Subjective versus objective measures in valuation of water quality

Abstract

In environmental valuation, the description of the current state of the environment is a fundamental part of eliciting individual values. The description can be based either on objective measures of quality or people's own perceptions. If perceptions differ systematically from objective measures, valuation results may be subject to bias. This study examines the divergence between summer house owners' perceptions of water quality and objective quality classification. Logit and ordered logit models are employed to identify factors that explain the divergence between perceptions and objective water quality and the direction and magnitude of the divergence. We pay special attention to variables essential in valuation, and include variables describing the respondent, the summer house and the water body. The results show that approximately 50% of respondents perceive water quality differently from the objective quality. Factors related to the water body and to the summer house property are found to affect the divergence between perceived and objective water quality, and respondents' attitudes and age explain the direction and magnitude of the divergence. The results imply that valuation results based on subjective perceptions may differ from those using objective measures, particularly in the case of low water quality.

Keywords: valuation, water quality, perceptions

1. Introduction

In monetary valuation of environmental quality the information of the current state of the environment is fundamental part in eliciting individual values. In revealed preference methods, such as the hedonic property pricing method, the quality information can either be based on objective measures from environmental monitoring or subjective perceptions received from a survey. In stated preference studies, the state of the art is to describe the present state of the environment to the survey respondents, but it is also typical and suggested, that subjective perceptions of environmental quality are gathered and used beyond the objective information. If willingness to pay is dependent on subjective perceptions about the environmental quality, these perceptions define the environmental good and systematic divergence from the objective quality according to individual or environmental characteristics can bias valuation results (Whitehead 2006).

From a researcher's point of view it is important to decide whether to base the valuation study on the objective monitoring data or on subjective perceptions of environmental quality. In many cases objective, scientifically measured, environmental quality indicators provide a commensurate and thus an easier platform for the researchers to build their analysis on. Especially in data intensive valuation methods like the hedonic pricing method, where the number of observations is large and the time-frame of the study may reach many years back, existing data sources are competitive, and the collection of subjective perception data is in many cases difficult and time-consuming (Bockstael & McConnell 2007, Baranzini et al. 2010).

However, in many cases there are several benefits in using subjective data on environmental quality instead of objective measures. First, subjective environmental quality perceptions are often easy and cost-effective to acquire if an environmental valuation method itself demands survey data. Scientifically measured data that correspond to each individual's environmental conditions are not always readily available and, most importantly, may suffer from being out of date or out of location for the time period and the site under study.

Second, people's behaviour is based on their perceptions (Bockstael & McConnell 2007, Poor et al. 2001). Thus a correct description of people's perception of environmental amenities should provide the most accurate estimates of values attached to these amenities. Objective measurements may not be consistent with public's subjective perceptions of environmental quality. If perceptions differ from the objective data, it is the *perceptions* that predict the preferences, and should therefore be used in the analysis (Bockstael & McConnell 2007). If objective quality presented in the valuation survey is inconsistent with individual's beliefs, the number of protest answers in stated preference studies may also increase or the reliability of responses decrease.

Having the benefits of subjective information in mind, a burning question is to assess whether perceptions of environmental quality are consistent with their objective, scientific counterparts, in such a systematic way that researchers could generalize their results regardless of the type of data used. If perceptions do not generally follow the objective measurements of environmental quality, it is essential to know the typical factors that produce or instigate a deviation between perceptions and scientific measurements. It is also important to know whose perceptions deviate from the objective measures, and in what kind of environmental settings this deviance is most considerable.

The literature exploring valuation and the effects of using objective versus subjective measures of environmental quality is relatively scant. Most of the studies from the valuation context are in the framework of revealed preference methods of environmental valuation, i.e. hedonic pricing (Poor et al. 2001, Baranzini et al. 2010) and recreation site choice studies (Adamovicz et al. 1997, Jeon et al. 2005). Some studies have shown similarity of perceptions and objective measures (Baranzini et al. 2010), and some that there might be differences (Adamovicz et al. 1997, Poor et al. 2001, Jeon et al. 2005). However, the reasons for divergences have gained less attention.

Thus far, only a few valuation studies have explored the use of objective and subjective measures of water quality, the focus of this study. Poor et al. (2001) examined the convergent validity of subjective and objective measures of water clarity in a hedonic property model. Their data indicated that people tend to underestimate water clarity compared to the objective measure. The results suggested that objective measures leading to lower implicit price estimates are better predictors of property sales prices than subjective measures. Both objective and subjective measures of water quality have been found to have a significant effect on recreation site choice (Jeon et al. 2005), and the models including water quality perceptions have outperformed models that exclude perceptions. In Jeon et al. (2005) the recreationists' water quality perceptions were correlated with both individual objective measures and with different objective water quality indices, such as EPA's water quality ladder, but the relation of perceptions and objective measures was affected by the recreational activity. Besides the valuation studies, the accuracy of water quality perceptions have been analyzed by Steinwender et al. (2008), Faulkner et al. (2001) and Lepesteur et al. (2008) showing some general tendencies.

The purpose of this study is to analyse whether the perceived water quality differs from the objective measures. Furthermore, we focus on the difference between objective water quality measures and two distinct types of water quality perceptions. First, we define the conditions that strengthen the divergence between objective measures and perceptions. Second, we examine the direction of the divergence; when there is tendency to overestimate (underestimate) water quality so that the perceived water quality is higher (lower) than the objectively measured water quality[1]. Third, we focus on the conditions that are associated with the magnitude of the divergence. Based on the divergence analysis, we discuss the implications to valuation studies.

Our data originates from a valuation study, but we focus on water quality perceptions and do not present the valuation results. We employ the data of a large scale survey sent to all those who purchased a private summer house in Finland during the year 2004. The summer house purchasers provide an excellent study population as they have very likely paid particular attention to the environmental conditions of their property. The survey collected information of individual perceptions on water quality at the time of purchase of the property and at the time of the survey. This data have been complemented by the scientifically measured water quality information enabling comparative analysis. The objective environmental quality indicator we use in this study is the general usability classification of water quality that, to some part, is observable by a layman and, to some part, only observable with scientific equipment.

