the pronounced degree of gain-loss asymmetry observed for the price attribute may be taken as evidence that monetary outlays are construed of losses rather than foregone gains. This provides support for the theory of reference dependent preferences proposed by Munro and Sugden (2003). The evidence from our analysis also provides support for the hypothesis that people behave according to the theory

of ‘mental accounting’ (Thaler, 1999), since we observe patterns of declining marginal sensitivity to bill increases even though the amounts considered are relatively small compared to the income of most respondents. According to these results, loss-aversion in the price attribute is a significant source of the WTP-WTA asymmetry observed in the analysis and should be given careful scrutiny both for survey design and for the purpose of deriving welfare estimates from discrete choice experiments.

In accounting for non-linearities in respondent’s value function, we establish that the WTP-WTA ratio varies according to the particular provision change under consideration. Accounting for this effect is a particularly appealing property of the discrete choice experiment approach. Such flexibility is not evident from studies that focus on a single discrete change for a particular good. The approach also allows estimation of an individual WTP-WTA schedule, whereas most existing studies typically compare WTP and WTA elicited within different groups of respondents. In the light of the findings reported here, the previous results from the literature comparing WTP and WTA should be reinterpreted by accounting for the magnitude of the change considered.

The presence of reference point effects and loss-aversion confirms findings from the experimental literature and raises a number of important issues for both analysts and decision-makers. From the analysts’ perspective our results suggest that the common use of linear utility specifications may be erroneous, particularly when considering scenarios involving both gains and losses. Our study makes a case for the adoption of more flexible functional forms allowing for the influence of non-standard and behavioral factors upon stated preferences. Given the lack of theoretical guidance, the choice of econometric specification is ultimately an empirical issue. Accordingly specification search (e.g. through the use of dummy-coded, non-parametric utility function) should be undertaken and reported.

In the context of economic appraisal, an implication of non-linear preferences is the role of the current provision level of the good. Given a non-linear WTP-WTA schedule, a change in the reference point could generate a very different outcome for the appraisal of a particular project. First, we note that the implementation of a particular project could shift the reference point, thereby modifying the value of subsequent changes. However, in the context of ex-ante

appraisal informed by stated preference surveys, it is the values expressed before the change that are relevant (as would transactions made under a set of market prices observed before the policy is implemented). Second, for the assessment of projects generating heterogeneous impacts across the relevant population, economic appraisal should ideally control for variations in both the status quo and the change experienced. In sum, such reasoning highlights the need for careful contextualization of each study, notably in terms of the definition of the reference situation as well as its perception among the population.

From a broader perspective, the empirical confirmation of reference point effects and a priori loss aversion raises further issues and asks for continued research. Indeed, some commentators argue that such results should be taken at face value as indications of a genuine and persistent disparity of loss versus gain values (Knetsch, 2005). On this basis, economic appraisal should be based on a schedule for the WTA-WTP, with potentially varying marginal values across the change in outcome envisaged. However, a counter view is that such disparities may be a feature of the elicitation procedure itself, focusing on ‘decision utility’ (Sugden, 2005a,b). In alternative settings, eliciting ‘experienced utility’, the observed disparities may themselves diminish (although not necessarily disappear) as ex-post status quo is integrated into the decision-making process (Kahneman and Sugden, 2005). This is, however, a wider debate than can be covered in the present work and is still far from resolved. For the present therefore we restrict ourselves to the parsimonious analysis of data derived from stated preference surveys for which our results show that reference point effects and loss-aversion are significant. Given the weight of experimental research and findings from other stated preference techniques such as contingent valuation, such a finding should not be a surprise and cannot be ignored in the design and analysis of discrete choice experiments.

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Appendix

Figure 3: Gains-loss asymmetry for external sewer flooding (EX1)

