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An application of contingent valuation and decision tree analysis to water quality improvements

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Abstract

This paper applies contingent valuation and decision tree analysis to investigate public preferences for water quality improvements, and in particular reduced eutrophication. Such preferences are important given that the development of EU water quality legislation is imposing significant costs on European economies. Results are reported of a survey undertaken of residents of Århus County, Denmark for water quality improvements in the Randers Fjord. Results demonstrate strong public support for reduced eutrophication and identify key determinants of such support.

Keywords: Contingent valuation; Decision tree analysis; Water quality; Eutrophication; Randers Fjord

1. Introduction

The European Union's Water Framework Directive (2000/60/EC) has provided the legislative framework for water quality improvements within its region, seeking to restore all water bodies to 'good ecological status'. In embracing the Urban Waste Treatment Directive (91/271/EEC) and the Nitrates Directive (91/676/EEC), a principle concern of this legislation has been the impact of eutrophication on water quality. Eutrophication is the accelerated production of organic matter in a water body and is linked to an increase in nutrients, in particular nitrogen and phosphorus, being discharged into aquatic ecosystems (Bricker et al., 1999). It has been recognised by the scientific community as constituting a serious threat to the ecology of and services provided by freshwater systems since the mid-1900s and to estuarine and coastal systems since the 1980s (Elliott and de Jonge, 2002). Furthermore, there are plans to extend the scope of legislation within the European Union (see Apitz et al., 2006) with the introduction of the EC Marine Strategy (EC, 2005a) and the proposed Marine Strategy Directive (EC, 2005b), which seek the restoration of marine ecosystems and require 'good environmental status'. Despite these developments, published evidence on public preferences for such measures is scarce, and this is despite the high costs borne by society in the form of 'costs of treatment, mitigation and/or compensation' (Elliott and de Jonge, 2002) in implementing and/or meeting the requirements of this legislation.

In this paper, an evaluation is undertaken of public preferences for reduced eutrophication, particularly with respect to its implications for water quality improvements. The focus of the evaluation is the Randers Fjord, Denmark,[1] and the preferences of residents of the neighbouring Århus County for a less eutrophied Fjord, where costs of implementing the Urban Waste Water Treatment Directive alone in the catchment have been estimated to be in the region of €300 million (Atkins and Burdon, 2006). While the approach adopted here follows the widely used

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[1] The Randers Fjord was one of four chosen study sites for the EU-funded project EUROTROPH, which investigated nutrient cycling and the trophic status of European coastal ecosystems.

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contingent valuation methodology (CVM), the findings update and extend preliminary results in Atkins and Burdon (2006), further contribute to a small empirical literature which reports investigations into eutrophication at other locations (Söderqvist, 1996; Markowska and Żylicz, 1999; Gren et al., 2000; Bateman et al., 2006; Frykblom et al., unpublished) and may constitute the first survey evidence of this kind for an estuarine system. In addition, this paper advances the use of decision tree analysis as a basis for the investigation of the CVM survey respondents' behaviour. Classification and regression (decision) tree analysis is a recursive partitioning technique which predicts the membership in the classes of a categorical dependent variable (or predicts values of a continuous dependent variable) from one or more explanatory variables (Breiman et al., 1984). This technique here is used to examine relationships between both CVM voting and bid decisions, and identified characteristics of individual survey respondents.

The remainder of the paper is structured as follows. In Section 2, the theory and empirical literature on goods and services provided by estuarine and coastal systems is reviewed, with a particular emphasis on the valuation of public preferences and eutrophication. In Section 3, eutrophication in the Randers Fjord is described and the CVM survey and findings presented. In Section 4, decision tree analysis is used to evaluate the CVM bidding decisions. Conclusions are drawn in Section 5.

2. Background

There is a large theoretical and empirical literature on the goods and services provided by the natural environment (see De Groot et al., 2002; Eftec, 2005), and a small literature on the goods and services provided by the estuarine and coastal environment (Turner et al., 2001; Beaumont et al., 2007). Much of this literature takes as its starting point the framework established by Boyle and Bishop, 1985 in their analysis of the *total economic value* of wildlife resources, whereby a range of use and non-use values can be identified for an estuarine ecosystem. Use values are derived from consumptive and non-consumptive human interaction with the ecosystem, and might include activities associated with recreation (fishing, boating and other water sports), commercial fisheries, agriculture, industry, and tourism along with biodiversity, research and education. Retaining an option to use the ecosystem in an uncertain future may constitute an important additional use value. In contrast, non-use values can take various forms including existence, altruistic and bequest values (Bateman et al., 2002). Existence values often reflect a sense of well being and are derived from knowledge of an ecosystem's existence, but are not associated with actual or planned use. Altruistic values are an expression of concern for the availability of the ecosystem for others in the current generation. Bequest values are associated with the current generation placing value on ensuring the availability of the ecosystem to future generations.

Estuarine goods and services can be diminished by deteriorating water quality associated with increased levels of eutrophication. While the impacts of increased nutrient concentrations can vary greatly with the individual features of the system in question, Bricker et al. (1999) identify generic 'estuarine use impairments' (p. 7) as primary and secondary symptoms of eutrophication and goods and service flows, presented schematically in Fig. 1.

The fact that many of these effects and impairments impact on goods and service flows which are either not marketable or marketed at prices that do not reflect their social worth, necessitates the adoption of non-market valuation procedures to assess the values placed by society on any changes in the flows. The contingent valuation methodology is such a non-market valuation procedure as it relies on direct questioning of consumers to obtain willingness-to-pay bids for a scenario created by the analyst. In effect, where an actual market place in an environmental good or service flow may not exist, a hypothetical market can be created, and agents requested to reveal the value that they place on a proposed change in the flow. In practice, this methodology has the potential to reflect a range of ecosystem goods and services if an appropriate scenario and bidding process can be established (see Turner et al., 2001; Bateman et al., 2002 for a more detailed explanation of the technique). An alternative approach is choice modelling, which also relies on stated preferences; this is particularly applicable where relative values for different attributes of an environmental resource are being sought (Bateman et al., 2002). The application of CVM to investigate public preferences and to elicit willingness-to-pay for reduced eutrophication in the Randers Fjord is discussed in the following section.

Turning to empirical applications, the authors are unaware of any previous applications of CVM investigating eutrophication in the Randers Fjord. However, the technique has been used to examine water quality improvements, including eutrophication, in the US (Bockstael et al., 1989), Europe (Söderqvist, 1996; Markowska and Żylicz, 1999; Gren et al., 2000; Hanley et al., 2003; Bateman et al., 2006; Murato et al., 2006; Frykblom et al., unpublished) and Asia (Yaping, 1997; Tapvong and Kruavan, 2000). The studies undertaken within Europe include two related CVM surveys in Sweden and Poland which were part of a larger project that sought to evaluate the costs and benefits of a less eutrophied Baltic Sea (see Gren et al., 2000 for further details). This Baltic study obtained contingent willingness-to-pay valuations in both countries using a mailed questionnaire as the survey instrument, with the results extrapolated to obtain values for other market and transition economies which border the Baltic Sea. The studies found that the perceived benefits of reducing eutrophication in the Baltic Sea by 50% through a notional 'international action plan' designed to abate such pollution to be substantial – estimated to be SEK 31,527 million (€3720) million per year when extrapolated to all nine coastal states. Of particular interest to the current paper