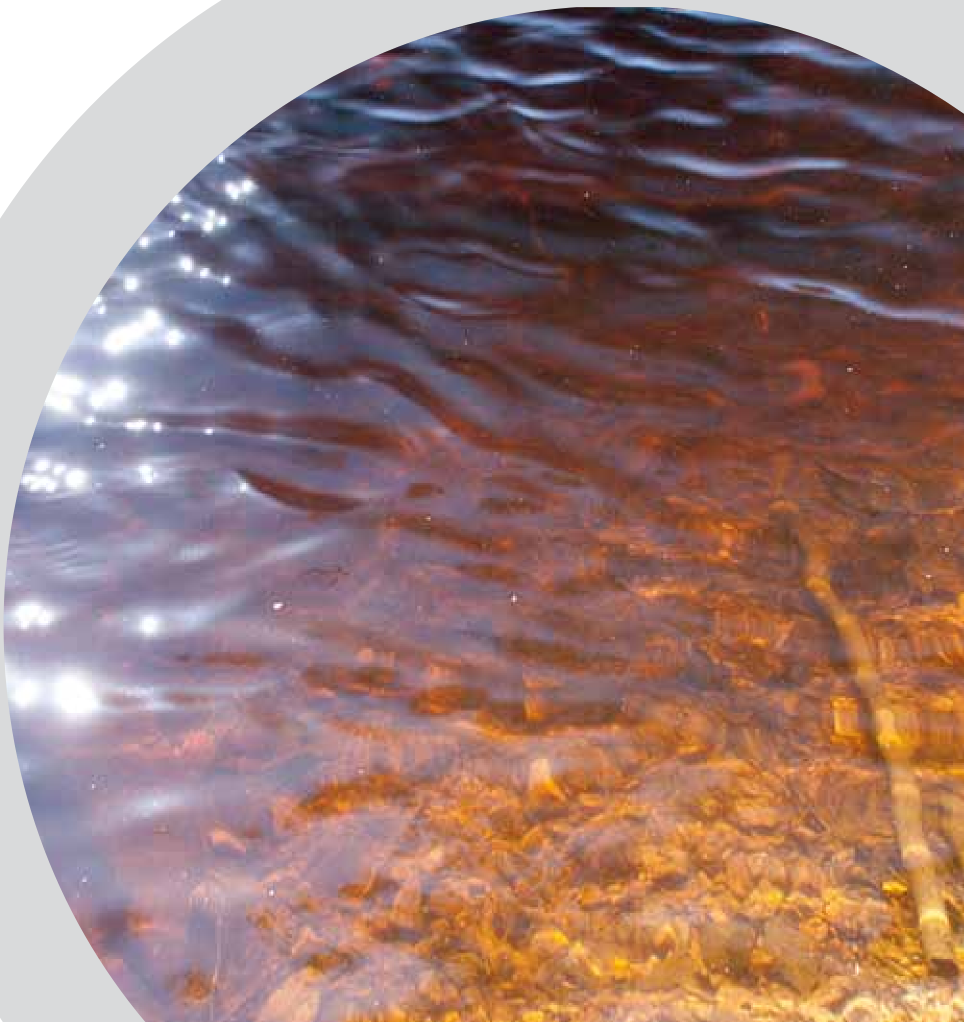
MTT SCIENCE 23

Recreation Value and Quality of Finnish Surface Waters

Revealed Preferences, Individual Perceptions and Spatial Issues

Doctoral Dissertation

Janne Artell



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Recreation Value and Quality of Finnish Surface Waters
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Abstract

Water recreation is an irreplaceable part of experiencing the aquatic environment, but is threatened by the eutrophication of inland and coastal waters. Time and resources are spent daily on visiting water recreation sites and long time investments are made on water recreation with purchases of recreation properties near water.

In this thesis the value of water recreation is studied through econometric analysis on actual market behavior. In the first stage, value for day-to-day local water recreation is estimated using the travel cost method. Water clarity is found to affect swimming and fishing activities significantly, while boating is less sensitive to deteriorated local water quality. A one-meter improvement in water clarity would, on average, increase local day-to-day recreation benefits from swimming from 31 to 92 million euros annually, and from 43 to 130 million euros for fishing activities.

In the second stage, the summer house markets are studied, representing a long term financial commitment to water recreation. The analysis employs data on unbuilt, waterfront summer house lots, where water quality is found capitalized in prices. Using a water usability index to describe quality, compared to the satisfactory quality category, good water quality lots have a price premium of 9 %. Excellent water quality lots have, on average, over 19 % higher prices than a lot at a satisfactory water body. Willingness to pay for water quality is found weakly non-linear. This implies that the protection of good quality water bodies is important, as the monetary losses from quality deterioration are larger than the benefits of improvement in general.

The final study in the thesis examines the difference between subjective perception and objective scientific measures of water quality. For policies to have the intended effect, it is important that quality measures by which policy is defined and the perceived quality are either similar, or that the policy maker understands what the differences between the two measures are. Using survey data we find that one half of summer house owners assess water quality in a similar fashion with the official water usability index. The other half perceives quality systematically different with slight overestimation. In the case of travel cost studies, objective recreation-focused water quality measures reflect perceptions better

when analyzing trips to nearby areas. For hedonic property pricing studies, price is not found to affect the probability of assessing quality differently. The result dissolves fears of causing econometric problems by the choice of quality measure.

This thesis brings out new information on water recreation values in Finland and Europe using observed market behavior. Further, the thesis describes how the perception of water quality differs between the policy maker and the consumer. The thesis finds Finnish people as avid users of water resources willing to pay for better water quality, both in terms of increased traveling and through higher property prices. Economic grounds are found for the protection of water quality with applicable results for the implementation of the EU's Water and Marine Strategy Framework Directives.

Key words:
environmental valuation, water recreation, travel cost method, hedonic pricing method, measured and observed water quality

Suomen pintavesien virkistysarvo ja laatu
– Paljastetut preferenssit, kansalaisten näkemykset ja spatiaaliset kysymykset

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Tiivistelmä

Vesissä virkistäytyminen on korvaamaton osa vesiluonnon tarjoamista kokemuksista. Virkistyskäyttöä kuitenkin uhkaa sisä- ja ulkovesien rehevöityminen. Virkistysalueilla käyntiin käytetään aikaa ja resursseja päivittäin, siinä missä loma-asuntojen hankinta vesistöjen läheltä edustaa pidemmän aikavälin investointeja.

Tämä väitös tutkii vesissä virkistäytymisen arvoa todellisen markkinakäyttäytymisen perusteella ekonometristen menetelmien keinoin. Ensi vaiheessa arvioidaan päivittäisen paikallisen vesissävirkistäytymisen arvoa matkakustannusmenetelmän avulla. Paikallinen veden kirkkaus vaikuttaa uinti- ja kalastamisaktiivisuuteen veneilijöiden ollessa vähemmän herkkiä vedenlaadun muutoksille. Näkösyvyyden kasvattaminen metrillä lisäisi päivittäisten uintikäyntien arvoa keskimäärin 31–92 miljoonalla eurolla vuosittain ja kalastuskäyntien arvoa 43–130 miljoonalla eurolla.

Toisessa vaiheessa tutkitaan kesämökkimarkkinoita, jotka edustavat pitkän aikavälin sitoutumista vesissä virkistäytymiseen. Analyysissa havaitaan vedenlaadun vaikuttavan rakentamattomien rantatonttien hintaan. Vedenlaatua kuvataan tutkimuksessa käyttökelpoisuusluokituksen avulla. Verrattuna tyydyttävän vedenlaatuluokan omaavaan rantatonttiin, hyvä vedenlaatu kasvattaisi tontin hintaa noin 9 %. Erinomaisen vedenlaadun omaava rantatontti on keskimäärin noin 19 % kalliimpi kuin tyydyttävän vedenlaadun tontti. Maksuhalukkuus vedenlaadusta havaitaan heikosti epälineaariseksi. Hyvässä kunnossa olevien vesialueiden suojelu on siten tärkeää laadun heikennysten tuottaessa suhteessa suuremmat haitat kuin hyödyt vastaavasta laadun parannuksesta.

Väitöksen viimeinen tutkimus arvioi eroavaisuuksia vedenlaadun subjektiivisessa havaitsemisessa ja objektiivisessa, tieteellisesti määritetyssä mittaristossa. Jotta vesipolitiikalla voitaisiin saavuttaa haluttu vaikutus on tärkeää että politiikantekijän käyttämä laatumittari vastaa havaittua laatumuutosta, tai että politiikantekijä ymmärtää mittarin ja havaintojen väliset eroavaisuudet. Kyselyaineisto paljastaa 50 % kesämökin omistajista arvioivan vedenlaadun samoin kuin virallinen käyttökelpoisuusluokitus. Muutoin vedenlaatu hieman yliarvioidaan. Matkakustannusmenetelmän osalta objektiiviset vesissä virkistäytymiseen keskittyvät vedenlaatumittarit kuvastavat koettua laatua paremmin,

mitä lähempänä vastaajaa olevaa aluetta arvioidaan. Kesämökin hinnan ei havaita vaikuttavan vastaajien tapaan arvioida vedenlaatua virallisesta mittarista poikkeavasti. Tämä tieto helpottaa hedonisten hintojen menetelmän soveltamista poistaen epäilyksiä menetelmän soveltuvuudesta arvottamiseen.

Tämä väitös tuo uutta tietoa veden virkistyskäytön arvosta Suomessa ja Euroopassa käyttäen hyväksi havaittua käyttäytymistä. Lisäksi väitös kuvaa kuinka politiikantekijän ja kuluttajan käsitys vedenlaadusta eroaa. Väitös kuvaa suomalaisia innokkaina vesialueiden virkistyskäyttäjinä jotka ovat valmiita maksamaan paremmasta vedenlaadusta mitattuna niin pidempinä matkoina kuin kalliimpina kiinteistöhintoina. Tutkimus löytää vedenlaadun suojeluun taloudellisia perusteita tulosten ollessa käytettävissä EU:n Vesipolitiikan puitedirektiivin ja Meristrategiadirektiivin toimeenpanossa.