The paper is organized as follows. Section 2 discusses the previous literature on water quality perceptions and relates the results to the valuation of water quality. Section 3 describes the data and the objective and subjective measures of water quality and the methods used in the analysis. Section 4 discusses the results and section 5 presents conclusions.

[1] In the course of this study we discuss over- and underestimation of objective water quality. We do not mean to say with these phrases that the objective measure is the only correct one as it actually attempts to mimic the public's preferences and perceptions to some degree. As it, however, shortens the text considerably, we sometimes resort to saying that respondents over- or underestimate water quality. Note also, that even the objective water quality is subject to expert judgment in some cases, thus not being entirely objective.

2. Accuracy of water quality perceptions as a challenge for valuation

There is a wide literature of environmental perceptions focusing on the factors that explain differences in environmental perceptions between individuals. The formation of environmental perceptions has been explained in several theories (Kaplan 1975; Gibson 1979; Marr 1982; Sell and Zube 1986). Empirical studies provide a picture that environmental perceptions are associated with individual characteristics, such as socio-demographic factors (e.g. Flynn et al. 1994, Múgica & DeLucio 1996, Bonaiuto et al. 1999), and also the role of knowledge (Bell 2001, Burton 2004) and attitudes (Kaltenborn & Bjerke 2002) has been recognized. Although environmental perceptions in general are quite well studied, there are relatively few studies on the divergence between individual perceptions and actual environmental conditions. On a large scale, self-reported environmental quality has been found to differ from the objective quality so that the relationship is influenced by distance and environment type (Kweon et al. 2006).

According to the previous literature, water quality perceptions are associated with individual characteristics, such as socioeconomic and demographic factors, with one's location, setting, and proximity to water bodies (Brody 2004), environmental knowledge and attitudes (Danielson et al. 1995) but also factors related to water bodies itself (Steinwender et al. 2008).

The studies focusing on public's ability to evaluate water quality have shown subjective assessments to follow most measured water quality indicators in the case of water quality improvements (Steinwender et al. 2008). The assessments were clearly influenced by individuals' age and mood and meteorological conditions of evaluation time (Steinwender et al. 2008). Faulkner et al. (2001) found residents to be fairly astute observers of water quality improvements, particularly those who had most frequent access to the water body. However, environmental affiliations decreased the success of evaluation. Lepesteur et al. (2008) emphasized the role of own experience and social exchange over factual environmental information in forming individual perceptions of water quality.

From the economic valuation point of view, it is particularly interesting how variables fundamental in valuation are associated with the accuracy of water quality perceptions. If perceptions and objective quality differ systematically due to some individual and environmental attributes, this may create bias in valuation and needs to be taken into account in the analysis.

Regarding all valuation methods, it is relevant to evaluate whether the accuracy of perceptions differs depending on the characteristics of the water body, e.g. the actual level of water quality, or the type of the water body in question. From the previous literature we know that actual water quality is associated with the perceptions (Steinwender et al. 2008, Jeon et al. 2005), but what is more important in the case of valuation is to understand if and how the *accuracy* of perceptions is associated with the level of actual water quality or the type of the water body.

In the hedonic pricing method, the environmental quality is typically used to explain the price of e.g. a property, but it is also possible that the price of the property affects the quality perception, thus creating an endogeneity problem. Price has been suggested to be a relevant cue for consumer when no adequate information about intrinsic quality is available (Zeithaml 1988). The association between price and perceived quality has varied greatly according to products and individuals, but most of studies have found that price and quality are positively related (Rao & Monroe 1989, Völckner & Hofmann 2007). In the case of hedonic data, the association between the price and environmental quality can be price driven if the quality has been evaluated at the time of purchase on the grounds of price.

In travel cost models, the environmental quality explains the number of trips to a site during season or site choice. If water quality perceptions are systematically under- or overestimated, the position or the slope of the demand curve will be biased. In the traditional travel cost method, it is essential to see whether the number of visits or the travel costs are related to the accuracy of perceptions to actual quality. The previous literature has shown the effect of frequent observations on the accuracy of water quality perceptions (Faulkner et al. 2001). In a travel cost analysis this would imply that, on one hand, those who visit the sites most often can also evaluate their quality most accurately and, on the other hand, infrequent visitors may have difficulties in assessing the environmental quality. Then particularly the left side of the demand curve that is associated with higher travel expenses and a lower number of visits might be subject to more uncertainty compared to right side of the demand curve. In the case of summer houses this effect may be less obvious as people may choose to visit the summer house less often, but for longer periods of time.

In stated preference methods, such as contingent valuation and choice experiments, the essential factors are those describing the environmental good that is the focus of valuation. In water quality (and any other type of) valuation employing stated preference methods, the reference quality and the after policy quality, which together define the change to be valued are necessary parts of the information. If respondents' perceptions deviate from the presented quality levels, the valuation results may be biased (Whitehead 2006).

The previous valuation studies have shown the existence of heterogeneity of environmental preferences, also in the case of water conservation (Kosenius 2010). Accounting for the heterogeneity is important particularly for equity considerations. The heterogeneity may not, however, relate only to the preference structure but also to the perception of environmental conditions. For systematic equity considerations it would be important to separate the heterogeneity of the accuracy of environmental perceptions from the heterogeneity of preferences.

Based on the previously reviewed literature we form a list in Table 1 that gathers the variables of interest and their expected effect on the accuracy of water quality perceptions.

Table 1. Assumptions of the association between water quality perceptions and valuation related variables

Valuation method	Issue	Variable of interest	Assumption related to the accuracy of perceptions
Stated preferences and stated choice	The good and its scope	Water body type Water quality level	? ?
Travel cost	The shape of the demand function	Actual use Travel cost	+ -
Hedonic pricing	The endogeneity problem	Price	+
Equity analysis	Heterogeneity of environmental perceptions	Income Socio-demographics	?