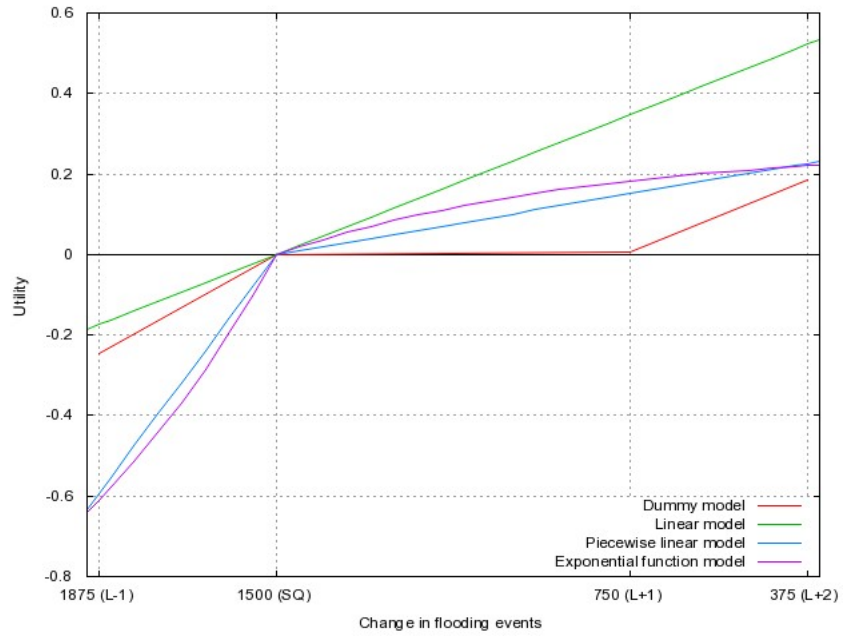


Figure 4: Gains-loss asymmetry for external sewer flooding (EX2)

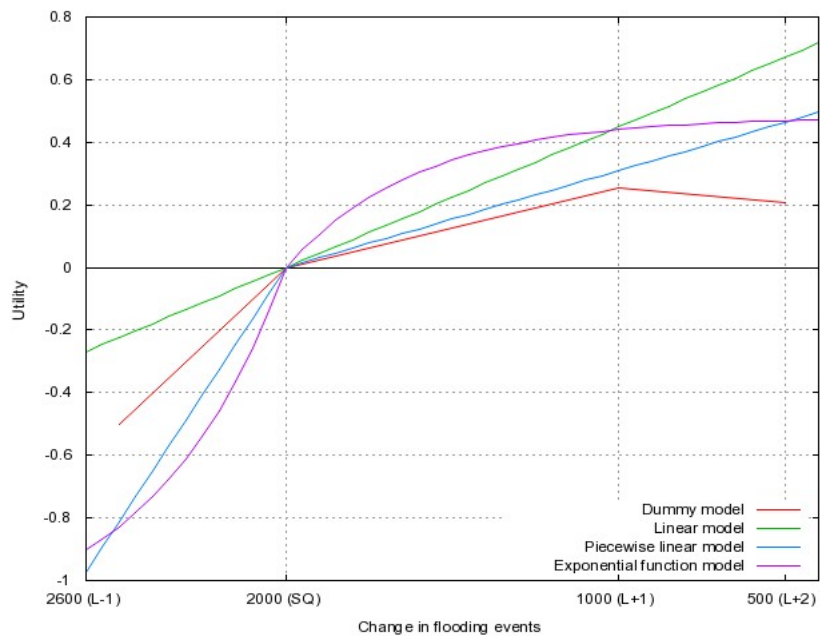


Figure 5: Gains-loss asymmetry for internal sewer flooding (IN1)