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List of essays

The thesis is based on the following essays:

1. **Vesterinen (Artell), J., Pouta, E., Huhtala, A. & Neuvonen, M. 2010.** Impacts of changes in water quality on recreation behavior and benefits in Finland. Journal of Environmental Management 91(4): 984-994. doi:10.1016/j.jenvman.2009.12.005

2. **Artell, J. 2013.** Lots of Value? A Spatial Hedonic Approach to Water Quality Valuation. Journal of Environmental Planning and Management, forthcoming. doi:10.1080/09640568.2013.772504

3. **Artell, J., Ahtiainen, H. & Pouta, E. 2013.** Subjective vs. objective measures in the valuation of water quality. Journal of Environmental Management, 130 (in progress): 288-296. doi: 10.1016/j.jenvman.2013.09.007

Author's contribution

The research idea for the first essay was jointly developed by all authors. Janne Artell was responsible for the statistical analysis and the main body of the manuscript. Marjo Neuvonen jointly contributed with Janne Artell to the methods section. Eija Pouta and Anni Huhtala contributed to editing the manuscript. Janne Artell is the corresponding author of the essay.

The research idea for the third essay was jointly developed by all authors. Janne Artell was responsible for the statistical analysis and the main body of the manuscript. Eija Pouta and Heini Ahtiainen contributed to the literature overview and editing the manuscript. Janne Artell is the corresponding author of the essay.

List of abbreviations

CBA	cost-benefit analysis
CS	consumer surplus
CV	compensating variation
EV	equivalent variation
EU	European Union
GIS	geographic information system
HELCOM	Helsinki Commission
HP	hedonic pricing method
kNN	*k* nearest neighbors method
MCA	multi-criteria analysis
MSFD	Marine Strategy Framework Directive
PIVET	pintavesien tilan tietojärjestelmä (surface water status data system)
REC	Regional Environment Center
RP	revealed preference
SAR	spatial autoregressive model
SEM	spatial error model
SP	stated preference
TC	travel cost
WTA	willingness to accept
WTP	willingness to pay
WFD	Water Framework Directive

Contents

1 Background

1.1 Water recreation and its valuation

Water recreation is an irreplaceable part of experiencing the aquatic environment. Time and resources are spent to visit swimming beaches, make fishing trips, or to enjoy the water environment on a sailboat or other types of boats. These daily decisions are accompanied by even more tangible investments to water recreation – summer houses are purchased near water bodies to further enjoy the recreational possibilities offered. In these respects, Finns are especially active users of surface waters: swimming is the next most popular form of recreation after walking (Sievänen and Neuvonen 2011) and of the near half a million summer houses in Finland 85 % are estimated to lie within 100 meters from a water body (Nieminen 2010).

Finland's water areas cover 10 percent of the country, there is one lake per 26 citizens, and the Baltic Sea coastline is the longest of all the nine littoral countries. Furthermore, Finns enjoy *everyman's rights* that allow nature recreation with few restrictions anywhere in the country (Ministry of Environment 2007a). With such ample everyday water recreation opportunities in Finland, it is surprising that the recreational value of surface waters and their quality has been overlooked nationally. In the European context, scarcity, in the form of threatened water quality and availability, has caused pressure to consider the value of water through the economic perspective. The pressure has emerged in the European Union legislation, i.e. the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) (2000/60/EC and 2008/56/EC). These directives set ecological quality targets for surface water conditions stressing the economical and technical feasibility of reaching the set goals.

Costs of water quality improvements are typically estimable as the protection measures require investments with available market prices. The benefits from improved water quality, or conversely, the lost recreational and other benefits due to deteriorated water quality have no distinct market value and have thus been largely neglected in the earlier European scientific literature. The gaps in knowledge have driven new studies to assess the benefits of water protection. Most valuation studies on water protection benefits originate still from North America concentrating on relatively small study areas and, more often than not, *hot-spot* issues in terms of threatened or poor water quality (e.g. Michael et al. 1996 and 2000, Poor et al. 2001, Gibbs et al. 2002, Leggett and Bockstael 2000, and Poor et al. 2007). Hanley et al. (2006), Martin-Ortega and Berbel (2010) and Taylor and Longo (2010) are among the few European studies studying water quality value in relation to the WFD. Hanley et al. (2006) focus more on ecosystem values than recreation, Martin-Ortega and Berbel's (2010) study reflects a Southern European view of river water quality, and Taylor and Longo (2010) value reduced eutrophication in the Black Sea. All three valuation studies are based on choice-behavior of people under varying hypothetical scenarios, not actual behavior, and are conducted under distinctly different conditions and water areas typical to Northern Europe.

EU directives need to address diverse ecological settings across the Member States, thus a challenge has been to assess the value of water quality in the general European context. Generalization can be achieved by transferring values, or benefits, from prior valuation studies between similar sites using the benefit function transfer method, or assess the determinants of benefits using meta-analysis of multiple different valuation studies. Benefits transfer methods, however, typically suffer from severe transfer errors in values due to cultural and economic differences (Gibbs et al. 2002, Lindhjem and Navrud 2008, and especially Hanley et al. 2006 for benefits transfer in WFD).

The gap in the existing European primary valuation literature related to the Water Framework and Marine Strategy Framework Directives prevents conducting a comprehensive meta-analysis or benefits transfer that would take into account the diverse water conditions and recreation cultures within the EU. Conducting primary valuation studies at the national scale is thus urgently needed all around the Union to construct locally effective and meaningful water management plans. This thesis focuses on the water quality protection and water recreation in Northern Europe providing policy support with new primary valuation information and means to interpret earlier results using different quality indicators. I provide estimates of water recreation benefits under varying water quality conditions using information on actual behavioral patterns as has been called after by, for example, Sievänen and Pouta (2011).

Value of water quality is studied in this thesis by exploring short and long run water recreation market decisions using environmental valuation techniques designed to reveal consumers' preferences. Short run water recreation decisions are covered in this thesis using travel cost analysis to assess near-home water recreation value in relation to local water quality conditions. The study provides policy relevant information generalized to the national level on the extent of daily water recreation, its sensitivity to local water conditions and value estimates for a typical water recreation trip. Daily water recreation decisions are, however, limited by the location and water recreation possibilities in the proximity. Analyzing short run decision making only disregards values embedded into long run market decisions, such as property purchases near water recreation areas. In the long run consumers can decide their place of residence, and, in the Northern European context, the location of a summer house. To complement the estimated values of daily water recreation, this thesis also assesses the value of water quality capitalized into the prices of waterfront summer houses in Finland using the hedonic pricing method. Together, these values provide a national level overview of water recreation values that can be used in water management planning and as an example of Northern European water recreation value estimates.

The aims of this thesis are not limited to only providing value estimates. The thesis also explores how water quality indicators used in valuation studies correspond with public perceptions using statistical methods on a large scale survey data on summer house owners. If the public perception of water quality is different from the measures and indicators the policy maker and the researchers use, valuation studies, their results and henceforth policy recommendations will be affected. Thus exploring divergent public perceptions and objective water quality measures and its implications is important for both research and policy making. Finally, this thesis explores how existing databases can be used and combined for valuation work and what additional information is required. As many databases are collected by law, they present a tempting source of data for extensive national and even international scale environmental valuation, especially if they can be amended with information vital for valuation purposes.

1.2 Water protection in Finland

Each European country has unique water quality conditions and issues. Where some southern countries suffer from droughts, the surface waters of Finland are predominantly threatened by eutrophication. Eutrophication results from excessive nutrient concentration in waters. Depending on the balance and existing stock of nutrients in the receiving water body, an additional influx of phosphorus and nitrogen may cause uncontrollable growth of biomass, mainly in the form of algae. This in turn starts a chain of reactions leading to a shift in the ecosystem balance. The shift may include changes in dominant fish species, frequent algal blooming, decreased water clarity, and overgrowth of other vegetation at the cost of perennial underwater vegetation (see e.g. HELCOM 2009 and Kuikka 2010). These effects generally decrease the quality and recreation possibilities in surface waters. Coastal construction projects and regulation of water systems are other noteworthy pressures to water recreation possibilities, but are less pronounced on the national level.

While most lakes in Finland are already in either good or excellent ecological status, most rivers and large areas of the coastline fall below the target level. The majority of the national population lives near poorer water quality areas intensifying the effects and importance of improving (protecting) poor (good) water quality. Figure 1 shows the water quality in terms of recreational usability and ecological quality as measured by the Finnish Environmental Institute overlaid on population density figures in the regional level. The darker the shade of the area the more dense the population is in the region.

Water management legislation in Finland is based on the Act on Water Resources Management (1299/2004) and the Government Decree on Water Resources Management (1040/2006). In the *Guidelines to water protection by year 2015* (Ministry of the Environment 2007b), a third of its kind since the 1960's, the Finnish government has set the targets of water protection according to the WFD and national legislation. The guidelines consider the protection of Finnish surface waters, both inland and on the coast of the Baltic Sea, and ground water. The regional measures to attain the WFD target of good ecological status in all surface water by 2015 are controlled and planned by Regional Environment Centers (REC). The RECs must, by law (1299/2004), construct a management plan for their area of governance. These centers govern the seven mainland river basin districts the country has been divided into. Åland, as an autonomous region, governs the implementation of the directive at its own sea region. The aim is to stop and reduce eutrophication of inland and coastal water areas by 2015 (Ministry of the Environment 2007b). Other aims include decreasing threats by harmful substances to the ecosystem and health, stopping the deterioration of the water ecosystem, maintaining or improving ground water levels and quality, and resolving the harmful impacts of regulation and construction on recreation and the water ecosystem.