3. Data and methods

The survey method

The data for this study comes from a large scale water quality valuation survey sent to all summer house purchasers in Finland who had made the purchase during the year 2004. The survey elicited data for both revealed and stated preference methods. For the purposes of this study we employed especially the data on the perceptions of water quality at the time of purchase and at the time of the survey. After a pilot survey of 200 property owners in November 2008, the final survey was sent to 2 547 property owners between the end of 2008 and early 2009. The survey was administered jointly through the internet and mail. The respondents were initially approached by a letter asking them to fill an online survey, followed within a week by a reminder postcard. After one month non-respondents received a final contact where the online survey address was complemented with a paper version of the survey. Excluding the respondents who could not be reached the response rate to the final version of the survey was over 51 %, i.e. 1 249 responses.

Objective measure of water quality

The objective measure of water quality used in this study was the general usability classification provided by the Finnish Environment Institute. The classification is based on the average suitability of water bodies for water supply, fishing and recreation in Finland (Finnish Environment Institute 2010). Several criteria are used in the classification, including the amount of chlorophyll-a, total phosphorus, transparency, turbidity and colour, amount of oxygen, hygienic quality of the water, algal blooms and concentrations of harmful substances. The classification, shown in Figure 1 on a map of Finland, is based on data from the period 2000-2003 and covers 82% of lakes, 16% of the length of rivers and the coastal sea area within Finnish territory. The data reflect well the average water quality before and at the time of summer house purchase. They represent also the most recent available objective data at the time of the survey, as the new classification based on the ecological state of the water bodies was not yet complete.

The usability classification includes five categories from poor to excellent. Poor and passable categories are not recommended for recreation as there may be severe algal blooming, occasional fish deaths, or actual health risks. Water bodies in the satisfactory quality class may have repeated algal blooming. This category includes also watercourses that are notably humic due to natural causes. Satisfactory water quality is generally suitable for most recreational requirements. The good and the excellent categories have no restrictions for recreational use and in an ecological sense the water bodies are in or near their natural state.

We linked each summer house and thus each respondent to a corresponding water usability class using GIS software. The data included only sales within 250 meters from the nearest quality classified water body to prevent assigning objective water quality values to summer houses that in reality resided near a different water body. From the data in Table 2 we see that owners of lake-front and river-front properties are represented at all five usability categories, while respondents with coastal properties lack both excellent and poor quality sites. Most lakes in the sample have excellent or good water quality classification, while rivers and sea areas are mostly at good or satisfactory level.

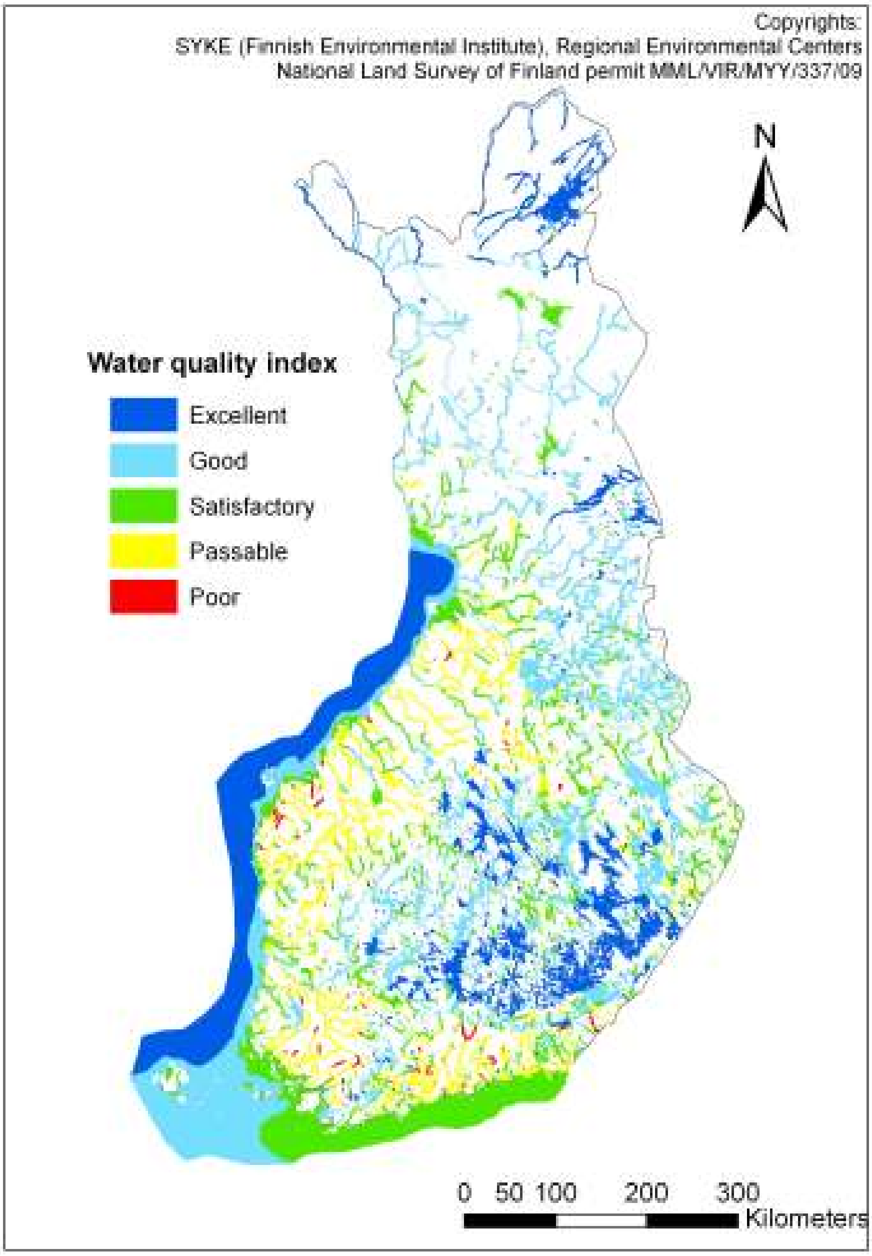

Figure 1. Objective water quality classification in Finland in 2000-2003.