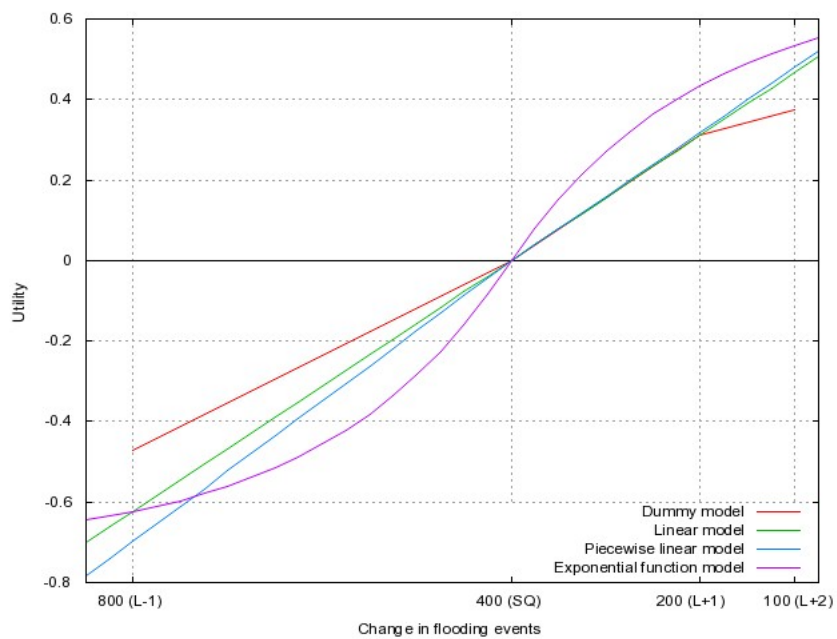


Figure 6: WTP-WTA asymmetry for external sewer flooding (EX1)

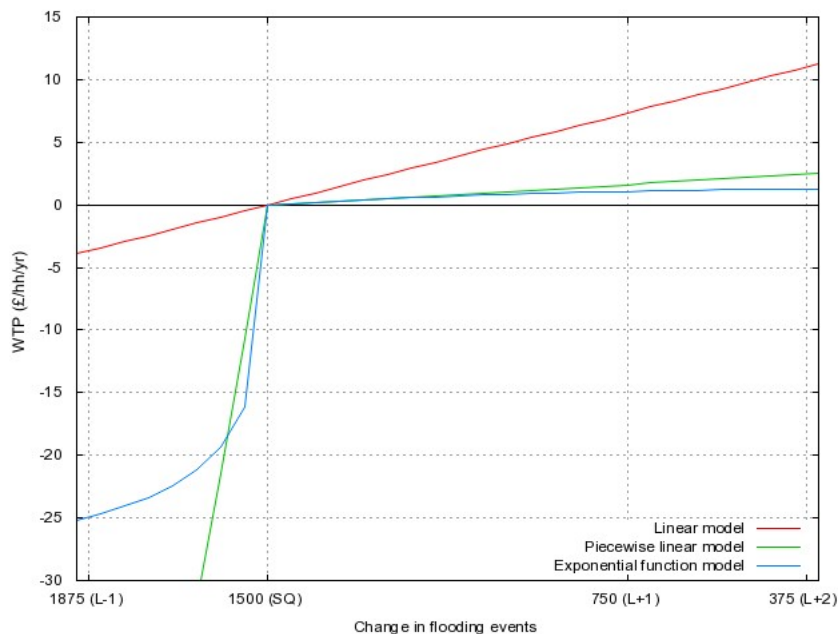


Figure 7: WTP-WTA asymmetry for external sewer flooding (EX2)

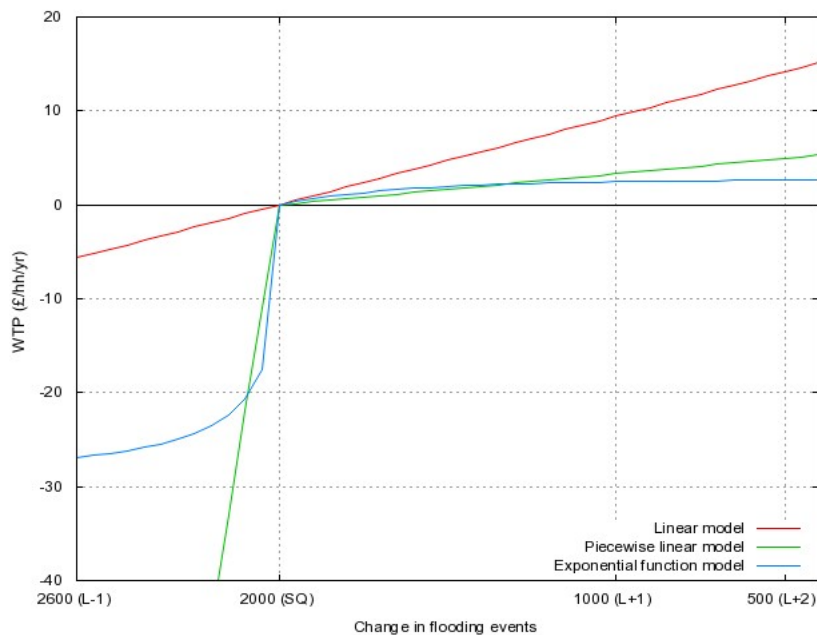


Figure 8: WTP-WTA asymmetry for internal sewer flooding (IN1)