While the WFD and MSFD are the major drivers of water protection in Europe, Finland has close ties to the Baltic Sea, a marine area including Russia as the only non-member, and thus without harmonized water legislation, littoral state. The long coastline makes Finland an important stakeholder in Baltic Sea related issues, reflected in its activity in the Helsinki Commission, HELCOM. HELCOM works, among other things, to set internationally binding targets on nutrient load reductions to combat eutrophication in the Baltic Sea. The Baltic Sea Action Plan (HELCOM 2007) is an example of this international co-operation aiming to protect the Baltic Sea under four categories of action: eutrophication, hazardous substances, biodiversity and nature conservation, and maritime activities. The agreement was taken to Finnish water policy by a Finnish Government's decision-in-principle already in 2002 (Ministry of the Environment 2002).

Both the Water Framework Directive and the Marine Strategy Framework Directive require an assessment of benefits from improving water quality, or, conversely, the lost benefits due to inaction to design management policy. For example, the WFD introduces the concept of disproportionate costs of actions to return water bodies to their natural conditions requiring the assessment of benefits and costs, a feature also included in the Finnish Act on Water Resources Management (1299/2004). There are, however, also other ways environmental valuation is useful to policy makers.

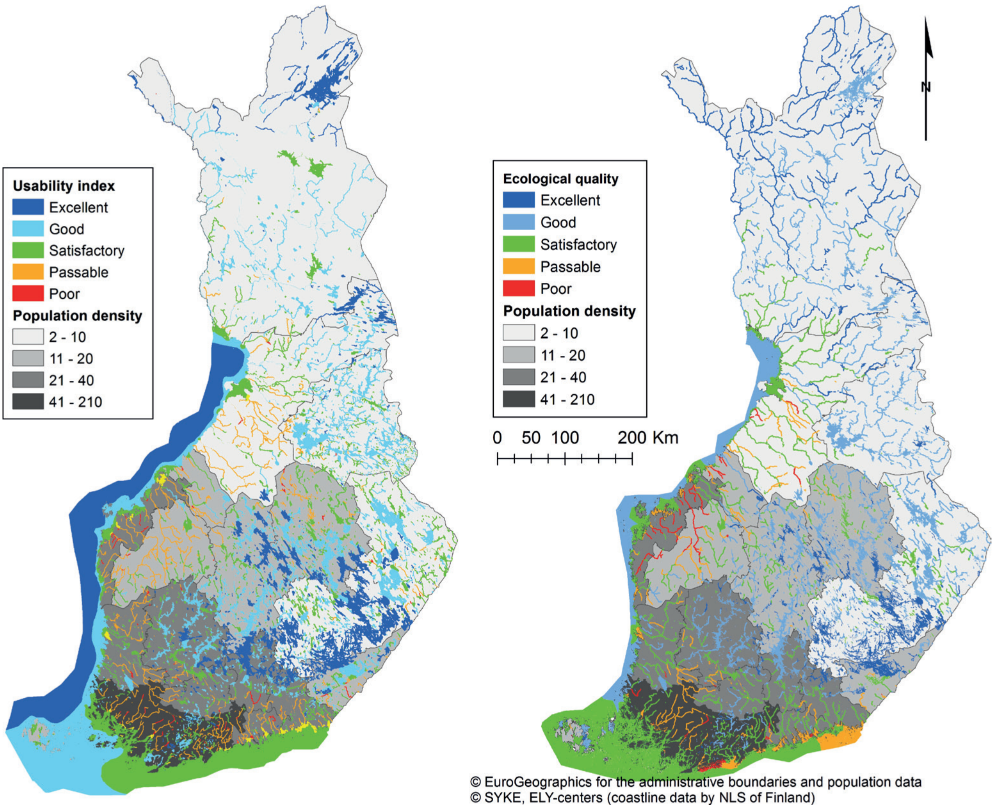

Figure 1. Water quality measured with a usability index (2000–2003) on the left panel and the ecological quality (2008) on the right panel and population density (2010) of Finland.

1.3 Environmental valuation as a policy support tool

Environmental valuation can provide support to policy-makers in numerous ways. An obvious case is the ex-ante or ex-post cost-benefit analysis (CBA) of projects or policies, which is also the most frequent use of valuation (Pearce and Seccombe-Hett 2000). Cost-benefit analysis allocates resources efficiently taking the cost and benefit structure of policies and projects explicitly into account. Local nature of benefits may yield a different recommendation on resource allocation than a process based purely on cost-effectiveness. Environmental valuation methods can be used to estimate the non-market values, i.e. benefits, of ecosystem services under pressure in the policy or project. Turner (2007) notes that CBA can be used either as a strict decision rule, as it is often considered, or as a part of a more holistic chain of effects from policy or project implementation. The latter refers to multi-criteria assessment methodology that uses CBA as one component among other, also non-monetary, effects related to the policy or project with different allocated weights, i.e. importance. An example of using multi-criteria analysis with environmental valuation information, including the results from this thesis, is found from Marttunen et al. (2012) that considers a holistic water protection planning of river Karvianjoki in Finland.

Environmental valuation can also provide cue to setting prices and taxes to consumers through creating markets for previously non-marketed goods and bads. Pearce and Seccombe-Hett (2000) note that national park entry fee pricing, among others, can be controlled through the estimation of travel demand to the site using environmental valuation methods. In fact, the travel cost method, discussed in section 2.3, was established to give answers to this exact question. Taxes, on the other hand, can be set to reflect the externalities caused by polluting human activities. The monetary effects of these externalities can be estimated with valuation methods (Pearce and Seccombe-Hett 2000). For example, there is literature on the statistical value of life (see e.g. a review by Viscusi and Aldy 2003) that could affect the taxing or limiting activities that pollute or are unsafe. Moreover, environmental valuation has been used for litigation purposes, of which the foremost example is the Exxon-Valdez damage assessment in 1992.

Environmental valuation methods can also identify attributes of an environmental amenity and policy choices that generate the most welfare to the public and, in some cases, provide a source of information to the public of the environmental issues under valuation (Pearce and Seccombe-Hett 2000).

While environmental valuation has many useful applications, uncertainties exist. Values are subject to change in time and the level economic welfare. They also vary in different cultures. Even the methods used for valuation are not infallible and researchers cannot determine if the results they acquire are exactly correct. These reasons beg to question, if policy makers should even try to use valuation studies in policy without accurate results. As a counter argument, to wait for exact results would be, as Freeman III (2003) puts it, "equivalent, in many cases, to never using cost-benefit analysis". He also reminds that if uncertainties can be assessed at some range, it provides certain cues for the policy maker: if the upper bound of attainable benefits is below the lower bound of costs, the project or policy is economically irrational, and *vice versa*.

An important source of uncertainty of results is produced not by valuation methods as such, but rather the description of the environmental good under valuation. Regardless of the valuation method, the description of the valued good and environmental pressures is vital for coherent research and results usable in policy design. The concept of water quality and assessment capabilities may differ between the layman and the policy planner. The layman relies on own senses and publicly available information on water quality, while the policy planner sets targets based on more detailed scientific information. For example, the WFD stresses the *good ecological status* of water bodies, which may be a very different concept to the layman's notion of good water quality. To prevent biased policy advice from valuation studies, it is thus paramount to understand the differences between officially used water quality measures and the individual subjective perceptions of water quality.

2 Valuing the environment – revealed preference methods

2.1 Economic value of environment

The valuation of environmental amenities stems from the need to give monetary value to non-market goods that have no market price by definition – in this case, water quality and its protection. Without quantifiable value and lack of clear ownership, private markets cannot price these goods, leading to market failure. Non-market goods typically exhibit properties of a *public good* to a varying degree, where a *pure public good* is non-excludable and non-rival. (Just et al. 2004).

In the context of this thesis, non-excludability means that anyone can enjoy water recreation and non-rivalry means that the recreational activities of an individual do not restrict others' recreational activities. Air is a common example of a public good exhibiting both conditions, whereas water recreation access is more bound, for example, by private land ownership even with everyman's rights and limited capacity of recreational sites.

Following Bateman et al. (2002) the total economic value of a good or service is a concept of economics that encompasses all values that can be measured in economical terms[1]. The total economic value is split into two main categories: use-values and non-use values. This thesis focuses on water recreation – a prime-example of an activity providing use-values. Use-values can be further categorized to direct use-value[2] and the option value. Direct use-value is a simple concept – activities in direct contact with water like swimming, fishing and boating provide a value to the fisher. Option-values come from potential to recreate in water, even if there is no current activity. These values can affect prices of marketed goods in touch with water recreation. For example, summer house owners purchase an option to freely recreate in the adjacent water body. The

[1] The *intrinsic value*, the value of existence *per se*, is immeasurable in monetary terms as a value independent of preferences.

[2] Indirect use-values have also been identified in the literature: Turner (1991) notes that these values relate to ecosystem services supporting and protecting economic activities.

value of that option is capitalized into the price of the summer house[3].

Use-values of water recreation can be identified by examining behavior in markets that, while not giving direct values to recreation, somehow reflect the opportunities for and quality of water recreation. Environmental economics employs methods called *revealed preference* methods (RP) that elicit preference ordering of individuals through market decisions (Bockstael and McConnell 2007). Certain types of market behavior data, such as property market and visitor data from popular recreation sites, are available from official records. Surveys are, however, often needed to supplement the non-specific data in those registries, or collect entirely new sets of data.