Table 2. Distribution of the general usability classification categories across water body types in the sample

	Objective measure					
Water body	Excellent	Good	Satisfactory	Passable	Poor	Total
Lake	267	253	104	23	1	656
River	3	12	25	13	1	54
Sea	0	38	79	10	0	127

Subjective measures of water quality

We used two different variables to describe the subjective perceptions of water quality: perception of water quality at the time of purchase (WQBUY), and informed perception of current water quality based on own experience (WQINF). Both subjective water quality measures were defined to the water body adjacent to the summer house.

WQBUY was simply the respondent's assessment of the water quality at the time of purchase, i.e. in the year 2004. The answer categories were the same as for the objective measure, a five-step scale ranging from poor to excellent. This assessment was completely uninformed. The respondents merely stated what the water quality was in their opinion without anchoring the answer to some predetermined classification.

WQINF represented an informed assessment of current water quality based on respondent's own experience. The respondent was first presented four water quality factors: clarity of water, fish species, blue-green algal blooms and sliming. The factors and their levels (excellent, good and satisfactory) were described in detail. After this, the respondent was asked to rate the water quality according to each factor. The categories ranged from excellent to worse than satisfactory, with the worse than satisfactory class corresponding to passable and poor water quality in the objective measure. In this study we have taken the mean of these four quality levels and rounded the result to the nearest quality category.

Tables 3 and 4 present the cross tabulations of the general usability classification and water quality perceptions. The objective measurement is shown in columns and the perceptions in rows. The percentages represent the shares of perceived water quality in relation to each objective classification level, and the percentages sum to 100% by columns. Table 3 shows that in classes from *excellent* to *satisfactory*, approximately half of the respondents have perceived the water quality at the time of purchase as the same as the objective classification. Most differences can be found in the *passable* category, where a majority of respondents have considered the water quality better than the objective. The same phenomenon is present in Table 4, where most divergences can be found in the lowest objective quality category, *worse than satisfactory*.

Table 3. Cross tabulation of the objective classification of water quality and perceived quality at the time of purchase (WQBUY)

	Objective measure					
	Excellent	Good	Satisfactory	Passable	Poor	Total
Perception						
Excellent	149 (55.6%)	80 (27.0%)	15 (7.9%)	7 (11.9%)	0 (0.0%)	251
Good	104 (38.8%)	154 (52.0%)	73 (38.2%)	17 (28.8%)	0 (0.0%)	348
Satisfactory	14 (5.2%)	52 (17.6%)	80 (41.9%)	24 (40.7%)	0 (0.0%)	170
Passable	1 (0.4%)	8 (2.7%)	19 (9.9%)	10 (16.9%)	1 (100.0%)	39
Poor	0 (0.0%)	2 (0.7%)	4 (2.1%)	1 (1.7%)	0 (0.0%)	7
Total	268 (100%)	296 (100%)	191 (100%)	59 (100%)	1 (100%)	815

Table 4. Cross tabulation of the objective classification of water quality and perceived quality at the time of the survey (WQINF)

	Objective measure				
	Excellent	Good	Satisfactory	Worse than satisfactory	Total
Perception					
Excellent	123 (45.6%)	57 (18.9%)	10 (5.1%)	1 (1.7%)	191
Good	131 (48.5%)	198 (65.8%)	101 (51.0%)	27 (45.0%)	457
Satisfactory	16 (5.9%)	42 (14.0%)	74 (37.4%)	29 (48.3%)	161
Worse than satisfactory	0 (0.0%)	4 (1.3%)	13 (6.6%)	3 (5.0%)	20
Total	270 (100%)	301 (100%)	198 (100%)	60 (100%)	829

Statistical models

The analysis was divided into three parts (see Figure 2), where we had altogether 5 dependent variables. We estimated the divergence and direction models using our two subjective water quality measures, WQBUY and WQINF, and the magnitude model using one subjective measure water quality, WQBUY[2].