Non-use values can form a significant portion of the total economic value of an environmental good. Non-use values can be considered to carry an economic version of existence value, the fact alone that we know water bodies to exist in good status may bring individual utility (Bateman et al. 2002). Additionally, altruism and bequest values form a part of non-use value. An altruistic individual would, for example, value the benefits of good water recreation possibilities for other people in the current generation. Bequest value extends this value to the future generations' value of the amenity.

As the definitions and their examples show, non-use values are nigh impossible to observe through market behavior, directly or indirectly, and are thus most often elicited through specially designed surveys. In these surveys individuals are directly approached and their opinions and willingness-to-pay, the value, for an environmental amenity or a change in its quality are asked. The multiple methods using this type of direct approach in valuation are categorized as *stated preference* methods (SP).

While SP methods have been criticized for being subject to biases due to the hypothetical nature of valued scenarios and issues related to the comprehension of the surveys by respondents and survey design, they are currently the only methods able to capture non-use values (Brown 2003). In the case of water recreation, though, use-values likely prevail as the largest contributor to the total economic value due to the general proximity and high number of recreational possibilities offered by water areas. Furthermore, use-values are difficult to discern from non-use values in SP studies (Cummings and Harrison 1995). It is also important to contrast results from studies using actual behavior[4] in contrast with stated behavior. While these reasons make it important to study use-values separately, it must be kept in mind that the total economic value remains elusive with revealed preference methods.

2.2 Revealed preference and welfare measures

Revealed preference methods infer environmental values through the actual consumption decisions of consumers in markets that are in connection to the demand of the environmental good under assessment (Flores 2003). For revealed preference analysis market values must, thus, either reflect the value of the

[3] Just et al. (2004) note that option value is not a well-defined measure of welfare change. In the context of summer house markets, however, the market mechanism capitalizes the value of all forms of water recreation into the property price regardless the preferences of an individual buyer. This setting is very different from the option value of witnessing a live polar bear in its natural habitat before the habitat is destroyed.

[4] RP methods are not entirely free of survey bias, as they often employ survey data.

environmental good (e.g. travel costs to a water recreation site), or be considered to have the environmental value embedded into the market value of a good (e.g. water quality effect on adjacent property prices).

Values estimated using revealed preference methods have several remarks. One, the values are elicited through real market behavior giving tangible evidence for willingness to pay for an environmental good. Two, the valued goods must have accompanying markets or human activities with cost-information for analysis. Three, the values estimated using RP methods can only assess use-values and thus do not represent the total economic value of the environmental good.

Value estimates based on actual behavior provide an important point of comparison to valuation studies using hypothetical markets, i.e. stated preference methods. This thesis applies two different valuation approaches to valuing water quality effects on water recreation. These approaches, namely the travel cost method (TC) and the hedonic pricing method (HP), their underlying theory, and their recent applications to water quality issues are introduced in sections 2.3 and 2.4.

Consumer surplus (CS), compensating variation (CV) and equivalent variation (EV) are three measures used to describe changes in welfare due to a change in environmental quality. In the context of this thesis, each measure depend on revealing the demand for water quality. Consumer surplus is the most popularly used welfare measure, mainly because it does not require the estimation of unobservable Hicksian demand functions. The compensating variation and equivalent variation measures[5] give the income adjustment needed to keep the utility level constant after a change in water quality, i.e. a movement along a Hicksian demand curve. The consumer surplus is, in contrast, based on movements along and shifts[6] of the Marshallian demand curve holding income, not utility, constant.

The Hicksian compensating variation for improved water quality, q_1, (q_0 for the current water quality) is defined using the indirect utility function as

$$v(p, q_0, y) = v(p, q_1, y - CV), \qquad (1)$$

while the Hicksian equivalent variation can be defined as

$$v(p, q_1, y) = v(p, q_0, y + EV), \qquad (2)$$

where p represents current prices and y current income (Bockstael and McConnell 2007). The compensating variation looks at the value of environmental change from the initial utility level, whereas the equivalent variation is defined using the utility level after the environmental change. For a water quality improvement the compensating variation can be considered as the willingness to pay (WTP) for the improvement, while the equivalent variation is considered as the willingness to accept (WTA) additional income to forego the improvement. If the marginal utility

[5] Bockstael and McConnell (2007) note that compensating variation, and thus also equivalent variation do not represent a pure welfare change as they are tied not to utility *per se*, but to a numéraire good. The numéraire is typically money for the sake of convenience. Changing the numéraire to another type of good could produce very different welfare change estimates since the marginal of utility of money can differ between individuals. The assumption is far from harmless, but as utility is immeasurable, it is one that economists have to recognize and accept in their analysis.

[6] The consumer surplus grows or shrinks *along* the Marshallian demand when the price of the environmental good changes. A shift in the Marshallian demand occurs if income, preferences or the quality of the environmental good changes. In this case the consumer surplus shrinks if the demand decreases and vice versa.

of income is negligible, or the change in water quality is small, both the WTP and WTA measures are equal. More so, for the consumer surplus to represent welfare changes accurately requires small changes in water quality or special conditions. Under these conditions the consumer surplus welfare measure is bounded by compensating variation from below and equivalent variation from above.

Bockstael and McConnell (2007) remind that assessing CV and EV as exact welfare measures requires two critical assumptions: non-essentiality and weak complementarity. Non-essentiality means that the area under the demand curve is finite, i.e. a choke-price that quenches the demand to zero exists. This is a feasible assumption for water recreation, as it is not vital for survival. Mäler (1974) introduced the notion of weak complementarity, a restriction stating that for unused goods there is no value to the consumer in improving the quality of the good. In terms of water quality and recreation, this would mean that a water quality improvement on the coast would not affect the recreation behavior of those visiting only inland lakes.

2.3 Travel cost method

The travel cost method was established in 1947 when Harold Hotelling proposed a way to indirectly measure the demand for a non-market good to the National Park Service (Arrow and Lehmann 2005). His idea was simple – the costs undergone to reach a national park, in the form of entrance fees and actual travel costs would reflect, at a minimum, the benefits from visiting the site. By constructing a demand curve from visitor data would then allow to compute the consumer surplus to visit the site.

As an environmental valuation method, the travel cost method has been extensively used in the United States to value multiple different types of environmental services. Ward and Beal (2000) list TC studies valuing a wide array of environmental issues including, but not limited to, wildlife, prevention of natural disasters, outdoor recreation facilities and forests.

Phaneuf and Smith (2005), Hanley et al. (2003) and Ward and Beal (2000) provide a good overview of the history of the travel cost method. Initially, analysis was built on recreation data collected by identifying the home region (zone) of visitors by the license plates of their cars (Hanley et al. 2003). Then the travel costs from the respective zones were calculated and aggregate population figures were used in the analysis. The work by Clawson and Knetsch (1966) was an important stepping stone for the method, as they constructed a demand curve for a recreational site using the zonal approach (Ward and Beal 2000). In the 1970's the research shifted from zonal aggregates to individual specific data rather as the traditional approach had problematic statistical issues (Hanley et al. 2003). With survey-collected individual data it was possible to look into the value of time spent travelling and on-site, but also improve zonal travel cost analysis considerably (Loomis et al. 2009). Newer approaches in travel cost studies employ models that further explore factors explaining, for example, site choice under varying environmental conditions. A increasingly popular variant of travel cost method uses stated preferences, i.e. contingent behavior modeling to determine hypothetical quality improvements (see e.g. Whitehead et al. 2000 and Whitehead 2005). These approaches are, however, difficult to conduct in a national scale with abundant water resources as the data requirements are heavy and require details on consumer behavior unavailable without extensive surveys.

Time and its value are an important aspect of travel cost analysis. The household production function formalized by

Becker (1965) models consumption limited by a fundamental resource – time. Households balance their time between income generating activities, i.e. work, and production of goods. Goods are produced by combining time and resources. By including time as a fuel to consumption, the framework allows the analysis of the values of both marketed and non-marketed resources. For example, a trip to a beach involves an opportunity cost in terms of lost time for other consumption and work in addition to other travel-related costs.

The recent water quality related travel cost literature uses often random utility models to explain site choices under varying water quality conditions. Such analysis has been typically conducted in the United States. When modeling site choice, the researchers model the choice of an actually visited site over other possible substitute sites. In the case of Egan et al. (2009) the researchers considered all of the 129 principal lakes in Iowa as substitutes to each other. Considering all sites as substitutes is less arbitrary than choosing a smaller subset of sites, either based on a random pick or proximity to the visited site, but computationally heavier. For example, Needelman and Kealy (1995) used a random subset of 19 lakes out of 500 possible sites in their analysis. Another site choice study related to water quality is by Parsons et al. (2003). It is obvious that data requirements to analyze site choice can be massive in a national scale, especially in a country where there are literally hundreds of thousands of lakes. As the site choice models require special information on visited places, gathering extensive data on such behavior can be expensive. Data for travel cost methods can come in many forms, however. National recreation inventories, i.e. surveys on citizens' recreational activities in nature may provide a cheap and extensive database for travel cost analysis.

European travel cost studies on water recreation and water quality have been conducted mostly to Swedish marine areas. Soutukorva (2005) and Sandström (1996) are the few examples found from gray literature. Of these studies Sandström made an interesting approach to making the value estimates comparable with costs. The important link between the values and costs was done by modeling water clarity, which served as a proxy for water quality, by nutrient levels in the water. Such links are very important for policy analysis, since they provide tangible value results and applicable policy recommendations.