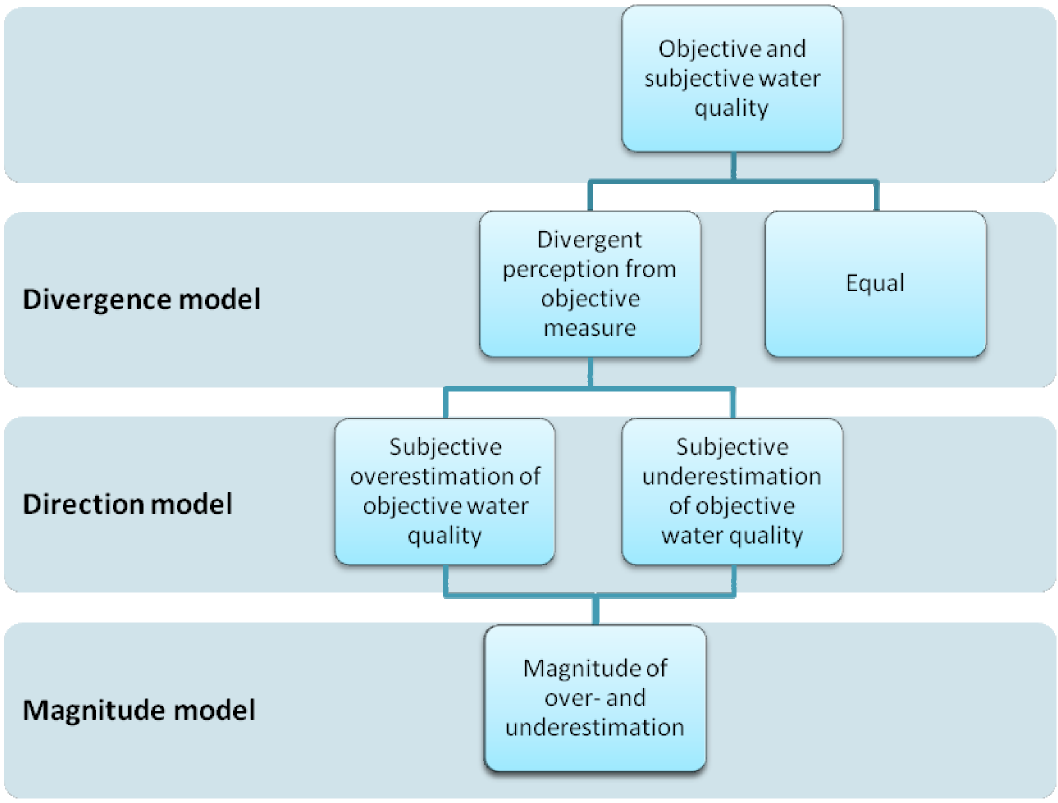

Figure 2. The structure of the analysis

First we analyzed if there were underlying factors explaining the difference between individual's perception of water quality and the objective measure of quality based on the general usability classification. The dependent variables in the first stage divergence models were DIVBUY and DIVINF, which simply denominate if there was a difference between objective and perceived water quality. Note that the objective water quality was coded differently depending on the subjective water quality variable used. With perceived water quality at the time of purchase (WQBUY), the scale was from 1 (excellent) to 5 (poor), and with the perceived water quality at the time of the survey (WQINF), from 1 (excellent) to 4 (worse than satisfactory).

[2] We note that the survey elicited information of both instances at the same time, but we feel that there was enough distinction between the two points in time to provide reasonable answers.

In the second stage, we included only those observations in which the subjective and objective water quality deviate from each other. The direction models predicted DIRECTBUY and DIRECTINF, binary variables describing if the objective water quality was *higher* than respondent's subjective perception. Thus, if the person underestimated (overestimated) the water quality in comparison to the objective measure, the dummy took the value one (zero).

Logistic regression was chosen to model divergence and the direction of divergence because the dependent variable was dichotomous. Significance tests for a single coefficient were based on the Wald test and the likelihood ratio test was used to test the significance of the model (Hosmer and Lemeshow 2000).

The third stage of the analysis delved into the magnitude of the deviation, that is, which factors had an effect on the size of the difference between perceptions and objective water quality. On that stage the ordinal variable MAGNBUY presented the magnitude of the difference between the objective and subjective water quality. The magnitude of divergence was modelled with ordered logit because there was reason to believe that the different levels of magnitude would not be equally apart. Using OLS would have treated the differences between the magnitudes of differences equal in size, whereas the ordered logit specification allows the differences to be studied as a ranking (Greene 2008) [3].

Independent variables

Based on previous literature and our focus in valuation, we included explanatory variables that characterize the respondent, the summer house and the water body. Descriptive statistics of the explanatory variables used in analysis are shown in Table 5.

[3] The STATA software uses a specification that sets the constant zero (Inlow and Cong, 2009) while Greene's (2008) ordered probit/logit specification sets the first cut point in the model as zero. We present our results using the STATA specification.

Table 5. Descriptive statistics for explanatory variables

Respondent characteristics	Description	Obs	Mean	Std Dev	Min	Max
AGE	Age of the respondent, continuous	1127	52.586	9.991	20	87
INCOME	Household's gross monthly income, thousand euros (2004)	1085	5.595	2.473	0	10
EDUC	1 for respondents with university level education, 0 otherwise	1136	0.228	0.420	0	1
INSPECT	1 for respondents who inspected water quality prior to purchase, 0 otherwise	1136	0.936	0.245	0	1
IMPSIZE	1 if the size of the water body was an important factor in purchasing decision, 0 otherwise	1115	0.675	0.468	0	1
VERYIMPQ*	1 if water quality was a very important factor in purchasing decision, 0 otherwise	1110	0.487	0.500	0	1
IMPQ	1 if water quality was an important factor in purchasing decision, 0 otherwise	1110	0.276	0.447	0	1
RATHERIMPQ	1 if water quality was rather important factor in purchasing decision, 0 otherwise	1110	0.127	0.333	0	1
NOTVERYIMPQ	1 if water quality was not a very important factor in purchasing decision, 0 otherwise	1110	0.056	0.230	0	1
NOTIMPQ	1 if water quality was not at all important factor in purchasing decision, 0 otherwise	1110	0.054	0.226	0	1
Property characteristics						
ISLAND	1 if the property resides at an island, 0 otherwise	1127	0.175	0.380	0	1
SOUTH*	1 if the property is in Southern Finland, 0 otherwise	1132	0.345	0.475	0	1
EAST	1 if the property is in Eastern Finland, 0 otherwise	1132	0.299	0.458	0	1
WEST	1 if the property is in Western Finland, 0 otherwise	1132	0.225	0.418	0	1
NORTH	1 if the property is in Northern Finland, 0 otherwise	1132	0.123	0.328	0	1
PROPSIZE	Size of the property, hectares	1132	0.535	0.355	0.2	2
PROPPRICE	Property price, thousand euros (2004)	1132	48.926	41.402	0.38	470
PROPDIST	Respondent-reported distance from home to the property, hundred kilometres	1124	1.405	1.835	0	17.61
Water body characteristics						
SEA	1 if the adjacent water body is sea, 0 otherwise	1132	0.108	0.310	0	1
RIVER	1 if the adjacent water body is a river, 0 otherwise	1132	0.040	0.195	0	1
LAKE*	1 if the adjacent water body is a lake, 0 otherwise	1132	0.574	0.495	0	1
LOWUSAB	1 if the usability classification is passable or poor, 0 otherwise	817	0.067	0.251	0	1
HIGHUSAB	1 if the usability classification is excellent or good, 0 otherwise	817	0.692	0.462	0	1
MIDDLEUSAB*	1 if the usability classification is satisfactory, 0 otherwise	817	0.241	0.428	0	1

* These represent the base cases, so they are omitted from the models.