The demand for water recreation in relation to travel costs is estimated using econometric methods. I will next introduce a basic travel cost model for estimating the value of visits to a single representative site which is the most relevant model family to the one used in this thesis. Single-site models are typically used to estimate the total (recreational) value of a site, measured by consumer surplus (Parsons 2003). In figure 2, the average consumer surplus is the area below the estimated (Marshallian) demand curve[7] for water recreation, $f(tc, x)$, and above the average travel cost to the site, p_0. At price p_{choke}, the trip demand, N, is quenched to zero, satisfying the non-essentiality requirement introduced earlier. It should be noted that a traditional single-site model cannot estimate values for changes in water quality due to lack of quality variation needed in statistical analysis[8]. Multi-site models follow typically two veins, the hedonic travel cost and random utility modeling approaches. These models and their basis on the utility theory are well described in Pendleton and Mendelsohn (2000).

[7] See Haab and McConnell (2002) for a derivation of travel demand using the household production function approach.

[8] See section 3.1 'The travel cost method – Data and econometric estimation' on how the issue is worked around in this thesis.

Parsons (2003) goes over the stages in building a single-site travel cost model and gathering information on determinants that affect the demand. In its simplest format the demand or the number of trips, *N*, depends only on the costs, *tc*, of visiting the site. Other demand-determinants, vector *x*, used in single-site models are typically individual socio-demographic attributes and travel costs to a substitute site. As a regression function with standard normal distributed error term, ε, this model can be presented as

$$N = f\,(tc, x) + \varepsilon. \qquad (3)$$

Even though the travel cost method is based on actual behavior, the researcher is often forced to estimate or use average measures for travel costs as actual travel costs are rarely available. In these cases the researcher can affect the estimated welfare effects drastically (Randall 1994). Parsons (2003) suggests using figures from well reputed sources for car travel, while others have used surveys to elicit more accurate travel cost data straight from the study population (e.g. Ovaskainen et al. 2012 and Hagerty and Moeltner 2005). The weakness in using cost estimates by the study population is that they may not assess the travel costs to the full extent, i.e. the demand function will estimate the value smaller than actual costs would indicate. As the researcher has less control on perceived costs, double-counting may occur when, for example, adding travel time-related costs to the model.

Multi-purpose traveling poses also challenges to the researcher. The longer the travel distance and time spent at the site, the more important it is to understand what portion of the time is sacrificed for travel and which part of the time spent traveling produces utility to the consumer. For example a scenic route choice or visiting relatives en route to the final destination may produce additional utility that should be taken into account in the travel cost analysis. Ignoring such effects will cause overestimations of value to the site under valuation. Due to the inherent difficulties related to these issues, there is a wide literature discussing the effect of time on recreation and the "correct" value of time used in the analysis (Ward and Beal 2000).

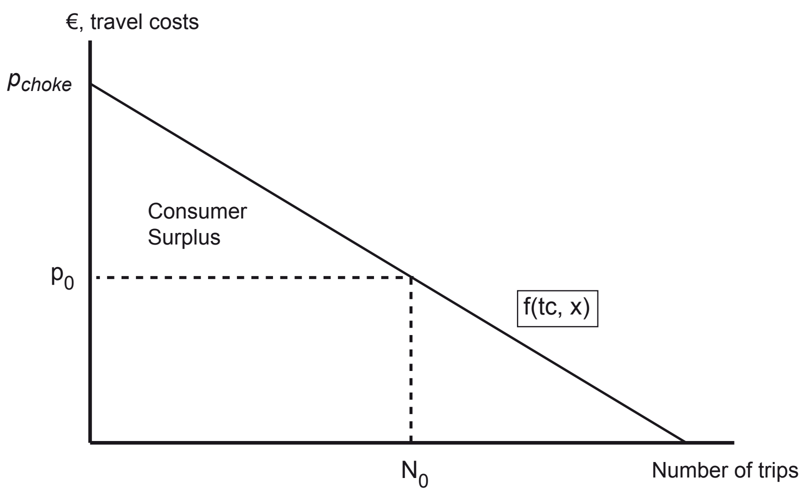

Figure 2. Consumer surplus measure and water recreation trip demand.

In the econometric analysis the functional form of recreation demand is not trivial. Unbiased estimation of environmental values requires the econometric model to reflect the actual demand. The distribution of recreation trip frequency is often skewed so that most individuals have a near-zero-frequency[9] of trips, while the right hand tail of the distribution stretches far. In other words, most individuals make only a few, if any recreation trips, while a scarce number of active individuals make a large number of trips. In addition, the number of trips is discrete and positive by nature. Using an ordinary least squares estimator would not reflect these special characteristics of recreation demand. An option is to use a zero-truncated count-data model for the analysis (Englin and Shonkwiler 1995, Cameron and Trivedi 1998). Poisson distribution is a natural candidate for such estimation, but requires the equality of the mean and variance of the trip frequency distribution. The more general negative binomial distribution, which includes the Poisson distribution as a special case, can be used if the restriction does not hold.

The travel cost method can be used to value only specific visits to a recreation site. The method does not take fully into account the values of consumers who have purchased a property nearby or even adjacent to the recreation site to enjoy it more frequently (Parsons 2003). To complete the picture of the use-value of water recreation, we can employ the hedonic pricing method to assess the recreational values capitalized into properties near recreation sites.

[9] If the travel cost survey is made on-site, the visiting frequency distribution will have only positive values, whereas a survey directed to the general population will have also non-visitors, i.e. zeros in the distribution.

2.4 Hedonic pricing method

The underlying idea of the hedonic pricing method is simple: marketed goods comprise of a bundle of attributes that each contribute to the market value of the good. Thus, comparing market goods with differing attribute levels of the valued good provides an indication of the value of the environmental attribute capitalized into the market prices. The method has long roots reaching to the work by Court (1939), Griliches (1961), and Lancaster (1966) who studied quality variation and consumer behavior (Bishop and Timmins 2011). It was not, however, until the work of Rosen (1974) when the theoretical framework to assess hedonic prices was established (Bockstael and McConnell 2007). Rosen proposed a two-stage approach to construct separate demand functions for each valued attribute of the marketed good. In the first stage an implicit price for a quality attribute can be assessed. The implicit price reflects the value of a marginal change in the quantity or quality of the valued attribute. Attribute-specific demand functions constructed in the second stage are ideal for situations where a non-marginal change in the level of the attribute is assessed. The second stage analysis has not been, however, popular due to difficulties in analysis. Bartik's (1988) results provide some help by providing bounds to the value-estimates so that the first-stage implicit price estimates (e.g. for better water quality) serve as an upper bound to the actual benefits. Even though the hedonic pricing method has been under constant theoretical and empirical development, few hedonic property price studies address issues related to second-stage demand curve estimation. Most empirical studies have thus settled with first-stage analysis (Bishop and Timmins 2011, Bockstael and McConnell 2007).

While the hedonic pricing method is a standard tool to value non-market goods, there are relatively few applications on water quality. Bockstael and McConnell (2007) and Phaneuf et al. (2008) suspect the lack of quality variation in market areas to deter research possibilities in many areas. Thus far there have been no published European studies using hedonic pricing on water quality and recreational values. Prior literature has focused to United States with most studies conducted in the East Coast (e.g. Boyle et al. 1999; Leggett and Bockstael 2000; Michael et al. 2000; Poor et al. 2001; Boyle et al. 2001; Gibbs et al. 2002; Phaneuf et al. 2008).

The omitted variables problem is exacerbated in hedonic pricing analysis. Variables unknown by the researcher, like neighborhood reputation, but correlated with variables used in analysis, such as available services, cause biased estimates of implicit prices (Bockstael and McConnell 2007). Thus it is very important to have as much information on the valued good as possible. An oft overlooked factor is, surprisingly, the location of a property and its neighborhood attributes. In addition to the actual location of the property, the neighboring properties may also interact. Prices may spill over, i.e. prices in a neighborhood tend to be similar. Furthermore, neighboring properties may exhibit similar price-affecting attributes unknown to the researcher. Exploring spatial effects in hedonic analysis is thus important to avoid biased results. (LeSage and Pace 2009.)

Despite its importance, the hedonic pricing literature on water quality has not actively applied spatial econometric methods. Leggett and Bockstael (2000) have thus far produced the only published article on water related hedonic pricing with a spatial approach. Spatial hedonic modeling has been, however, employed in other types of environmental problems, e.g. wildfire risks (Donovan et al. 2007) and air quality (Kim et al. 2003).

Rosen's (1974) theoretical framework of property prices models both the consumer and producer side. While Rosen's work enables a dynamic analysis of the markets, the typical hedonic pricing application assumes that the supply of properties is fixed in the short term. Following Bockstael and McConnell (2007), the consumer's utility maximization problem can be expressed as

$$\max u(z, a; \delta) \text{ s.t. } y = z + P(a), \qquad (4)$$

where consumer's utility, u, is a function of z, the numéraire good, whose price is set to one, and a, the vector of attributes of the purchased property (e.g. adjacent water quality, lot area, location), with given individual preferences, δ. Utility maximization is restricted by income, y, that can be spent on the numéraire good and a bundle of property attributes, whose price is reflected by the function $P(a)$, the hedonic price function. The hedonic price function is like a menu of attributes that affect the price of the property. In short run the menu is constrained by the existing supply – not all combinations of attributes are available, so the consumers maximize their utility under a restricted set of goods.

The hedonic price function itself is an envelope of individual bid and offer functions (figure 3). The bid functions describe the maximum willingness to pay for a single attribute q, (e.g. water quality) for a property with a set bundle of attributes, a, keeping other things equal (e.g. the utility level, u, income, y, and individual preferences, δ) (Rosen 1974, Bockstael and McConnell 2007). The offer curve represents the profit maximizing supply curve for q, keeping profits and the supply of other attributes, a_{-q}, equal (Champ et al. 2003). The hedonic price function for q, $P(q|a_{-q})$, connects the locuses (equilibriums) of the bid and offer functions for water quality, *ceteris paribus* (Rosen 1974, Champ et al. 2003)

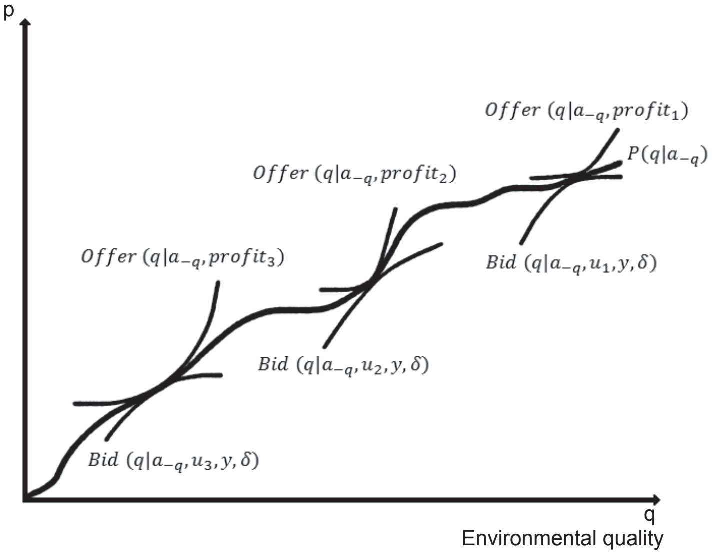

Figure 3. Hedonic price function formation as an envelope of supply (offer curves) and demand (bid curves).

representing market clearing price and attribute level combinations. Changes in tastes, income, and the supply of attributes affect the shape of the hedonic price function (Bockstael and McConnell 2007). Being an envelope of bid and offer curves of multiple attributes, the hedonic price function is not restricted to have a "well behaved and pretty" functional form. These properties have effects on the welfare analysis using the hedonic pricing method.

Extracting demand functions for price-affecting attributes with the hedonic pricing method has two stages: identification of the hedonic price function and the demand function formation based on the first stage analysis. Implicit prices for an attribute are estimated as the first derivatives of the hedonic price function. These prices can be thought as spot prices holding everything else constant. Estimating the hedonic price function requires the researcher to identify the price affecting attributes and estimate the function. Separating the bundle a of price affecting attributes further to a vector of attributes related to the lot, $\boldsymbol{X}$, e.g. area and land cover type, vector of location related attributes, $\boldsymbol{L}$, such as distance from local services and population centers, and water quality, q, in the adjacent water body, the hedonic price function, P, for an unbuilt lot can be constructed as:

$$P = \beta \boldsymbol{X} + \tau \boldsymbol{L} + \eta q. \qquad (5)$$

Variables β and τ represent the vectors of unit prices[10] for the lot and location related attributes, respectively. Variable η represents the unit price for water quality.

As the hedonic price function is an envelope function, there is no single functional form for its description. In practice one should not assume a linear as in the above example, though. Linear hedonic price function would imply constant marginal prices enabling *complete repackaging*, which means that consumers would be able to

[10] The unit prices are unlikely independent of purchased number of units and may have interdependencies. The linear form used here is for simple exposition.

pick any kind of bundle of attributes from the market irrespective of having such a bundle within the realms of possibility (Taylor 2003). A popular alternative is to use a logarithm-transformation of property prices.

Estimating exact welfare measures requires demand functions. Rosen's (1974) hedonic framework suggests identifying the individual attribute demands after estimating the hedonic price function. This is done by modeling observed water quality varies against its estimated implicit price from the first stage. The individual demands are, however, endogenous, as the hedonic price function is not linear in parameters (Bockstael and McConnell 2007, Epple 1987). Another issue is the need of socio-demographic data to recover demand curves – property sales data rarely carry such detailed information.

For changes in water quality that are non-localized, such as the requirements by the WFD (i.e. good ecological status in all surface waters by 2015) Bockstael and McConnell (2007) remind that exact welfare measure change is not obvious. There is no way to know how much a demand function would shift for water quality in the case of a market-wide improvement. Bartik's (1988) reasoning suggests though, that an estimated change in implicit prices due to a change in water quality is a lower bound estimate of compensating variation, so that quality deterioration losses are overestimated and improvement benefits underestimated.

The spatial interactions and similarities between neighboring properties are a source of model misspecification and biases due to omitted variables if not taken into account. Property prices can be spatially dependent if prices reflect the price-levels of the area and neighboring properties may share an attribute not captured by the researcher but affecting the error term in the analysis (LeSage and Pace 2009). The spatial econometric models used in this thesis are covered in section 3.2.

3 Applied research data and methods

3.1 Travel cost method – Data and econometric estimation

Essay I of this thesis employs the travel cost method to assess the value of water recreation and water quality using information from a non-specifically valuation oriented nature recreation survey and official water quality data. The method presented in this research provides means for countries with similar data sources to replicate the analysis with speed and low costs.

The data providing travel cost information comes from a survey to the Finnish national outdoor recreation demand and supply inventory (Sievänen et al. 2001). The survey was conducted in two stages between 1998 and 2000, where the initial stage included telephone interviews of approximately 10 000 respondents representing the whole mainland Finland. A subsequent in-depth paper survey on nature recreation was sent to near 5 500 voluntary respondents from the initial stage. The in-depth survey elicited recreation information of a wide variety of recreation in natural conditions, including natural water formations. Essay I employs information on three typical water recreation activities: swimming, fishing, and boating.

The data available from the survey, explained in depth in Essay I, molded the analysis to be constructed in two stages: modeling participation probability and recreation frequency for the individual's home municipality with respect to municipal average water quality in stage 1, and estimating the value for a typical day of near-home water recreation in stage 2.

The stage 1 analysis was supplemented using geographic information system (GIS) techniques with additional information of the average water quality from the Finnish Environmental Institute's Finland's Surface Waters (PIVET) database for the study time period. Water quality was presented by the average water clarity measure in the municipality's surface water areas. The choice of water clarity was based on previous literature (e.g. Sandström 1996 and Soutukorva 2005 for travel cost method, and Boyle and Taylor 2001 for the hedonic pricing method) where the concern was to use a quality measure that a layman would easily recognize and understand.

Stage 1 analyzed how local average water quality affects, day-to-day water recreation participation rates and frequency. As Finland has an abundance of water recreation sites and available recreation data cannot identify visited places or possible substitute sites at a national scale, the local quality averaging approach provides a reasonable way to assess quality effects to general water recreation frequency. From the econometric model families, the hurdle model combination with a binary logit model for participation probability and a negative binomial model for count data on recreation frequencies was found most suitable (Cameron and Trivedi 1998).

Remembering the discussion in section 2.2, the weak complementarity assumption requires consumers to be indifferent to quality changes at a non-visited site, which seems to contradict the choice to model also participation probability due to quality changes. However, Bockstael and McConnell (1993) note that a discrete improvement in quality may cause an individual to change behavior as the context in which utility is maximized has changed. Moreover, as those who recreate and those who do not, likely originate from different sub-populations, we cannot assume that one model alone could explain the variation of both participation and trip frequency due to a change in water quality.

The actual valuation of a typical water recreation day at a representative site was conducted in stage 2. The analysis employed information from the most recent water recreation trip, including information on how many identical trips the individual had conducted in the past year. Here the weakness of the wide focus of the survey was imminent: as the survey elicited information of the most recent nature recreation trip, including walking in the nature, winter activities and so on, a relatively small number of water recreation trips were available for analysis. Thus the three water recreation activities were pooled and a value for a typical water recreation day was estimated using negative binomial count data model. Four travel cost models were constructed with different travel cost estimates – both the travel costs estimated by the researcher, and those reported by respondents were used with and without the opportunity cost of time.

As discussed in section 2.3, the role of chosen travel costs can affect the results drastically. In addition to researcher specified distance-based cost and a value for travel time, we employed a cost-measure specified by the survey respondents to provide a contrast to the researcher's view of costs.

3.2 Hedonic pricing method – Data and econometric estimation

The hedonic property pricing study, Essay II, of this thesis assesses price effects of water quality capitalized into summer house prices in Finland. As the data requirements for a national scale hedonic assessment are high – the hedonic pricing method requires information on all relevant price affecting attributes for unbiased results – I use data on unbuilt summer house lots. These properties have far fewer price affecting attributes compared to the built counterpart, and this data is often available from the official records. In addition, spatial information for these properties is also available, providing possibilities to conduct spatial analysis. These conditions assure that problems related to omitted variables and subsequent biases are more diminished in this setting than in the analysis of built properties.

The real estate market price information originates from the official Purchase Price Register maintained by the National Land Survey of Finland. There were approximately 6 000 private market sales of single waterfront summer house properties in Finland in 2004. Unbuilt lots account for some 43 % of these sales, which contributed the cross-section data used for analysis in Essay II. The large share of unbuilt lots suggests that there are still ample opportunities to build new summer houses. As the data is, however, a cross-section of the market, it cannot be confirmed that the newly introduced lots present the existing stock of lots, built or unbuilt. The expectation would be that the best spots have already been purchased, and that poorer quality areas open up for sales later on. Compared with sales of built properties in 2004, the lot specific attributes do not differ markedly suggesting that the supply of land suitable for good summer house location does not yet suffer from sales of *the runts of the litter*. The same phenomenon can also be witnessed in relation in terms of water usability. Figure 4 shows the spatial location of the sales used in Essay II in relation to the water quality index used in the hedonic analysis. It is evident that the spatial distribution of unbuilt lot sales is diverse and not concentrated on poorer quality areas.