Respondent characteristics included socio-demographic variables such as age, income and education. These are interesting from the viewpoint of equity considerations. We used also factors describing respondents' attitudes, such as importance of the size of the water body and importance of water quality in the purchasing decision as these are likely to reflect the respondents' affinity to water quality.

Characteristics describing the property were the price and size of the property, the area where it is located according to the European Union NUTS2 classification, whether the property resides in an island and the respondent-reported distance from home to the property. For hedonic pricing, it is important to examine whether the price of the property affects the perceived water quality, thus creating an endogeneity problem. The distance from home to the summer house may serve as a proxy for travel costs, and therefore it is interesting from the point of view of the travel cost method.

Water body characteristics were included for the examination of implications for stated preference methods. We included three water body types; lakes (which is the base case for the analysis), sea areas and rivers. In addition, the objective measurement of the water quality was included to analyse its effect on the accuracy of perceptions. As the water quality scales used were only five and four steps wide, the objective measurement of water quality was not included in the models describing the direction or the magnitude of subjective perception's difference to the objective water quality. These variables would have presented a source of endogeneity in the models, as it is possible to diverge only in one direction from the endpoints of the quality scale, and similarly the possible magnitude of the divergence is dependent on the respondent's location on the objective scale.

In our literature review we found also other variables to be tested for affecting the difference between subjective and objective water quality assessments. We tested if the intensity of recreational use of the water body or the number of nights spent at the summer house had an effect, but found none in any of the models. Thus these variables were not included in the final models. Additionally we tested variables including if the respondent had spent his/her childhood at a rural setting, if the purchased lot had any buildings, and the gender of the respondent. These variables were also excluded on the same grounds.

4. Results

Association between perceived and actual measures

The first step in the analysis was to examine how well people's perceptions correspond to the objective measure of water quality, i.e. the general usability classification. Table 6 presents the dependent variables and their summary statistics. Approximately 50% of people perceived the water quality the same as the objective quality, and this applied both to perceptions at the time of purchase and at the time of the survey. The result showed that in general the public's perception of water quality is rather well represented by the general usability classification, or the other way around, that the usability classification is so practical and well formulated that it is capable of representing public's perceptions.

Table 6. Dependent variables used in regressions

Dependent variable	Description	Obs	Mean	Std Dev	Min	Max
DIVBUY	1 if objective water quality is not equal to perceived quality at the time of purchase, 0 otherwise	799	0.514	0.500	0	1
DIVINF	1 if objective water quality is not equal to perceived quality at the time of survey, 0 otherwise	814	0.517	0.500	0	1
DIRECTBUY	1 if objective water quality is better than the perceived quality at the time of purchase, 0 otherwise (DIVBUY=1)	411	0.489	0.500	0	1
DIRECTINF	1 if objective water quality is better than the perceived quality at the time of survey, 0 otherwise (DIVINF=1)	421	0.477	0.500	0	1
MAGNBUY	magnitude of difference between the objective and perceived quality at the time of purchase (DIVBUY=1)	422	1.185	0.446	1	3

In general, the proportions of people over- and underestimating were of similar size. The divergent responses (DIVBUY=1 or DIVINF=1) were slightly skewed to the objective quality measure giving lower estimates than the subjective perception. This means that the respondents have rather overestimated than overestimated the objective quality measure on average. The magnitude of the difference ranges from 1 to 3 classes. In the MAGNBUY model the share of one-step difference is 84% (87%), two-step difference share is 15% and the share of the largest three step differences is slightly over 1% There were no four-step differences present in the MAGNBUY model. The shares of two- and three-step differences were even smaller for the perception at the time of the survey. For this reason it was pointless to estimate the magnitude model for the time of the survey.

To analyse the association between perceived and actual water quality further, we examined if individuals' perceptions of water quality were correlated with the objective measure. We used two subjective measures and correlated them pairwise with the general usability classification. The correlation coefficients were all significant and their magnitude ranged from 0.478 to 0.526, shown in Table 7. The correlation was highest between the perceived water quality at the time of purchase and the general usability classification, which is logical as they have been made close in time. However, at that point the experiences of the water quality were still quite limited compared to perceptions formed later on.

Table 7. Correlations between subjective and objective measures

Subjective measure	**Pearson correlation**	**Spearman's rho**
WQBUY	0.515***	0.526***
WQINF	0.478***	0.486***

*** Significant at the 1% level

Divergence

In the first models we analyzed if there were underlying factors explaining the divergence between individual's perception of water quality and the objective usability classification. The models differed by the dependent variable; that is, whether the subjective assessment has been made at the time of purchase (DIVBUY) or at the time of the survey (DIVINF). Statistically significant variables were found in factors describing the respondent, the property and the water body, and more variables were statistically significant in the DIVBUY model. The results are shown in Table 8.

Of the factors describing the respondent, only income and higher education were found to weakly affect the divergence in the DIVINF model. A higher income reduced the probability of divergence between the subjective and objective classification, but a higher education level increased the probability of perceiving the water quality the same as the objective measure.

Table 8. Divergence model results

Logistic regression, dependent variable: DIVBUY or DIVINF				
	DIVBUY		**DIVINF**	
	n = 743		n = 753	
	Coef.	Std error	Coef.	Std error
AGE	-0.006	0.008	0.006	0.008
INCOME	-0.042	0.036	-0.07*	0.036
EDUC	-0.068	0.190	0.35*	0.191
INSPECT	-0.440	0.454	0.065	0.398
IMPSIZE	0.327	0.213	0.248	0.208
IMPQ	0.204	0.186	0.214	0.183
RATHERIMPQ	0.434	0.273	0.357	0.273
NOTVERYIMPQ	1.097***	0.416	0.397	0.429
NOTIMPQ	0.735	0.481	-0.03	0.479
ISLAND	-0.506**	0.202	-0.301	0.202
EAST	0.391*	0.215	0.078	0.220
WEST	0.358	0.223	-0.13	0.226
NORTH	0.289	0.319	0.135	0.310
PROPSIZE	0.360	0.239	-0.092	0.243
PROPRICE	0.001	0.002	-0.001	0.002
PROPDIST	0.116**	0.048	0.026	0.051
SEA	0.565**	0.284	0.351	0.277
RIVER	-0.256	0.399	0.159	0.391
LOWUSAB	1.578***	0.476	2.273***	0.603
HIGHUSAB	-0.396*	0.221	-0.773***	0.218
Constant	0.160	0.714	0.226	0.671
Log pseudolikelihood	-479.40		-479.28	
Wald χ^2	54.59		66.01	
Pseudo R^2	0.0689		0.0811	

Individual coefficients are significant at the *** 1%, ** 5% or *10% level

The relative importance of water quality at the time of purchase had only weak signals of affecting the divergence. Compared to those who claimed that water quality was a very important factor in the purchasing decision, both models showed that, in general, all the other groups were more likely to have a different subjective water quality assessment than the objective classification, as all but one of these coefficients had a positive sign. The only statistically significant variable was for the group that considered water quality being a *not very important* factor in the purchasing decision in the DIVBUY model.

The property-related variables were found to affect the divergence between the subjective and objective water quality in the DIVBUY model. If the lot resided on an island it was more likely that the respondent perception of water quality corresponded to the objective classification, which is reasonable as a personal contact to water is intuitively more probable for those who own an island property. A longer distance from home to the summer house increased the probability of divergence, which could be due to the fact that those who have a long distance visit the summer house less. It is somewhat surprising that whether the respondent had inspected the water quality prior purchasing (INSPECT) had no significant effect on divergence. Then again, approximately 93 per cent of the sample had inspected the water quality by some means.

The region of the summer house had an effect on the probability of divergence in the DIVBUY model in Eastern Finland, where it was more likely that perceptions diverged from the objective classification compared to the rest of the country.

In the DIVBUY model the results indicated there to be significant differences in the probability of divergence across water body types. We found perceptions of sea water quality to diverge more often from the objective quality than other lakes and rivers. A possible reason for this is the local variability of sea water quality, combined with the fact that the objective water quality classification has a coarser spatial resolution on the coast than in inland waters, and thus local conditions may not be as well represented by the classification.

Both models showed that the better the objective water quality was in the adjacent water body, the more likely it was that people's perception of water quality was consistent with the objective measure. Poor and passable water usability classifications were associated with a more probable divergence between the subjective and objective assessments. These results would suggest that it is more difficult for individuals to assess low water quality accurately, or that the objective water quality classification does not conform to people's perceptions at the lower end of the scale.

Direction

In the second stage of the analysis we studied the direction of the divergence between the perceptions and the objective classification. More specifically, we applied the logit model to examine the probability of people underestimating the objective water quality, that is, the dependent variable takes value 1 if people have perceived the water quality lower than the objective measure. The results are shown in Table 9.

Table 9. Direction model results

Logistic regression, dependent variable: DIRECTBUY or DIRECTINF				
	DIRECTBUY		**DIRECTINF**	
	n = 379		n = 388	
	Coef.	Std error	Coef.	Std error
AGE	0.029**	0.012	0.049***	0.013
INCOME	-0.039	0.055	-0.040	0.053
EDUC	0.211	0.294	0.198	0.286
INSPECT	-0.492	0.580	1.066*	0.624
IMPSIZE	0.453	0.311	0.459	0.312
IMPQ	0.763***	0.278	-0.366	0.283
RATHERIMPQ	0.847**	0.386	-0.343	0.399
NOTVERYIMPQ	1.312**	0.539	0.084	0.595
NOTIMPQ	1.209*	0.674	0.253	0.738
ISLAND	-0.173	0.315	-0.124	0.330
EAST	-0.143	0.348	0.324	0.337
WEST	-0.442	0.340	-0.478	0.349
NORTH	1.029**	0.478	0.017	0.500
PROPSIZE	0.340	0.339	0.226	0.386
PROPRICE	0.001	0.003	0.003	0.003
PROPDIST	0.092	0.073	-0.019	0.068
SEA	-1.912***	0.391	-3.005***	0.541
RIVER	-1.398**	0.607	-1.583***	0.537
Constant	-1.713*	0.993	-3.388***	1.026
Log pseudolikelihood	-227.34		-212.57	
Wald χ^2	54.41		83.15	
Pseudo R^2	0.1343		0.2089	

Individual coefficients are significant at the *** 1%, ** 5% or *10% level

Of the respondent-related factors, income and education did not affect the direction of the divergence significantly. Taking into account the results from the divergence models, this would suggest that there is no systematic over- or underestimation according to these factors. Age, on the contrary, had a significant positive effect in both direction models, implying that people were more likely to underestimate the objective water quality the older they were. This may be due to older people being witness to significantly better water quality conditions than the younger generation at least in the sea coast areas, leading thus to higher points of comparison or quality standards. In the

DIRECTINF model there was a weak signal that people who had inspected water quality in some way at the time of purchase were more likely to underestimate the objective measurement at the time of the survey.

From the DIRECTBUY model results we can see that the importance of water quality as a purchasing criterion was highly significant in determining the underestimation of objective water quality. In comparison to those people who considered water quality a very important factor in purchasing decision, all other categories were found significantly positive, i.e. those who cared less for water quality tended to underestimate water quality.

In the DIRECTBUY model we found that for summer houses located in the Northern Finland, people were more likely to have a lower perceived water quality than the objective quality.

Both models showed that the water body type is a significant factor in determining the direction of divergence. For properties not located adjacent to a lake, there was a statistically significant propensity to overestimate water quality. This means that people were more likely to state better water quality for rivers and sea areas than the objective measurement suggests compared to those with lakeside properties.