The water quality index shown in figure 4 is based on the Finnish Environment Institute's (2004) general usability classification from the time period between 2000 and 2003. The usability classification's aims are to provide information on the average suitability of surface water areas for different types of recreation and supply of potable sweet water in five categories, from poor to excellent. Usability is expert determined, but has guidelines and a mathematical model behind the grading (Vuoristo 1998). Several measures including chemicals, nutrients, biomass, and more visible indicators of water quality, like water clarity, are considered in the quality index. The lowest categories, poor and passable, are given to water areas where recreation possibilities are severely restricted. Satisfactory classification is given to waters with generally suitable conditions for recreation, with slight algal blooming or other nuisances. The good and the excellent categories imply no restrictions for recreational use and the water body is in, or near, the natural state. The classification pre-dates the ecological water quality scale required by the WFD but is similar in many senses.

The location data included in the property sales data enabled not only the addition of the water usability index data to the analysis, but also further spatial exploration of the data. For the spatial econometric approach a meaningful neighborhood set was needed. Parametric spatial econometric models require the researcher to determine a neighborhood set, a weighting matrix that assigns properties as neighbors, that is assumed to correspond to the real-world sphere-of-effect of the observations. Property sales are typically recorded in point-data format, meaning that the sale's location is shown as a point in a map. Creating a neighborhood set for point-data mainly falls into two categories, distance-based and *k* nearest neighbor sets. Distance-based methods use a metric to determine an area around each observation where its neighbors are located. The metric is not limited to physical distance; network distance or travel time distance are also viable alternatives (Scott and Janikas 2010). The *k* nearest neighbors (kNN) method, however, limits neighbors to a predetermined number regardless of distance. Using kNN method can prove valuable when the spatial agglomeration of, for example, summer house lots in Essay II will depend on the macro-location of the observation. In areas with high numbers of observations, e.g. Southern Finland, the intensity of spatial dependency can be attributed to a smaller area compared to areas with sparse observations, e.g. Northern Finland. Conversely, in a distance-based neighborhood set, ensuring that each observation has at least one neighbor may lead to using so large distances that in areas with many observations smaller nuances of spatial effects can be overlooked as the

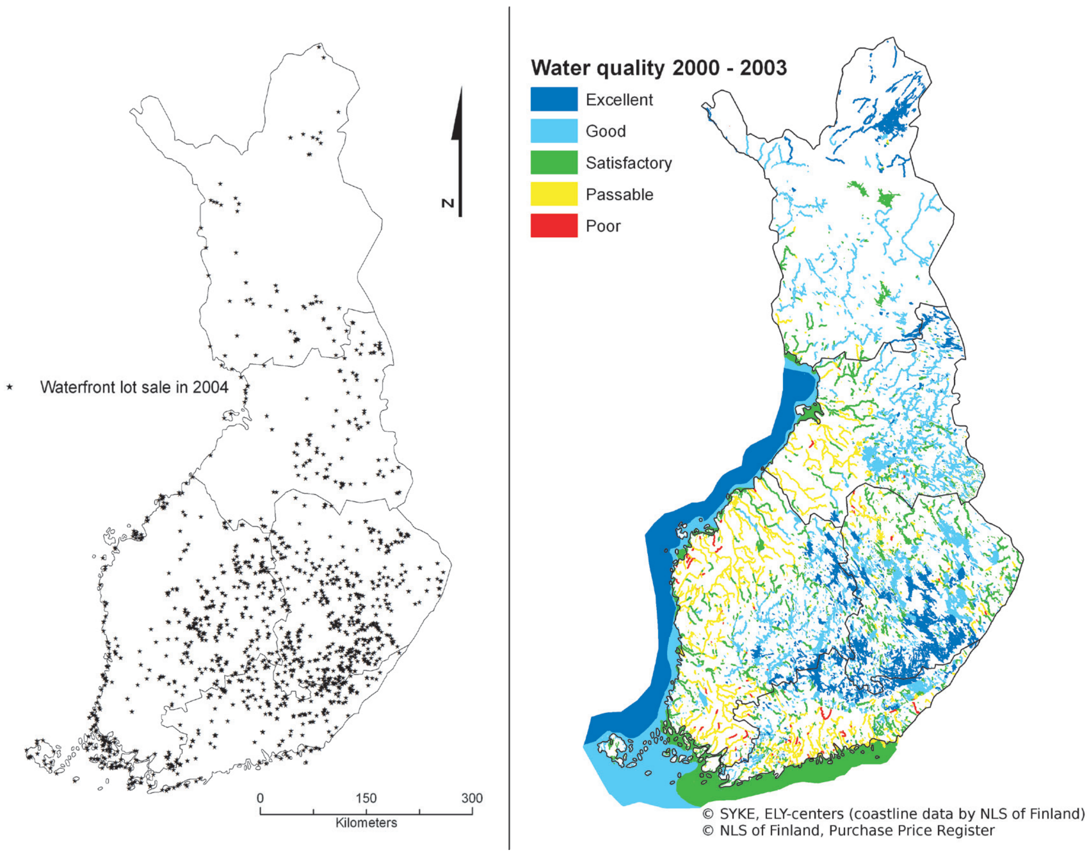

Figure 4. Unbuilt summer house lot sales used in Essay III analysis compared to the Water usability index by the Finnish Environment Institute.

distance would make all those observations neighbors.

The weighting matrix literally weights the neighboring observations' attributes in the estimation. However, the weighting strategy is up for the researcher. In a distance-based neighborhood set, the influence of neighbors to one observation can be set to decay with distance so that far away neighbors have negligible first-order impact on an observation. In kNN strategy the weighting of the neighbors can also follow a similar strategy, but a more common strategy is to row-normalize the weights so that each neighbor has an equal first-order influence on an observation. In Essay II, three neighborhood sets were originally constructed, with three, five and seven nearest neighbors, of which the 3NN-set was used for final analysis. The choice of smallest nearest neighbor specification was based on similar results with other neighborhood sets with a concern that the inclusion of more neighbors in remote areas might relate very far away observations as neighbors.

After defining a meaningful neighborhood set, the existence and type of spatial dependence present in the study sample can be tested using heteroskedastic-robust Lagrange multiplier tests available by, for example, the *Spatial dependence: weighting schemes, statistics and models*-package in the R-statistical software (Anselin et al. 1996). The spatial dependence can manifest in multiple forms, of which I introduce the two simplest applications. The spatial autoregressive model (SAR) and the spatial error regression model (SEM) incorporate the neighborhood weighting matrix, $\boldsymbol{W}$, into the ordinary least squares regression framework (LeSage and Pace 2009). The neighborhood matrix complicates the estimation of spatial models because all observations are linked to each other as first-order and higher order neighbors, i.e. neighbor's neighbors, and so on. In the spatially autoregressive model there is a *spatial lag* of neighboring observations' dependent variable, e.g. property price. The motivation behind the functional form is that neighboring units have actual interaction that causes the dependent variables to be connected. Property markets are likely to have this feature, as sellers are able to see their neighbors' offers in many cases. The model can be presented as

$$y = \lambda \boldsymbol{W} y + \beta X + \varepsilon, \tag{6}$$

where λ is the coefficient of spatial lag and the error is normally distributed. Estimating the equation requires rearranging the terms

$$y = (I - \lambda \boldsymbol{W})^{-1} \beta \boldsymbol{X} + (I - \lambda \boldsymbol{W})^{-1} + \varepsilon. \tag{7}$$

Similarly the spatial error model, motivated by spatial heterogeneity, can be constructed as

$$y = \beta \boldsymbol{X} + u, u = \delta \boldsymbol{W} u + \varepsilon, \tag{8}$$

where ε represents the standard normal distributed error term.

The spatial models provide additional knowledge introduced by the extra dimension of information. The spatial analysis enables the analysis of direct and indirect effects. The direct effects are observation specific effects, such as the price change induced by a water quality change for a single property. The indirect effect takes into account, however, the spatial spillovers of prices, i.e. how the price change of one observation reverberates through the whole system of properties through neighborhood effects. The total effects sum the direct and indirect effects together. (LeSage and Pace 2009.) Essay II demonstrates the direct and indirect effects of a water quality change in summer house lot prices.

3.3 Water quality as a commodity – Perception versus measurements

Providing value estimates for an environmental good requires that the good itself is well defined. The environmental good and its quality considered by the policy maker may differ from the viewpoint and perceptive capabilities of consumer. An environmental good can be thought through an ecological viewpoint, as with the WFD and MSFD, or through different utilitarian aspects, such as consumption (e.g. drinking water) and recreation (e.g. swimming, fishing, boating) possibilities. In this thesis the focus is on recreation so the *good* we describe as *water quality* should consist of elements important to water recreation.

Hedonic pricing studies on recreational water quality have used water clarity often as an indicator of quality (Michael et al. 1996, Boyle et al. 1999, Michael et al. 2000, Poor et al. 2001, Boyle and Taylor 2001, Gibbs et al. 2002, Krysel 2003). Many of these listed studies are, however, follow-ups of each other which may explain the abundance of water clarity as the indicator of choice. Water clarity is assumed to be easily observable and noted by the public (e.g. Sandström 1996, Gibbs et al. 2002, Soutukorva 2005). Furthermore, water clarity data is often available and is correlated with nutrient levels, and thus eutrophication status of the water body. Others examples of quality indicators include more restricting quality variables, such as fecal coliform bacteria levels (Leggett and Bockstael 2000) or combinations of indicators, for example Phaneuf et al. (2008) use total suspended solids in addition to levels of total phosphorus and dissolved oxygen in the water and Poor et al. (2007) use total suspended solids and dissolved inorganic nitrogen. Essays I and II use water clarity and a compound indicator of recreational suitability of water areas as a proxy for water quality, respectively.

Essay III studies the differences and factors between individual perceptions and objective measurements of water quality. The data of the study is based on a survey sent late in the year 2008 to 2547 private summer house property purchasers of year 2004, resulting in 1249 responses. The survey was conducted jointly through the internet and mail in three stages: initial contact and a reminder to fill out the questionnaire online, and a paper version of the survey as the final reminder. The twenty-page survey (see Appendix 1) elicited information on the respondent's summer house, recreation activity at the summer house, water quality perceptions and questions related to water quality valuation. In Essay III we use questions related to water quality perceptions for the time of property purchase (2004) and the time of the survey (2008). These perceptions were contrasted in Essay III to the usability index introduced earlier in section 3.2.

The initial water quality perception measure was based on an uninformed scaling of water quality, i.e. a feeling of which quality level the water was in at the time of the purchase. The water quality scale had five steps, each with a name corresponding to the objective usability index: poor, passable, satisfactory, good, and excellent.

The second quality perception measure was based on the current water quality in terms of four indicators of water quality: water clarity, fish species present, blue-green algal blooming and sliming of structures and equipment. Each of the four indicators and their visible effects was described to the respondent in four quality steps: worse than satisfactory, satisfactory, good and excellent.

To study possible common sociodemographic factors underlying differences between the two forms of perceptions and objective measures in Essay III we employ a biprobit model. To further analyze the direction of mismatching perceptions and objective measures, i.e. under- or overestimations of the objective water quality, we use multinomial logit models.

4 Summaries of essays

4.1 Essay I: Impacts of changes in water quality on recreation behavior and benefits in Finland

Essay I provides an alternative to benefit transfers and meta-analyses using national recreation inventory data combined with water quality data to assess benefits from water quality improvements through increased recreation participation. The essay studies the association of water clarity in individuals' home municipalities with the three most common water recreation activities – swimming, fishing and boating.

Improved water clarity is found to increase the frequency of close-to-home swimming and fishing, as well as the number of fishers. Aggregate water clarity in home municipality is not, however, found to affect boating participation or frequency. Boaters have less direct contact with water compared to the other two activities which may partly explain this difference. Another explanation is that people may not have mooring for their boats in their home-municipalities causing disjointed recreation behavior from local water clarity conditions. In addition to water quality, from local environmental conditions good weather is found to have an effect on swimming and boating activity levels.

The average consumer surplus per trip ranges between 6.30 and 8.30 euros for respondent reported travel costs, whereas with researcher-estimated travel costs the range is between 18.90 and 19.00 euros. Including the opportunity cost of time does not bring large increases in the estimates, which is unsurprising as the analysis is on daily recreation with relatively short travel times.

Joining the water clarity effects on recreation activity and the average value of a general near-home one-day water recreation trip enables benefit estimation for improved water clarity. Benefits would be in the range of 31 to 92 million euros annually for swimmers and 43 to 129 million euros per year for a uniform one-meter improvement in water clarity in Finnish surface waters.

In addition to benefit estimates a simplistic model on water clarity and nutrient balance for sea-areas and lakes is constructed in Essay II. With the water clarity model it is possible to assess the required nutrient reduction in the water to improve water clarity. Using previous estimates on nutrient reduction costs in Finland the study finds a rough indication that recreation benefits are similar in size to estimated costs for a drastic one-meter improvement in national average water clarity.

4.2 Essay II: Lots of Value? A Spatial Hedonic Approach to Water Quality Valuation

Essay II assesses the value of water quality capitalized into property prices. With data on unbuilt lot sales and water usability index as a recreational quality indicator the study uses spatial econometric techniques in the estimation of first-stage hedonic property price analysis.

The study finds that across different models water quality affects prices significantly for all but passable water quality when compared to the reference property with satisfactory quality. The estimated implicit prices for quality categories follow a logical story, the worse the quality the less people are willing to pay for a summer house lot and vice versa. The estimated values cautiously suggest a non-linear relationship between water quality and property prices. With this statement comes the notion that the usability index may itself be non-linear in nature, which would reinforce the finding if true. As policy makers use quality indicators, which may be inherently non-linear at their behavioral response, it often implies the importance of maintaining and protecting good water quality where it exists as the losses from quality deterioration are marginally larger than from an equal improvement.

The study also finds that unbuilt lot prices have a spatial dependence in the form of a spatial lag. Taking this dependence into account in the modeling results in smaller willingness to pay estimates for good and excellent water quality than using non-spatial ordinary least squares approach. An average summer house lot with good (excellent) water quality is estimated to have a price premium of some 9 % (19 %) more than a lot with satisfactory water quality with a spatially explicit model. A non-spatial model would estimate the effects to be 13 % and 30 % more, respectively, showing that ignoring spatial dependence can cause even severe biases to estimation.

As the results are based on first-stage hedonic price estimation, i.e. implicit prices rather than full demand function estimation, the interpretation of the results needs caution. Based on earlier theoretic literature the results present an upper bound for summer house lot owner's benefits from improved water quality, *when considering the benefits only from the side of capitalization to property value*.

4.3 Essay III: Subjective vs. objective measures in the valuation of water quality

Essay III focuses on the heterogeneous interpretation of water quality by individuals and the policy maker. Studying the reasons and trends in quality perception differences between the subjective and objective viewpoints provides valuable information on possibly surprising behavioral response, or lack thereof, to water quality changes.

Using a large scale survey results from summer house property owners the study finds that one in two respondents discern water quality differently from an objective recreation-centered water quality measure even when measured at a coarse interval. Statistical modeling reveals several individual specific and environmental factors contributing to divergent quality perception, but the most important results in the context of this thesis are the effects related to variables used in the travel cost and hedonic property pricing method.

Variables often used in the travel cost method are, to some extent, in sync with divergent quality assessments. Underestimating the objective measure is more likely with increased distance between the individual and the assessed water body. Also prior unfamiliarity with local conditions is attributed with higher probability to perceive water quality differently from the objective. Interestingly, active water recreation does not have a statistical effect in divergence. Thus for travel cost analysis, objective recreation-focused water quality measures will reflect perceptions better when trips to relatively near areas are analyzed.

For hedonic property pricing studies, price is not found to affect the probability of assessing quality systematically differently from the objective. This result is very important, as it shows that endogenous sorting does not depend on the quality measure used, while it may still be present in the sales data. Preference based sorting occurs when summer house purchasers with higher preferences for water quality would purchase the good quality properties and *vice versa*. If present, the effect complicates hedonic pricing analysis.

An important result affecting all valuation studies is the finding that the type of water body under assessment has a significant effect in the divergence of the objective and subjective quality measures. Water quality on the Baltic Sea is considered more often better than the official classification compared to owners of lakeshore and, in some cases, riverside properties.

Overall the respondents are more likely to overestimate water quality with an increasing rate the worse the objective assessment. While the lowest objective water quality categories suggest very poor recreation opportunities, people are still likely recreating in these waters. The observation may carry an important signal – if objective water quality is used in a valuation study, a change to poor objective water quality measure carries less drastic behavioral changes, or lost benefits compared to a situation where water quality would be measured in a subjective scale. These results emphasize the need to take individual perceptions into account in valuation studies if the study area includes water bodies, especially coastal areas, in relatively poor condition.

5 Conclusions and discussion

This thesis studies the value of water quality protection in Finland using revealed preference valuation methods, and assesses how different water quality measures coincide from the policy perspective in contrast to individual perceptions.

Essays I and II analyze recreational value and water quality in different angles to provide a fuller picture on the associated use-values. Essay I considers daily near-home water recreation finding swimming and fishing activity to significantly be affected by water quality. For boaters the results are inconclusive, but caveats in the data forbid the interpretation that water quality would not affect benefits from boating.

Essay II takes the side of a long term financial decision in conjunction with water recreation that is not covered by Essay I – the purchase of a waterside summer house lot. The analysis shows that water quality affects property prices positively. Weaker signals are found to indicate that the water quality effects on price are non-linear, meaning that the gains from protecting water quality generally exceed those of improving the water quality.

Combining the results from Essays I and II shows that Finnish people are keen to use the ample water resources in the country, but also sensitive and responsive to water quality as it affects recreational quality. The behavioral responses affect the participation rate and frequency of daily water near-home recreation property prices in markets connected with water recreation.

Essay III brings an interesting twist to the story by showing that subjective perceptions of water quality differ quite often from quality indicators and scales used by researchers and policy makers. For travel cost studies the analysis shows that water quality perception shows greater variability the further and unfamiliar the visited destination is. As Essay I uses near-home water recreation data for the analysis, the effect is likely subdued. For the results of Essay II the implications from differences between the objective and subjective water quality measures are two-fold. While endogenous sorting may be present in the market, it is not affected by the choice of water quality measure, subjective or objective. The message of Essay III, however, reminds that when policy builds on a set of objective quality measures, even if designed to reflect quality from human perspective, the recreational activity response from improving water quality at the lower end of the scale may not be what is expected. For property markets the improvement in the officially used measure for water quality may, however, affect benefits more directly. Since the implicit value for water quality is market driven, an official stamp of certain water quality level may command a price premium even if detached from actual effects to recreation. This consideration is important when assessing the benefits from the Water Framework and Marine Strategy Framework Directives.

To improve current information on use-values of water recreation further travel cost studies and more specific hedonic property price studies are warranted. Travel cost studies on longer than one-day travels need to be conducted, but require extensive data on travel behavior and possible substitute sites. Hedonic studies, on the other hand would need more specific data on built properties and buyers to enable a second stage hedonic estimation of water quality demand. Both revealed preference methods could also benefit from including stated preference data into the analysis. This would require large scale surveys specifically designed to elicit such information, but could provide information on behavioral response to unforeseen events and developments in water quality and recreation possibilities. The role of time and changing preferences is also lacking in the analysis: both valuation studies are based cross-section data, providing glimpses on current values and behavior but ignoring shocks and trends. Finally, the role of ecological quality indicators to recreational use and perceptions of quality should be studied further. Such research would enable policy makers to consider policy implementation effects both from the viewpoints of nature and recreation, i.e. non-use and use related effects and values.

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