Magnitude

In the last stage of the analysis we estimated what affected the size of the divergence between perceptions and the objective water quality classification using the ordered logit model. Most of the deviations were only one step away from the objective quality measurement, especially in the case of difference between the objective and perceived water quality at the time of the survey. Therefore we present only the model for the magnitude of perceived quality at the time of purchase (MAGNBUY). The results of the magnitude model are shown in Table 10.

The results suggest that older people were more likely to have a larger magnitude of divergence from the objective water quality measure at the time of purchase. Combined with earlier results, age did not bring about a larger probability for perceptions to diverge from the objective quality classification, but when there was a deviation, it tended to be generally an underestimation and the larger the older the person was.

Table 10. Magnitude model results

Ordered logistic regression, dependent variable: MAGNBUY		
	MAGNBUY	
	n = 379	
	Coef.	Std error
AGE	0.037**	0.019
INCOME	0.106	0.075
EDUC	-0.139	0.351
INSPECT	-0.855	0.599
IMPSIZE	-0.152	0.416
IMPQ	0.832**	0.395
RATHERIMPQ	0.720	0.540
NOTVERYIMPQ	1.282**	0.553
NOTIMPQ	1.529**	0.623
ISLAND	-0.236	0.469
EAST	-0.217	0.464
WEST	-0.527	0.458
NORTH	-0.657	0.655
PROPSIZE	-0.932**	0.409
PROPRICE	-0.004	0.004
PROPDIST	-0.114	0.132
SEA	-0.045	0.515
RIVER	0.840	0.578
DIRECTION	-0.407	0.315
Log pseudolikelihood	-152.30	
Wald χ^2	33.33	
Pseudo R^2	0.0967	

Individual coefficients are significant at the *** 1%, ** 5% or *10% level

Water quality importance in the purchasing decision had a significantly positive effect on the magnitude of the difference between perceptions and the objective water quality. Moreover, the probability of higher divergence increased the less important respondents considered water quality. This signifies that the interested parties are more likely to err less in assessing the water quality. The finding reveals that the importance of water quality to the study population should be studied in valuation studies. If the population is very polarized in their preferences for water quality it may produce a bias in the results. Based on the earlier models for quality at the time of purchase, while the quality importance does not forecast divergence between the measures, it may affect the direction of the divergence and, especially in the case of quality indifferent respondents, the magnitude of the difference.

Surprisingly, the size of the purchased property had a decreasing significant effect on the magnitude of divergence. Larger summer house lots tend to have more shoreline indicating more contact with water, which may be one reason for the decreasing effect in the size of the divergence.

5. Conclusions

Assessing the level of water quality is not necessarily an easy task for people, even though they have personal experience of the quality as summer house owners typically do. Roughly half of the surveyed respondents made a similar assessment of water quality as the objective general usability classification. There was a slight tendency for people to overestimate the objective water quality, but the magnitude of the divergence between perceived and objective quality was rather small as it was two or three water quality classes apart only in approximately 15% of the cases where divergence was found. Most differences between the subjective and objective quality were found for low levels of water quality, implying that people have most difficulties in assessing water quality that is below the average.

The results also showed that it matters how we elicit people's perception of water quality. The accuracy of evaluation was rather similar whether the subjective evaluation was the perception from the time of purchasing the summer house or the evaluation based on some years of experience using a water quality classification provided in the survey. Still there were differences between the models based on the two subjective measures, which are partly explained by the fact that the perceptions were made at different times. As such, our models explained better the differences at the time of purchase. Very surprisingly our models did not find the use of the water body, or being close to it for prolonged times, to affect the difference between subjective and objective quality in a significant manner. This could suggest the possibility that people form their perceptions of water quality very soon after initial contact, and are not likely to change that.

The results of this study provided slight signals that both subjective and objective water quality measures are possible in valuation studies, as many of the variables essential in valuation were not associated with the divergence of subjective and objective measures. However, from the perspective of stated preferences, particularly variables characterizing the level of water quality and the water body explained significantly the accuracy of subjective assessment. Low usability classification increased the probability of divergence between the perceived and objective water quality. This result implies that stated preference results based on subjective perceptions will differ from those using objective measures, particularly in the case of low water quality. Also, behavioural change deductions that are based on objective quality measures may be misleading. For the purpose of valuation this implies that people may not respond as expected to scenarios depicting poor initial water quality, or on the other hand, to scenarios presenting only small improvements when objective water quality indicators are used to frame the willingness to pay question.

The water quality assessment was also quite sensitive to the water body type, as overestimations of quality were more likely for respondents whose summer house resides adjacent to a river or a sea area. This may be due to the resolution of water quality maps being large for such water types, but it is also possible that for sea and river water quality people have slightly different perception of scale as to what is excellent water quality. As a further research topic it would be interesting to see if people have different scales for water quality depending on the type of water area, i.e. are the perceptual requirements for excellent lake water quality the same as for sea water or rivers.

Divergence was also increased by the distance to the summer house, which is in line with the previous literature (Brody 2004). In travel cost studies this might inflict uncertainty especially on the left part of the demand curve. From the point of view of hedonic pricing, the results were promising as the accuracy of evaluation was independent of the price of the summer house.

Beyond the variables of particular interest for valuation we found indications that subjective water quality perception was related to several individual-specific variables. This has importance in considering the heterogeneity of valuation results and equity issues. We found some evidence that higher income may decrease and higher education increase the probability of divergence. We also observed the age to be an important factor, such that the older generation appeared to underestimate the objective water quality more relative to younger people. The importance of water quality to the respondent also affected significantly the size and direction of the difference between the subjective perception and the objective water quality classification. The less respondents cared for water quality, the more likely they were to underestimate the objective water quality.

Previous research has shown that taking into account individual perceptions of water quality improve valuation results (Whitehead 2006). Our study pointed out some systematic dependence between the individual characteristics, environmental settings, and the accuracy of perceptions. The results emphasize the need to use individual perception particularly in cases where the environmental quality of the site differs considerably from the average quality in general. Also in situations where individuals are not very motivated to form a perception of environmental quality deserve particular attention if subjective perceptions are used in valuation.

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